Passive House for New Zealand

The warm healthy homes we need

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Published in 2019 by Sustainable Engineering Limited
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76 Virginia Road, Whanganui 4500, New Zealand

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ISBN: 978-0-473-46903-0

Acknowledgements

The author thanks Pro Clima NZ for funding the printing of this edition of our book. Its focus on health and building performance, as well as efforts to enhance education in the New Zealand building community, motivates us all to do better in our jobs and lives.

Editor: Rachel Rose
Designer: James Chatterton
Printed by Milne Print Ltd on Forest Stewardship Council certified paper, using vegetable based inks.

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Foreword

Professor Robyn Phipps,
Professor in Construction, Massey University

New Zealanders are proud to be the best, the strongest and the fastest in many sporting codes and endeavours. Our identity rightly includes our brilliance in sports. We invest thought, funding and effort in sport. The mantra “where the attention goes the energy flows” has contributed to our sporting prowess.

New Zealand housing and health statistics also rank internationally, but regrettably for all the wrong reasons. New Zealand has one of the highest rates in the world of asthma, affecting one in four New Zealanders; one of the highest rates of excess winter mortality, where 1800 more New Zealanders die every winter than in other seasons – possibly due to cold indoor temperatures in our homes; one of the highest rates of rheumatic fever; and one of the highest rates of hospitalisation caused by staphylococcus infections. The most vulnerable members of society – children, elderly and infirmed—are those at greatest risk. We also have, by international standards, a very high rate of fuel poverty – the cost of heating your homes compared to income.

Our homes should be a safe haven; resilient spaces that protect us from summer heat and winter chills, from driving rain and dampness. However, the majority of homes built to the New Zealand Building Code (pre-2004) are only 1° C warmer than the outside temperature, and well below the 18° C minimum temperature set by the World Health Organisation. Some children sleep in bedrooms that are literally as cold as a fridge, and nearly half of New Zealand homes have visible mould.

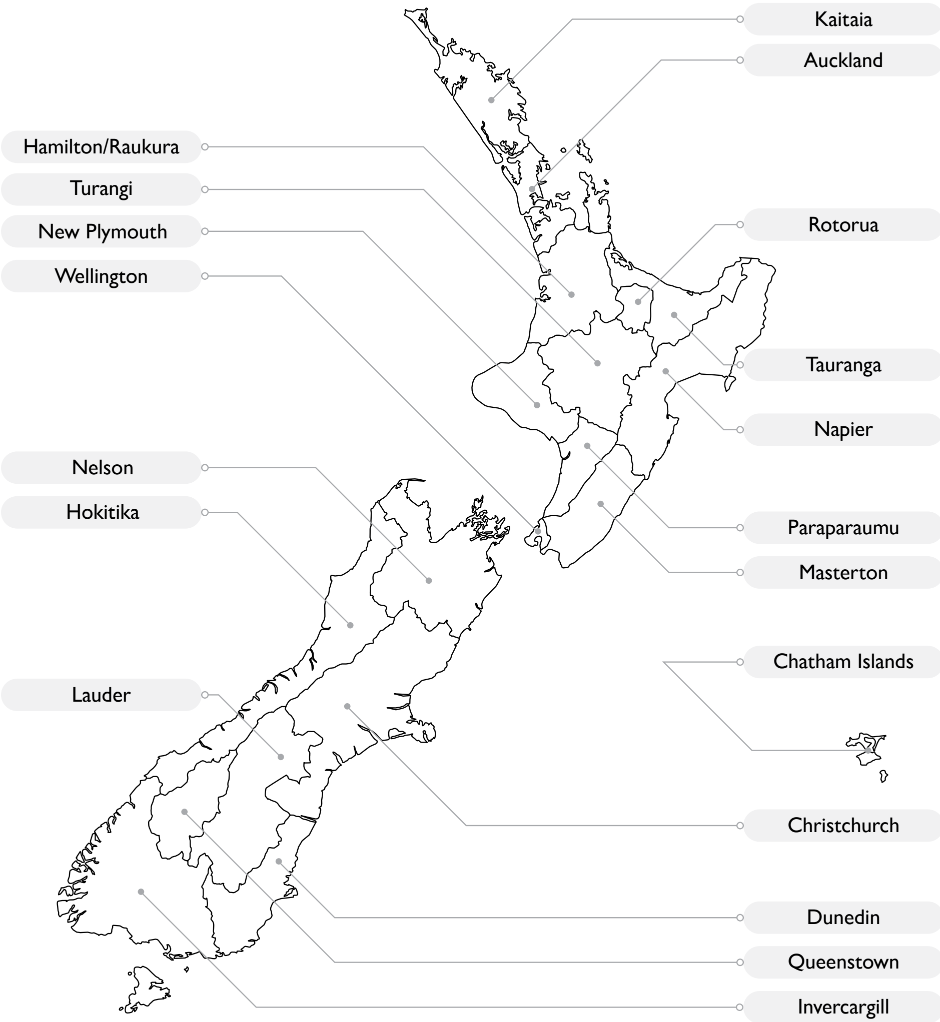
This timely book focuses attention on high performance and energy efficient homes. It heralds the tide change from the typical current view on what is the lowest standard of housing that we can tolerate or legally build, to how a warm, dry and healthy home can be achieved. Attention on high performing homes will certainly result in healthy homes and healthier people.

This book will spark lots of thought, funding and effort into energy efficient and healthy housing. It is my greatest wish that one day New Zealand will be ranked as a world leader in this domain. Where the attention goes the energy flows – this book is undoubtedly a step in the right direction.

Nga mihi,

Robyn

New Zealand's 19 climate zones



These are available as certified climate files in the PHPP software. They are based on extensive NIWA analysis.

1. The Problem

Too many homes make people sick

The current talk about the housing crisis is almost entirely focused on affordability to purchase and homelessness. Yet there is a more pervasive problem, afflicting New Zealanders whether they rent or own. Researchers like Professor Philippa Howden-Chapman have been researching the health and social implications of sub-standard housing for years: there is a tonne of evidence.

New Zealand homes are too often cold, damp and hard to heat. More than three-quarters of current homes were built before 1978, the year the New Zealand Building Code changed to require minimal insulation. Even more recent homes built to the current Building Code can be uncomfortable and expensive to run.

New Zealand's poor housing causes serious health problems, even early death. This country has a shocking excess winter mortality, estimated at 1600 deaths per year. That's avoidable human suffering and loss, a burden on our health system and creates huge opportunity costs on a personal and societal level.

Let me count the ways:

Cold: The average New Zealand home is 16 degrees inside during winter, the temperature at which the risk of respiratory illness increases. At less than 12° C, there is a higher risk of strokes and heart attacks. World Health

Organisation (WHO) guidelines call for an indoor temperature of at least 18–21° C if babies or elderly are resident.

BRANZ researchers installed temperature loggers in a representative sample of New Zealand homes the length of the country, gathering accurate data for a year about how and when New Zealanders heated their homes. They found half of bedrooms were *never* heated and that the average bedroom temperature between midnight and 9am was 13 degrees.

The effects fall more heavily on the poor: Those who come from low socio-economic homes have a hospitalisation rate three times that of people from homes in wealthier areas. WHO believes that a considerable proportion of childhood asthma cases are due to damp and mouldy homes.

Damp: Cold houses are usually damp houses; nearly a third of New Zealand homes are damp and rental properties are much more likely to feel damp than owner-occupied homes. Humans produce moisture through basic activities like cooking, bathing—and breathing. Moisture then condenses on cold surfaces. New Zealanders are all too familiar with heavy condensation on the inside of window frames and/or glass, that can run down the panes to pool on window sills.

"People do not find it strange to wear coats and outdoor clothing when indoors."

A Danish builder's observation about New Zealanders.

One in six New Zealanders are sick with respiratory illnesses, which costs $6.16 billion a year in public and private costs. Respiratory illness includes asthma, pneumonia and bronchiectasis, a life-threatening disease that results from repeated chest infections in early childhood. Some children grow out of asthma; those who contract bronchiectasis in childhood will have it for life. Pacifica children have an incidence of bronchiectasis nearly five times higher than the general population.

Mouldy: A third of New Zealand homes contain mould. Not all mould is dangerous to healthy people but some are potentially toxic and spores can aggravate pre-existing respiratory conditions such as asthma. Some people have an allergic response to mould or are more susceptible to its health effects because their immune system is compromised.

Mould follows damp; it is nearly impossible to keep mould at bay when indoor relative humidity rises above 70 per cent. New Zealand research measured bedrooms with over 70 per cent relative humidity for 90 per cent of time.

Mould can cause a range of chronic and acute ailments, including respiratory illness, headaches, rashes, all the way through to behavioural changes and debilitating fatigue, according to mycologist Dr. Heike Neumeister-Kemp.

Damp, cold and mould are a trio of problems that work together in a negative feedback loop: damp houses are very hard to heat and damp is a condition for mould to spread.

New Zealand homes are much damper (that is, they have higher relative humidity) than in many other parts of the world, because of our temperate climate and how we live in our homes. Modern construction materials and techniques are creating homes with less air leakage—almost by accident. Yet continuous mechanical ventilation and heating, which solves the problem of excess humidity in our climate, is very rarely seen in single-family dwellings in New Zealand.

The Building Code perpetuates this situation

The majority of homes are cold because they are expensive to heat due to firstly, design decisions driven by minimising capital costs and secondly, construction methods. That's a failure of policy as well as the market.

Why do we put up with it?

Immigrants from Europe and other Western nations frequently ask why New Zealanders put up with being so cold, and living in homes that are damp and hard to heat. (A friend from Canada who settled in the Antipodes quipped, "When they told me it only got down to 16 degrees in winter, I didn't realise they meant inside".)

The roots of the cause may run deep in the Pākehā psyche. Ben Schrader, who has written histories about New Zealand housing and urban culture, points out that settler dwellings from the 1840s were predominantly constructed from timber and that British immigrants likely did not understand its much poorer thermal properties compared to the homes made of stone and brick that they had left behind.

Evidence from the time attests to early New Zealand cottages being under-heated and miserably cold. "It can only be surmised that a settler proclivity towards stoicism—discomfort was an attribute of colonial life—meant they gave little thought to improving things," Ben Schrader writes in his book *The Big Smoke*. "So it became a New Zealand custom to heat the kitchen, where the coal range was, and the sitting room, but not the other rooms."

Historian Jock Phillips agrees: "Male frontier culture in New Zealand led to a denial of pain. To admit to coldness and discomfort was to reveal yourself as an effeminate urban weakling." Perhaps those early settler experiences linger on, continuing to shape expectations and ideas about what is normal.

Leading health researcher Professor Phillipa Howden-Chapman told *The Listener* in 2017, "There's quite a macho thing in New Zealand when it comes to heating. You would think that keeping warm was such a pleasure that if you had the money, you would want to keep warm, but that doesn't seem to apply in New Zealand. Even wealthy people choose to heat just one room."

Builder Kim Feldman grew up and learned his trade in Denmark. Danish houses are warmed by central heating all winter because the outside temperature is constantly below zero—unlike his new home in Taupō which has milder winters with fluctuating temperatures.

He thinks there's a lack of knowledge in New Zealand: "Many people are simply not aware that a poor indoor environment may have serious consequences for their health," he says. There needs to be more education. (He also notes, "People do not find it strange to wear coats and outdoor clothing when indoors.")

He also points to economic drivers. "Many people look at their home as an investment—and in many cases a short term investment. They want their homes to be big, impressive looking and cheap. That way they can make more profit in the shortest possible time.

"A lot of the new buildings today could easily be 10-20 % smaller and still comfortably accommodate the people living in them. The capital saved could instead be used to improve the indoor climate, for example by building a Passive House or at least doing more than the Building Code specifies.

"I think that many people are simply not aware what it feels like to live in a comfortable home, without mould on the window sills and a draught along the floor—or they think that such luxuries will cost them a fortune."

The Building Code is a performance based standard. This is, in theory, a good thing and admired by overseas building professionals. But: in practice, it fails because the minimum standards are too low and the industry regards them as a target to meet, not a legal minimum to exceed.

(BRANZ is now acknowledging this issue in its *Exceeding the Minimum* programme, which seeks to encourage both homeowners and building industry professionals to build dwellings above the Code-specified minimums. But at time of writing, this project remains largely in the research phase.)

If designers specify commonly used details, construction materials or types that have been designated as "acceptable solutions" in the Building Code, their designs will go through the Building Consent process quickly, down the "deemed to comply" route.

Doing better means not just spending more on components, but delays and additional costs in getting consents because it pushes consent applications down a so-called "alternative solution" pathway. For instance, architects specifying high-performance windows in bespoke homes complain about the additional hurdles they are asked to clear by risk-averse council staff. They may face requests for producer statements or other information, all of which costs them time and their clients money. This additional liaison also delays the issue of consents.

Asking whether architects and builders or their clients need to change their attitudes is a red herring. Fixing this problem requires change at a systems level. The Building Code needs revision, so that more modern, better performing materials, components and methods qualify as acceptable solutions.

The Building Code fails because the minimum standards are too low and the industry regards them as a target to meet, not a legal minimum to exceed.

The current Building Code requirements for wall, underfloor, ceiling insulation and windows are inadequate and higher minimum standards are required. This requires courage and leadership on the part of politicians, because increasing the performance standards will add to the cost of building and that is electorally unpopular.

Building costs are already high in New Zealand and a range of reasons are offered: high cost of land, labour costs and skill shortages and the size and shape of our market (small by international standards and geographically dispersed).

Building material costs alone are 20-30 % higher than in Australia. Housing and Urban Development Minister Phil Twyford pointed to an effective duopoly in suppliers in New Zealand and described the industry as rife with rorts and anti-competitive practices, sufficient for him to call for a market study investigation by the Commerce Commission.

If there are anti-competitive practices inflating building costs in this country, they need to be stamped out. New Zealanders deserve the best house they can buy for their money—paying for performance and durability, not for rebates and junkets designed to lock contractors into buying specific products.

Building Code climate zones are inadequate

New Zealand spans a wide latitude and people live at elevations from sea level to over 1130 metres above sea level. Our geography creates a wide range of climates but the Building Code specifies a mere three zones.

Using that scheme, a holiday home in the mountains in Queenstown is required to have no more insulation than a beach front house in Nelson, despite needing twice as much energy to heat.

In contrast, 18 distinct climate zones were originally identified by NIWA. In a project undertaken by the author in 2015 and partially sponsored by PHINZ, 30 years of NIWA's data from weather stations around the country was checked and its applicability for Certified Passive House calculations confirmed. Climate files are now certified for each zone, as shown in the map on page 6—even the Chatham Islands. This means anyone using PHPP energy modelling software (see page 28) can accurately predict the heating/cooling needs of a building anywhere in the country and design accordingly.

One in six New Zealanders are sick with respiratory illnesses, which costs $6.16 billion a year in public and private costs.

There is no need for designers to guess, given the cost of getting it wrong is high. Underestimate and a building will need more energy to heat and/or cool. Overestimate and money is wasted on insulation beyond what is needed.

How we occupy homes is changing

We don't build houses the way we used to. Materials have changed, and houses now contain less elements that can buffer changing levels of moisture or safely ventilate the moisture away—chipboard has replaced solid timber and plywood's replaced timber strip flooring.

Construction techniques have also changed: pre-fabricated components and more streamlined workflows get houses to "lock-up" stage faster, giving rain-soaked timber framing less opportunity to dry.

Neither do we live in our houses the way we did 20 years ago. We actively ventilate far less: houses are typically tightly locked for eight or even 10 hours a day while occupants are at work and school. Windows may be closed overnight for security reasons.

For this reason, even modern homes that meet the legal minimum can be problematic. Take the case of a new home in Auckland with double-glazing and insulation: its owners are a professional couple who shower in the morning then head off to work, leaving the house locked up until the evening. The bathroom fan operates only while the shower is on. That's insufficient to clear the steam, and the tightly shuttered house is damp and mouldy.

New Zealanders deserve the best house they can buy for their money—paying for performance and durability, not for rebates and junkets designed to lock contractors into buying specific products.

What hasn't changed: families mindful of the cost of heating keep doors and windows tightly closed during colder months.

BRANZ began to acknowledge the problem more than three years ago, when its building physicist Stephen McNeil called internal moisture "the most pressing contaminant in New Zealand homes".

Yet the Building Code fails to address ventilation. As long as windows *can* be opened, the Code assumes they *are* being opened to provide adequate ventilation.

New Zealand's Building Code urgently needs improvement to reflect the changes in building materials, construction materials and how people live in them; and to address the health problems created by our poor standards of building.

Inefficient buildings contribute to climate change

We need homes that are healthy for our people to live in. But we also need buildings that demand less from the planet.

New Zealand's discussion about climate change mitigation is dominated by our agricultural emissions. It obscures an alarming fact: buildings use a huge amount of energy, about 40 % of the total primary energy consumption in developed countries. This is the sector with the greatest potential to reduce energy use and thereby mitigate climate change.

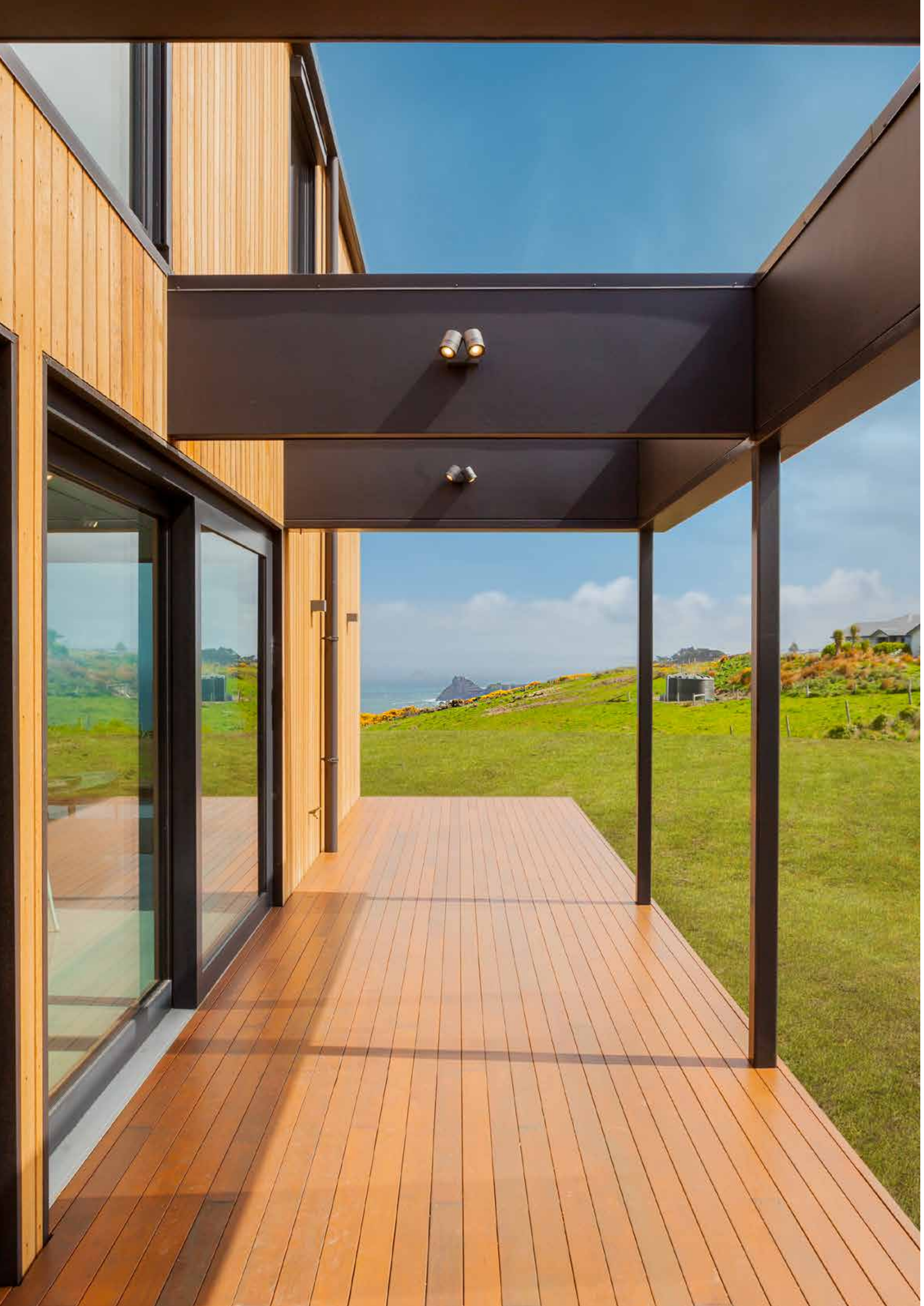
We can look overseas for examples of countries taking substantial action to meet carbon emission targets set under the Paris Agreement. Germany, Sweden, the United Kingdom and Canada, among others, are seriously focused on reducing the energy consumption of residential and commercial buildings.

Take Vancouver, which has the greenest building code in North America. Since May 2017, the City requires all rezoning applications to meet low emissions building standards. This has seen a phenomenal increase in buildings that meet the Passive House standard.

Radical change is needed. Tinkering around with small upgrades may be worse than doing nothing. It risks creating what climate change scientist Diana Ürge-Vorsatz calls "the lock-in effect".

Consider a building owner who invests in an easy improvement like replacing old, poorly fitting wooden joinery with aluminium double-glazed windows. That's better than before but falls far short of what is possible with thermally broken frames and double-glazing with low-E coating and argon fill. The cheap frames will conduct heat and collect condensation, leading to heat loss and moisture build-up—and very likely, mould. Yet the money already spent on new windows will create a significant obstacle to further upgrading them.

We can do better. We must do better.



II.
A SOLUTION

If the Passive House energy efficiency standard were adopted at scale in New Zealand, it would bring about a revolution in people's health and comfort. It would also deliver significant benefits with regard to the environment in general and the climate in particular.

From tiny beginnings in 2011, when the first New Zealand Passive House was designed, this standard is gaining ground. At the beginning of 2019, there are 24 Certified Passive Houses that meet its exacting standards of energy efficiency and scores more built to (or near) the standard. All of these go far beyond the legal minimum of the New Zealand Building Code.

What is Passive House?

It's a building that uses tiny amounts of energy for heating and cooling, so it's very cheap to run. It's very quiet inside and the temperature is comfortable and constant—everywhere in the house, all the time. The indoor air quality is outstanding thanks to high-level filtration; that's good for everyone but especially for occupants with respiratory issues like asthma or who suffer from seasonal hay fever.

At a more technical level, Passive House is an open source standard for extremely energy efficient buildings. A certified Passive House uses no more than 15kW per square metre, *per year* to heat a building (and the same amount again for cooling, if required). That's **81 % less energy** than is used to heat a typical single family home in Auckland to 20 degrees (and 92 % less than one in Christchurch).

The standard also sets an upper limit on air leakage (explained on page 34) and requires a comfortable indoor temperature (because freezing homes that are not heated at all also use very little energy!).

Passive House is a process as much as a standard. A Certified Passive House requires attention to detail and careful planning, from the initial design phase through every stage of construction. The quality of the build is independently verified by rigorous on-site testing.

As well as Passive House Classic, there are two other related classes:

Passive House Plus generates the same amount of renewable energy each year that the building uses. That's total energy use, not just energy for heating and cooling. It also accounts for energy storage losses—it's an honest reckoning of net zero. It's calculated in such a way as to be fair for single level single-family dwellings and multi-level apartments.

Passive House Premium generates as much renewable energy in a year that the building occupants use in their daily lives. It's set at a level to make a fully renewable energy grid work for everyone.

Sweden is taking climate change seriously and has committed to completely eliminate CO^2 emissions by 2050. The city of Växjö has funded two high-rise Passive House apartment buildings. They cost 5–10 % more to build than their conventional equivalent, quickly offset by their dramatically lower running costs.

The EU has directed that all new buildings must be close to zero energy consumption by 2020.

In addition, **EnerPHit** is a standard for retrofitting existing buildings to the Passive House standard.

In New Zealand's largely temperate climates, Passive Houses typically need no heating for almost all the year. For brief periods in winter, heating (for the entire house) may be provided by a radiant panel in a bathroom or a plug in electric heater.

Some Passive House owners have installed small heat pumps, given their efficiency and capacity to cool in summer as well as heat in winter as required. Heat pumps are so energy efficient that the cost to heat an entire 100 m² house would be scarcely more than the energy used by a late-model fridge.

The case studies in the following section vividly illustrate how little active heating and cooling is required.

Other than that, **Passive House is not prescriptive**. A house may be any size or style, and use a range of different techniques and materials. The client's requirements and the designer's preferences can all be accommodated, as the following case studies demonstrate.

There are multiple ways to achieve the required performance, which builds in flexibility. For instance, increasing floor and ceiling insulation could compensate for large, south-facing windows that open out onto a spectacular view or the private side of a small site. Or, opting for top-end glazing could allow for simpler details when insulating a concrete slab.

What's the difference between Passive House and Certified Passive House?

All genuine Passive Houses are designed to meet the performance targets outlined in the standard. A Certified Passive House has been independently verified: it's a mark of assurance and quality. It confirms that the building has been constructed well: the actual performance should equal the theoretical performance predicted in the design phase and all Passive House targets have been met.

Certification provides peace of mind for all involved. The client knows they have got what they paid for. The designer knows their work was correct. And the construction team know their job was well done.

Certification may bring a premium when it comes to resale of the building, as it happening overseas (in California, sales of single-family homes with third party certification are averaging 9 % more).

Note that Passive House is not a trademark so anyone can use it—although The Fair Trading Act prohibits false or misleading claims.

Myth No.1: Passive Houses are for cold climates, it's overkill for New Zealand.

You might still hear this from some factions within the building industry but it's rooted in a lack of understanding of what Passive House is.

It's true that Passive House (or ***Passivhaus***, in German) was developed in Europe's much colder climates. But the standard is used successfully around the world, including in temperate climates more like ours, such as California, Vancouver and south-east Australia.

Passive House sets a performance standard—it doesn't dictate what is required to reach that. So it's ***easier and cheaper*** to build a Passive House in New Zealand compared to say, Bavaria, where winter temperatures can plunge to -15°C. Less insulation will be required, perhaps double-glazing instead of triple.

Even within New Zealand, it is simpler to reach the performance target in Northland compared to Queenstown. The designer or architect adjusts the design to take into account the local climate. (That's why accurate regional climate zones are so important to efficient and accurate Passive House design—see page 6.)

A New Zealand homeowner gets all the benefits of a Passive House, at a cost and complexity that scales to suit the conditions.

Myth No. 2: Passive solar is just as good, without the fancy price-tag

Don't confuse Passive House with passive solar, an approach that relies on a north-facing orientation, concentrating glazing on the sunny side and storing energy in high-mass materials. It's not feasible in many circumstances, for instance if building medium density housing on small lots where aspect is not ideal, or if the million-dollar views are to the south.

Passive solar exponents talk about achieving comfortable ***average*** temperatures, but that average can conceal significant and uncomfortable variations in indoor temperature. Passive solar thinking and design has improved since its origins in the 1970s but there is no standard, no independent verification and no way to accurately predict how a building will perform before it is built.

A Certified Passive House uses passive solar gain if it is available but crucially, can calculate the effect of that energy at the design stage and include it in the performance modelling.

Collaborating not competing

Passive House can work seamlessly with considerations such as choice of site, enabling ageing in place, healthy building materials or prefabrication. Passive House gets vital, universal fundamentals right: extraordinary energy efficiency and human comfort and health. On top of that, different projects, designers and clients can specify other requirements that are important to them (for instance, see the iDEAL home on page 46) and may use rating systems like Homestar (for residences) and Green Star (for commercial buildings).

How is that possible?

The short answer is: because they are designed that way. Buildings should be designed for function, not only aesthetics. The early developers of the Passive House standard cared about how buildings performed: what they were like to live or work in, and how little energy they could take to run. These concerns drove the development of the technology and shaped the performance targets.

In technical terms, Passive Houses are incredibly energy efficient because of their high-performance building envelopes. Warm air in winter doesn't leak out; neither does cool air during a summer heat wave.

Older houses leak air most the time, typically up through the floor, from the ceiling and around windows and doors. It's not necessarily clean or fresh air and it means unpleasant draughts in winter when cold air sneaks in. How much air is moving depends on the strength of the wind outside. Left to leaks in the building envelope, this air change is an uncontrolled process that seldom provides just the right amount.

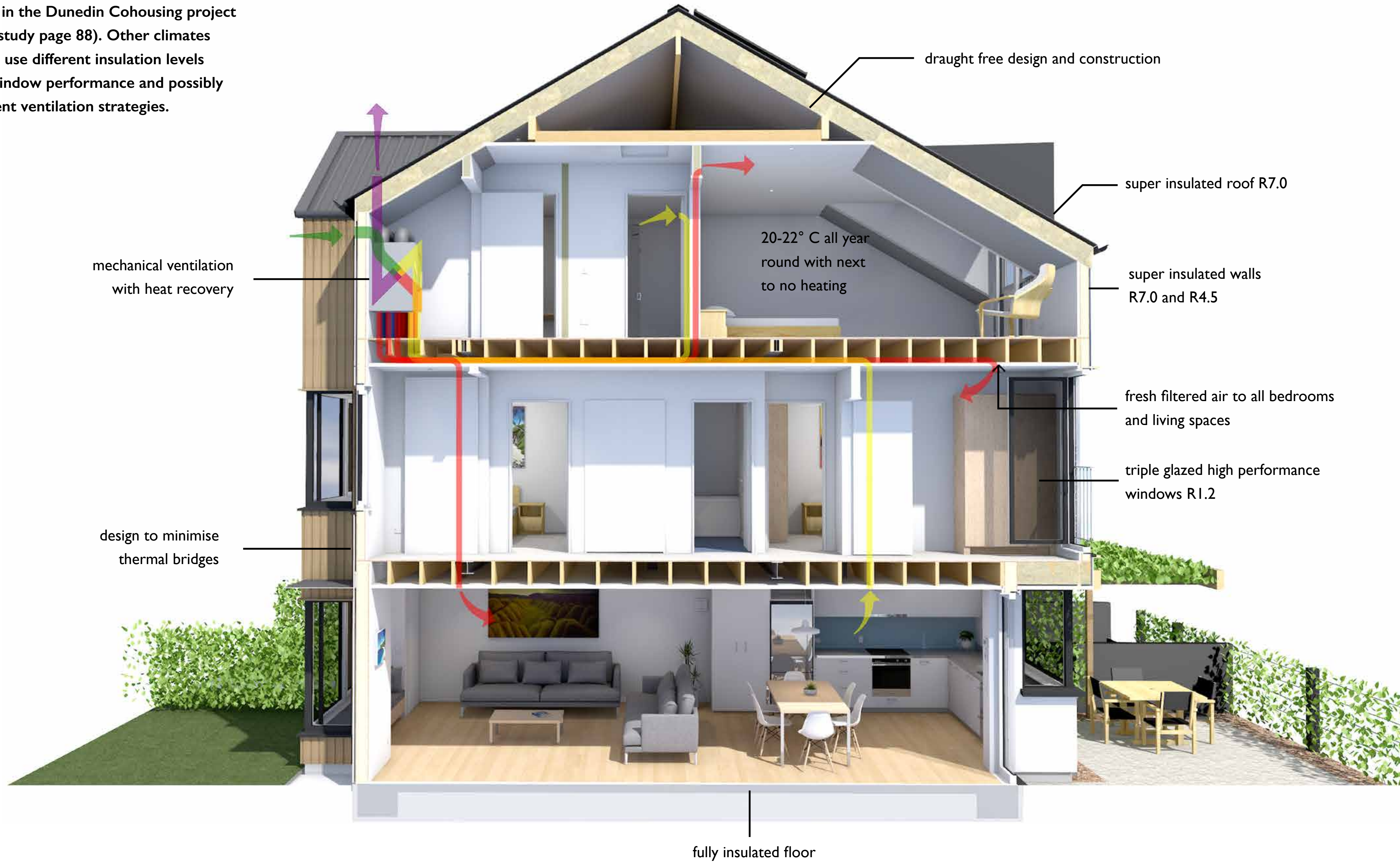
What's "air change"?

Air changes per hour (ACH) is a measure of how many times an hour the entire volume of air within a house is replaced.

For the sake of definition, it is expressed as ACH_n50, air changes per hour at 50 pascals. That is a measure of air pressure, equivalent to a moderately windy day.*

* Technically, 33 km/hr wind on all sides of the building at once (which is not usually how wind actually blows).

Passive House fundamental features found in the Dunedin Cohousing project (case study page 88). Other climates would use different insulation levels and window performance and possibly different ventilation strategies.



Any particular project can meet the standard by using the following elements, combined in different ways to suit the circumstances (the particular climate zone, aspect and other site opportunities or constraints, client preferences etc).

Excellent insulation
Floors, walls and ceilings are all carefully and thoroughly insulated to prevent heat loss. The amount of insulation varies, mostly to do with the climate. For instance, in a timber-framed wall construction, the thickness of insulation varies from as much as 235 mm in Dunedin to 90 mm in Northland. In comparison, the NZ Building Code requires only 90 mm of wall insulation, regardless of location.

High performance glazing
Even the very best windows conduct more heat than walls. Double-glazing is called for in a Certified Passive House in all parts of New Zealand, with triple-glazing sometimes needed because of climate or building shape.

Glazing performance can be improved using coatings and fills—low-E coating and argon fill are the most common but there are other specialist treatments available.

The joinery is the other consideration. Cheap double-glazed windows sit in thermally conductive aluminium frames. Heat will readily leak through the frames and the difference in inside and outside temperature will cause condensation to build up on the interior surfaces of the window frames when it's cold outside. In a Passive House, windows and doors sit in properly thermally-broken frames, eliminating these common problems. Heat loss would be reduced by three-quarters.

Thermal bridge-free zone
There are no weak links in a Certified Passive House. Joinery doesn't leak heat and neither do any other junctions or components. In conventional construction, thermal bridging happens where the foundation meets the walls, the walls meet the ceiling and roof and where steel columns are used. Details are used in Passive House design to eliminate all such points that allow for heat to escape (or penetrate, in a hot climate).

Building envelope
The whole building interior is encased in an uninterrupted air control layer—also called an airtightness layer. Attention to detail on the part of construction teams is needed to make sure this layer is installed correctly.

This innovation plays a crucial part in ensuring Passive Houses need so little energy to heat. It prevents the loss of heat and draughts; the high levels of insulation can then stabilise the internal temperature. It also prevents moisture damage to the building structure and is key to building durability.

Mechanical ventilation with heat exchange
Fresh air is good and Passive Houses ensure it. Clean air is provided through a small and extremely quiet continuous mechanical ventilation system. Incoming air is filtered of dust, pollen and particulate pollution. A clever heat-exchange system recovers about 90 % of the heat in the stale air being expelled and uses it to warm the incoming air. This prevents any sensation of draught.

It's important to understand that ordinary homes currently being built to the Building Code minimums are also much more air tight than New Zealand's older homes. It varies, depending on construction quality as much as anything, but a Code-built home would have between 3-5 ACH (an old villa might be at 20 ACH). But the Code assumes that windows will be manually opened to provide adequate ventilation. After considerable resistance to mechanical ventilation systems, BRANZ is finally coming around to an acknowledgement of their importance.

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

Very, very pleasant.

The temperature is always comfortable, no matter what it's like outside. (You may need to check the weather forecast or stick your head out the door to tell if you need a warm jersey when you're going outside.)

The air inside will be fresh, clean and a comfortable temperature, even with the windows closed. It will be quiet and peaceful: you can close out the noise from neighbours or traffic.

And your power bills to achieve this level of comfort? They will be tiny, as illustrated in the case studies that follow.

Myth No. 3: You can't open the windows in a Passive House—and who wants to live in a sealed box?

Of all misguided objections to Passive Houses, this is the stupidest. Of course you can open the windows! Some of the beautiful homes featured in the following section boast magnificent lift-slide doors that open up a whole *wall* of the house.

If you want the fabled indoor-outdoor flow, to keep an eye on the kids, or the sound of birdsong or ocean to drift through the house, go right ahead and throw open your windows.

But if you have neighbours who mow their lawns at 8am on Sunday, come home late at 2am or like to argue loudly at any time or day or night—or you live on a busy road with constant traffic noise—you might well appreciate how quiet your Certified Passive House is with the windows closed. Double (or triple) –glazing offers significant acoustic as well as thermal insulation.

The point is, you don't have to open windows and doors in order to ventilate your home, because your home is doing it for you: constantly providing fresh, filtered air at the same temperature. That way you'll never feel a draught and you're not paying to heat (or cool) air that is escaping outside. Your indoor air quality will be outstanding, no matter what is happening outside.

You want indoor outdoor flow? How about an opening more than 8 metres wide?

Proven

The first clients specifying Passive House in New Zealand were mostly people who had lived overseas and were used to far better standards of comfort and efficiency than even newly built New Zealand homes offered.

But this stage of early adoption is over. The Passive House Institute of New Zealand (PHINZ), a charitable trust, is actively educating and informing New Zealanders. At the beginning of 2019, there are 26 certified Passive House designers or consultants. Passive Houses have been built and successfully certified from Wanaka to Auckland. They include luxury, bespoke, million-dollar homes through to affordable family homes with a modest footprint.

Excellent designs can be entrusted to building firms that are quickly amassing experience in constructing Passive House details. There are now 33 Certified Passive House Tradespersons in New Zealand, trained in the specifics of building Passive Houses.

Underpinning Passive House design is the analysis done in energy modelling software called the Passive House Planning Package (universally referred to as PHPP). Courses are offered in New Zealand each year that teach its use to architects and designers; alternatively consultants can be hired for this part of the design work.

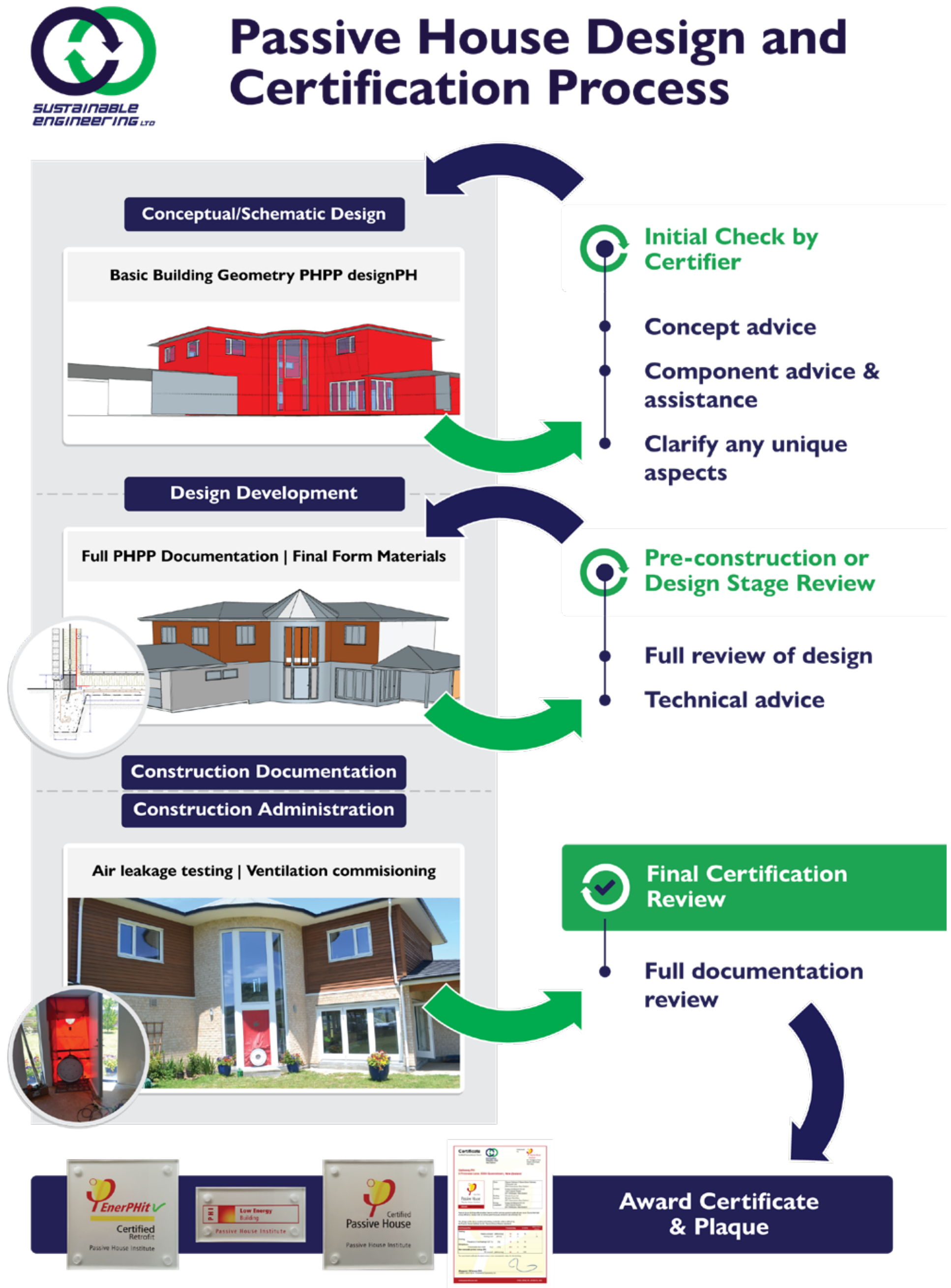
Remember the old saying, “measure twice, cut once”? That’s what designers can do, thanks to PHPP, testing iterations of their design until it reaches certification standards.

Passive Houses have been built in 40 countries around the world, in climates zones as varied as the tropics and Antarctica. The very first Passive House was finished in 1991 in Germany. Nearly 30 years on, it continues to perform as it was modelled.

Independently certified

Certifying a Passive House provides an independent guarantee that a new build will perform to the standard. The actual certification costs are not expensive, a mere half a per cent or less of an average new build.

It happens in two phases that parallel the building design process. The certifier will first review the plans, before any construction begins. This



Passive House Certification process works in parallel with the normal building design and construction process.

is invaluable because it will identify potential issues. If details need to be changed or added, the best time to do that is at the planning stage. Not on the construction site.

During construction, a blower-door test is performed on site—once the air control layer is in place but before any internal finishing. If there should be any issues with air leakage, the problem can be most readily tracked down and fixed at this stage of construction, before wall linings are fixed.

Secondly, once construction is complete a final blower door test is required. This provides scientific verification that the project meets the air changes per hour (ACH) standard. This serves as a check on the quality of construction.

Further, photographs are submitted to the certifier that show the build process matched the design documentation—for instance, correct windows, insulation level and quality of insulation installation. The ventilation system is checked and measured. Provided all the targets are met, the building is then issued a certificate: it's a Certified Passive House.

Internationally, independent verification is shown to increase resale value and it is very likely this will happen in New Zealand.

Creating Resilience

On a systems level, constructing new buildings and deeply retrofitting current buildings to the Passive House standard has the potential to dramatically contribute to carbon reduction targets. Buildings account for 40 % of energy use in developed nations. (In New Zealand, buildings are only 20 %—only because of our high agricultural emissions, which are an anomaly for a developed economy.)

At an individual, community and city level, building to Passive House standards will increase resilience to freak weather events and steadily rising average temperatures.

Blower door air leakage testing equipment. This is used to pressurize a building and measure how much air leaks out.

We urgently need resilient buildings and other infrastructure that can keep functioning despite freak weather events. Climate change is making itself felt by more extremes in weather: highs, lows, storms, droughts.

It is possible to build Passive Houses for outrageously hot climates like Australia and the Middle East. It is being done already and it needs to happen on a hugely increased scale. A Certified Passive House in Queensland or NSW—whether a home, apartment block, factory or office—would be an energy miser, ensuring occupants stay comfortable while still using an absolute minimum of energy. That means human comfort and safety, plus vastly reduced demand on the grid (and by extension, the planet).

In climates where energy is needed to cool, not heat, renewable energy makes even more sense. The peak demands on the grid (and stand-alone generation systems) occur during the day when the sun is shining, exactly when photovoltaic generation is also peaking.

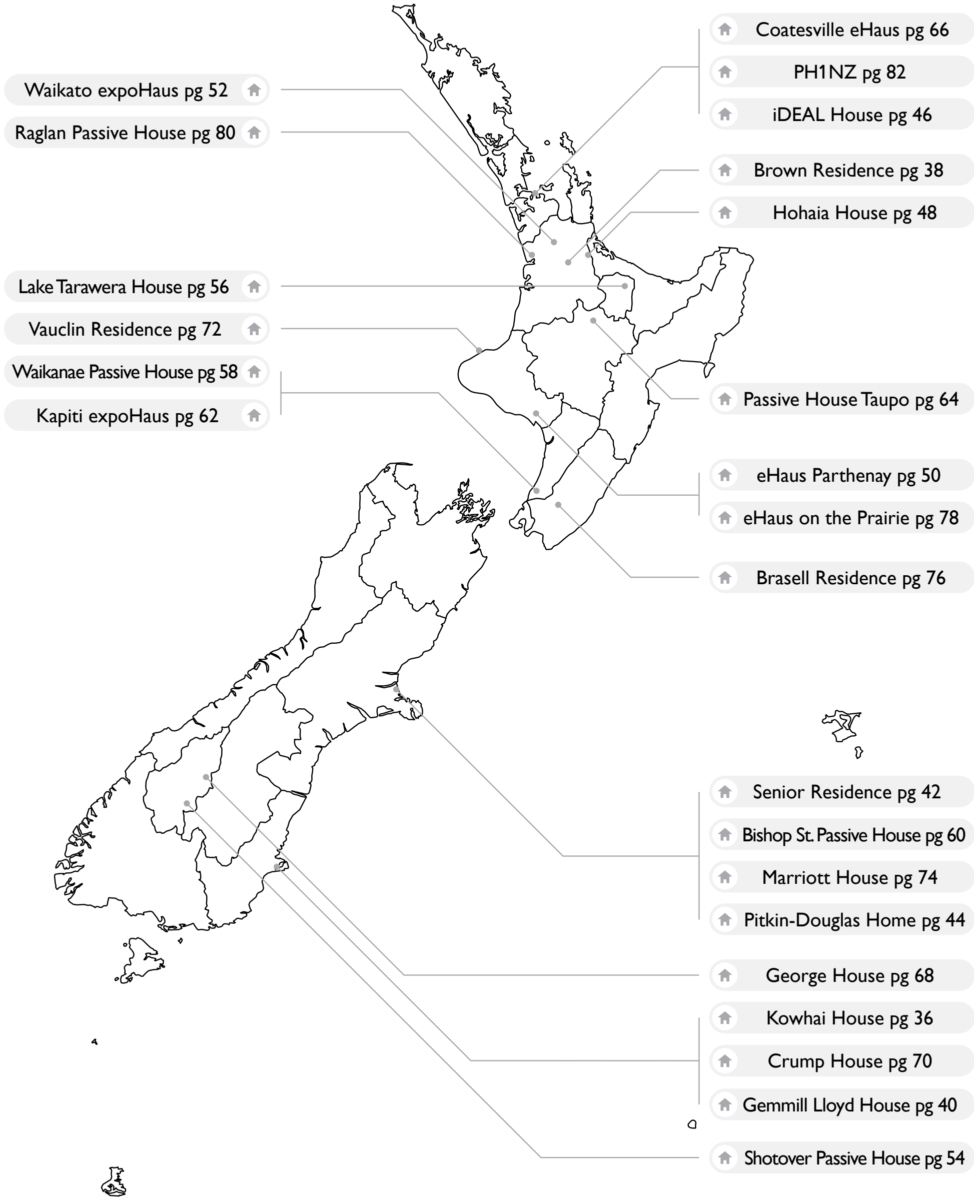
If developed nations are to reach emissions reductions necessary to slow climate change, we must slash the energy required to run buildings, both residential and commercial. Passive House can do this.

Australian grid overwhelmed during heatwaves

South-eastern Australia has suffered prolonged heatwaves during the past two summers and maximum temperatures records have been smashed. In 2018, temperatures topped 45° C in NSW, Queensland, Victoria and South Australia, earning Australia the dubious title of "hottest place on earth". The effects have been far-reaching and serious—deadly, even.

Such heat reduces the capacity of transmission wires to carry electricity even as demand for electricity soars due to the use of air-conditioning units.

Wholesale power prices soared to an unprecedented $AUD14 per kW/hr during peak demand periods in 2017, compared to a more typical $AUD 0.10 per kW/hr. The price spiked again in 2018, despite expansions to the grid's capacity. Rolling blackouts and planned outages occurred along the eastern seaboard in the 2016-2017 summer, as all systems strained under the load.



III. Case Studies

New Zealand's first certified Passive Houses

Meet the first 24 family homes whose outstanding design and build quality has earned them Passive House certification. They range from Auckland to Wanaka, from award-winning, luxury residences to more affordable, modestly-sized family homes. There is diversity in their appearance and the materials used in their construction.

Their owners' motivation for choosing a Passive House varied. All are alike in valuing their experience of living in a Passive House: the indoor air quality, the optimum indoor temperature, the peace and quiet, the tiny energy bills. This is good for those who live in these exemplary homes—and good for the planet

Those involved in bringing each of these houses to fruition believed in the value of certification. Each house has been independently verified to perform to the standards established in the design phase: the teams that built them got them right. Energy modelling means that performance can be accurately predicted during the design phase. Then blower door testing of the house once built confirms the quality of the design and construction.

The case studies are listed from most recently certified (not built) to oldest. Special mention must go to PH1NZ and the Passive House at Raglan for pioneering the way. They were the first certified Passive Houses in New

Zealand (in 2012 and early 2013 respectively) and trailblazers always carry a heavy burden.

Six years on from those pioneering builds, the environment has changed enormously. As you'll see detailed in the following stories, key components like windows are easier to source, a number of options for construction have been proven (there are four different types of wall assembly being commonly used, for instance) and more affordable components like locally manufactured uPVC windows are coming onto the market.

These 24 houses are the apex of a much more widespread change. Additionally, there are more Passive Houses built in New Zealand, but for various reasons not certified (or not yet). What designers and builders are learning working on Passive Houses is flowing through to other projects. The international Passive House Institute (PHI), in Darmstadt Germany, has recently introduced a new standard to recognise such builds and we include two certified "LEBs"—PHI Low Energy Buildings—in this section. You'll find them on page 48 and 56.

The legend that follows is worth your attention. Passive House metrics use terms that may be unfamiliar. They are simply and clearly explained below. Once you understand these terms, the metrics listed below each case study will show you at a glance where a house excelled and the challenges it faced in being certified.

Legend

Heating Demand: This is the amount of heat required to keep the home within the acceptable, comfortable temperature range, expressed as the amount of kilowatt hours per square metre per year. (This is approximately 5–30 % of the heating demand of a modern house built only to the Building Code minimum.)

Heating Load: The power used by a heater of sufficient size to maintain the comfortable temperature on the coldest days. (Note the heating load is expressed in *watts*, 1/1000th of a kW. A 200 m^2 Passive House can typically rely on a single 2kW heater—the size of an average portable fan heater or oil-filled column heater.)

Frequency of Overheating: A certified Passive House must not overheat—defined as 25° C or above—for more than 10 % of the time.

TFA: Treated floor area is a measure of the useful floor area *inside* the conditioned area of the home. It excludes stairways and wall thickness (both exterior and interior).

Form Factor: A ratio arrived at by dividing the total external surface area of the thermal envelope by the treated floor area. A multi-storey building will have a lower form factor than a single-storey dwelling. A simple shape like a square or rectangle will also have a lower form factor than a more complex shape. The lower the number, the less insulation needed in the same climate.

Air leakage: A crucial measure of building quality and major benefit of Passive House certification. Measured via a blower door test done toward the end of construction and verifies that the building will perform as modelled. It can be used as a proxy measure of the quality of building construction.

A Certified Passive House must come in under 0.6 air changes per hour (ACH) at 50Pa (a measure of air pressure, equivalent to a moderately windy day). A well-built conventional house constructed to Building Code minimums is typically 3.0 ACH_n50, five times leakier.

PER demand: Primary Energy Renewable demand measures total energy usage in the house (not just energy for heating and cooling) and includes (a) the power lost to the grid as power is carried from the power station to the home, (b) storage losses (as if the grid were fully renewable) and (c) losses in converting non-renewable fuels to electricity. Excess solar power generated in summer needs to be stored for winter use. PER demand is expressed on a per square metre basis per year. To calculate it for a specific house, multiple the PER demand by the building's TFA. A certified Passive House must be below specified maximums, which depend on the degree to which power consumed comes from renewable sources generated on site.

PE demand: Primary Energy demand has been superseded by PER demand but you'll see it referenced in older case studies and it can still be used on new buildings as well. It measures total energy usage in the house (not just energy for heating and cooling) and includes the power lost to the grid as electricity is carried from the power station to the home and the losses in converting non-renewable fuels to electricity. Buildings are required to be below 120 kWh/m^2/year if they certify using PE demand.

RE generation: measures the total amount of renewable energy generated onsite. This threshold is relevant to Passive House Plus and Passive House Premium builds (see page 18).

Visit *www.warmhealthyhomes.co.nz* to find details of construction materials used in each of the buildings profiled in this section.

KOWHAI HOUSE

Dunedin

Dunedin architect Rafe Maclean had previously designed Passive Houses for clients but this build was for his own family. Several family members suffer from asthma and a warm, dry, healthy living environment was a priority.

The simplicity of the three bedroom, two-storey home's form helped to reduce construction complexity while making the home more thermally efficient. Clever design makes the most of the modest footprint.

The site terrain and access to it were both challenging. Piles were used to enable building on the steep slope and prefabricated structural insulated panels (SIP) reduced time on site.

The air leakage test results were excellent (0.13 ACH_n50, easily below the 0.6 maximum), a particularly commendable result for the builders, who were building their first Passive House.

The European triple-glazed larch windows were made locally in Dunedin by ThermaDura. Wool products were chosen to insulate floor and walls.

Despite the cold, damp climate only a 1kW panel heater is needed to keep all parts of the home a constant and comfortable temperature. The Zehnder heat recovery ventilation system delivers excellent indoor air quality; all incoming air is filtered (on calm winter days in Dunedin, the air pollution from residential fireplaces burning coal can be seen and smelt in the air outside).

PROJECT TEAM

Architecture & Passive House Design
Rafe Maclean Architects
www.rafemaclean.co.nz

Construction
Stevenson & Williams – www.stevwill.co.nz

Structural Engineer
Ezed – *www.ezed.co.nz*

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	15 kWh/m²/year
Heating Load	8 W/m²
Frequency of Overheating	7.8 %
TFA	117 m²
Form Factor	3.2
Air leakage @ 50Pa	0.1 ACH
PER demand	48 kWh/m²/year

BROWN RESIDENCE
Cambridge

Dunedin firm Architype designed and built this home for a couple relocating to Cambridge who wanted a comfortable, energy-efficient house that would meet their needs as they aged. The layout, structure, services and aesthetics of the building tightly work together to create a simple yet extremely high-performance building.

The Brown residence was Architype's first North Island Passive House project; its team is accustomed to designing for much colder, southern climates. It illustrates perfectly how the complexity of a Passive House scales according to the climate in which it is built.

Waikato's relatively mild climate provided an opportunity to meet Passive House standards using a different, simple formula. Various combinations were considered in PHPP (see page 28) and this software provided certainty that a certification-worthy build was possible with the use of New Zealand-made SIPs, 300 mm thick ceiling insulation, double-glazed timber-framed windows and a simple (albeit carefully modelled) insulated slab. Wide eaves shade the high summer sun; combined with other design elements, no overheating is anticipated.

The architect met the challenges of the long, narrow site and district plan setback requirements, creating a layered building with strong horizontal landscaping that offers private, north-facing outdoor space.

PROJECT TEAM

Architecture & Passive House Design
Architype NZ
www.architype.co.nz

Construction
eHaus Waikato Brown Construction

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	14.7 kWh/m^2/yr
Heating Load	13.3 W/m^2
Frequency of Overheating	0 %
TFA	207.6 m^2
Form Factor	3.1
Air leakage @ 50Pa	0.3 ACH
PER demand	42 kWh/m^2/yr

GEMMILL LLOYD HOUSE

Dunedin

This home stands on a stunning site looking south-west over the dramatic coast line. The challenge the architects solved was to create a building open to those views while also sheltered from the ever-changing weather. A long elevation to the north-west serves to bring maximum sun, light and energy into the whole house.

The house is built with timber studs, based on the typical New Zealand timber construction method immediately familiar to builders and regulators. A Passive House methodology has emerged for this type of wall construction, with studs sized to match the specific climate zone. Here, 140 mm studs were specified; in another Dunedin project, 190 mm studs were required. (In comparison, an Auckland build would typically only require 90 mm studs.)

Deep pockets are created between the timber studs to take the insulation—fibre-glass in this case. Next comes an Intello air and vapour control layer, then a further 45 mm layer of insulation fixed in place with timber battens. The gypsum wall board lining is then fitted. The walls sit on a concrete slab isolated from the ground with 200 mm of XPS insulation.

Triple glazing was required this far south, and argon filled, low-E coated glass was chosen. The European windows supplied by Ecowindows are a combination of wood and aluminium—all the beauty of timber inside, with the durability and low-maintenance of aluminium outside.

This home was designed for a forward thinking family, who also specified a grid-tied photo-voltaic array. The house often generates more energy than it is using.

PROJECT TEAM

Architecture & Passive House Design
Team Green Architects
www.teamgreenarchitects.co.nz

Construction
Stevenson & Williams
www.stevwill.co.nz

Certifier
MEAD: Energy & Architectural Design
www.meadconsulting.co.uk

PASSIVE HOUSE METRICS

Heating Demand	13 kWh/m²/year
Heating Load	10 W/m²
Frequency of Overheating	0 %
TFA	182 m²
Form Factor	3.0
Air leakage @ 50Pa	0.5 ACH
PE demand	94 kWh/m²/year

SENIOR RESIDENCE
CHRISTCHURCH

This is a two-storey modern residence in the middle of Christchurch that replaces the family's home damaged in the Canterbury earthquakes. It's another Certified Passive House Plus home in Christchurch, generating power via a 7 kW solar photovoltaic array.

The home stands on a waffle pod slab, a very thick and strong foundation that can be used where liquefaction risk exists. It's commonly used in conventional construction since the Canterbury earthquakes. In a Passive House, the waffle pod must be fully insulated. In this case, strips of XPS insulation sit underneath the concrete ribs between the EPS foam pods, as well as underneath and outside the slab edge—completely insulating the slab from the ground.

Walls were constructed from 215 mm SIP (a bonded sandwich of two 13 mm thick orientated strand board layers with 190 mm EPS foam in the middle). A 50 mm service cavity on the inside of the SIP—where wiring and other ducting can be run without compromising the air and vapour control layers—was then also insulated.

PROJECT TEAM

Architecture
Hibernia Building & Design–*www.hiberna.co.nz*

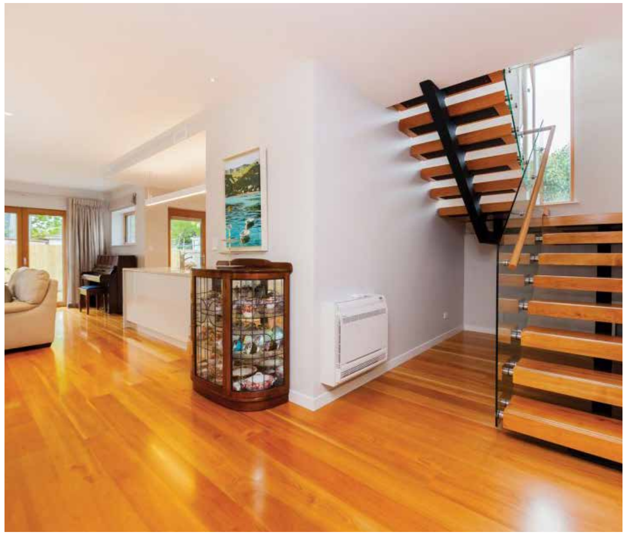
Passive House Design
eHaus – *www.ehaus.co.nz*

Construction
eHaus Canterbury North, Chatterton Builders
www.ehaus.co.nz

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	22.1 kWh/m²/yr
Heating Load	9.3 W/m²
Frequency of Overheating	1 %
TFA	198.1 m²
Form Factor	3.4
Air leakage @ 50Pa	0.51 ACH
PER demand	31 kWh/m²/year
Renewable Energy Generation	46 kWh/m²/year



Heating demand vs load

The heating demand for this house is slightly more than 22 kWh per square metre per year, above the Passive House maximum energy demand. How come it was certified? There are two ways a building can be certified with regard to energy use for heating. The first is heating demand; the second is heating load. This house qualifies on the basis of a heating load that is less than the maximum 10 W/m² permitted. In simplest terms, the heating load describes the size of the heater needed to keep the house at a comfortable temperature. This approach also applies to energy use for cooling.

The two alternative paths to certification acknowledge the diversity of climates in which Passive Houses may be built. A mild climate with occasional cold snaps will require a bigger heater running for a few days of the year, compared to a home like this in Christchurch where winters are cold and long, requiring a smaller heating source used over a long period.

PITKIN-DOUGLAS HOME

Christchurch

This striking family home is the first South Island residence to be certified as Passive House Plus; it meets Passive House performance standards plus generates as much energy as it uses over a year. Proving there need not be a trade-off between function and form, its architects were highly commended in the 2018 ADNZ Architectural Design Awards.

The house was built for young family returning to Christchurch after the Canterbury earthquakes. A narrow site dictated the simple, rectangular form of the 157 m² house but also reflected the clients' vision for a simple family home.

This Passive House Plus is built from pre-fabricated THECA timber wall and roof panels with blown fibreglass insulation installed at the factory. It sits on an insulated, 300 mm thick concrete slab. Triple-glazed, timber-framed windows were manufactured in New Zealand by ThermaDura. Window shutters on the north face assist in preventing over-heating in summer.

Energy is generated via photo-voltaic panels on the north-facing roof—enough to supply the house's energy needs in summer and send excess power back into the grid.

The design team selected a Wolf ventilation system due to the local support offered. The designers note that routing of ventilation ducting is best considered early in the design process.

PROJECT TEAM

Architecture & Passive House Design
THECA Architecture – *www.theca.co.nz*

Construction
Ethos Homes – *www.ethoshomes.co.nz*

Structural Engineer
Lewis Bradford
www.lewisbradford.com

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	15.8 kWh/m²/yr
Heating Load	9.2 W/m²
Frequency of Overheating	1.4 %
TFA	131.8 m²
Form Factor	3.1
Air leakage @ 50Pa	0.4 ACH
PER demand	42.2 kWh/m²/yr
Renewable Energy Generation	60 kWh/m²/yr

IDEAL HOUSE
Auckland

The owners of this large, modern home were well-informed about high-performance homes and knew what they wanted: he was GM of Knauf Insulation and she worked for the Green Building Council!

The house spans 245 m² over two levels in a greenfields development south-east of Auckland and was completed in 2014. It boasts four bedrooms, two bathrooms, two living areas, a small TV room and a double garage.

A grid-tied, 8kW photovoltaic array produces around twice what the home consumes over a year, including charging an electric car.

The home stays between 20–25° C year-round—without heating—and a heat-exchange balanced ventilation system means indoor humidity is 20–30 % lower than a conventional house.

The build illustrates how Passive House concepts can overlay other standards; the home earned 10 stars on the Homestar scale, its top rating. Homestar features include capacity to collect and store 50,000 litres of rain water, native plantings, accessibility and environmentally-friendly materials like Earthwool Glasswool insulation.

The owners wanted a Passive House built as close to "normal" New Zealand construction methods as possible and accordingly, specified aluminium joinery—thermally broken and triple glazed. This proved challenging to source locally at the time, and the build was delayed while uPVC windows were imported from Europe.

The walls are double-layer timber construction. The roof is constructed using I-beams and insulated with R5.2 glasswool above the Intello air tightness membrane; a 75 mm rondo suspended ceiling provides room for fresh air ducting.

In contrast to most New Zealand Passive Houses, the foundation is a standard pod raft slab with poured concrete nib, with insulation located above the concrete slab. Bamboo flooring was selected for its durability.

A blog (www.idealhouse.org) extensively documented the build and the owners generously ran fortnightly open homes for two years in order to educate and inspire others about the benefits of high-performance, sustainable homes. The owners subsequently launched a new company, Enveloped, to provide advice and supply and install the components needed to build quality homes like theirs.

PROJECT TEAM

Architecture
s3architechs – *www.s3a.co.nz*

Passive House Design
Ezed – *www.ezed.co.nz*

Site & Construction Management
Enveloped – *www.enveloped.co.nz*

Building Services
Fantech NZ – *www.fantech.com.au*

Certifier
Passive House Academy
www.passivehouseacademy.com

PASSIVE HOUSE METRICS

Heating Demand	8 kWh/m²/year
Heating Load	8 W/m²
Frequency of Overheating	7 %
TFA	209 m²
Form Factor	3.35
Air leakage @ 50Pa	0.5 ACH
PER demand	32 kWh/m²/year
Renewable Energy Generation	45 kWh/m²/year

HOHAIA HOUSE

Hamilton

Hohaia House sits unobtrusively among other new homes in a Matamata suburb, a modern, house with brick cladding and a long-run roof. But under the skin, it's a very different thing to its neighbours. It's certified as a Low Energy Building by the Passive House Institute, one of the first of its kind in New Zealand. It's a new category, meeting a performance standard not quite as rigorous as a Passive House—but significantly better than required by the NZ Building Code. It delivers all the health benefits of a certified Passive House.

The owner wanted a warm and healthy home with significantly reduced electricity costs and he got it. From spending $300 a month on electricity in their previous 1920s-built home, his bill has dropped to between $66 and $97. He's a shorts-all-year-round type of chap and didn't use any heating source at all in winter. In fact, he subsequently had a small heat pump installed in order to provide a measure of cooling in summer.

The house sits on an insulated concrete slab, has 270 mm of Knauf insulation in the ceiling and features European-made double-glazed windows with thermally broken frames supplied by Ecowindows.

PROJECT TEAM

Architecture & Passive House Design
TAWA architecture
www.tawaarch.co.nz

Construction
Richard Coleman

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	27 kWh/m^2/year
Heating Load	17 W/m^2
Frequency of Overheating	2 %
TFA	104.9 m^2
Form Factor	3.9
Air leakage @ 50Pa	1.0 ACH
PER demand	80 kWh/m^2/year

What makes a PHI Low Energy Building?

A PHI Low Energy Building (LEB) is the next-best-thing to a Certified Passive House. It was intended to recognise near-miss buildings which targeted Certified Passive House but just missed meeting the standard or are particularly challenging. These buildings are required to be equally as healthy and durable but are able to use slightly more energy than a Certified Passive House. To be certified a PHI LEB, the building must use no more than 30 kW/m^2/year for heating, and cooling; and achieve an <1 ACH_n50.

EHAUS PARTHENAY

Whanganui

This striking family home was the first in Australasia to be certified Passive House Plus. Its performance has been monitored and reported on and it also features in the book *Positive Energy Homes*.

The metal-clad south wall faces the road and is devoid of windows, blending in with the rural setting. The other three walls are clad with the Rockcote Insulated Facade System. The building's simple rectangular form maximises energy efficiency and ease of construction. It was designed and sized to match the Ecoblock wall system with a minimum of waste.

German-engineered windows were supplied by Ecowindows. A grid-tied 3 kW net zero solar photovoltaic system produces electricity over the entire year.

The house opens up to impressive mountain views to the north. A bold use of colour inside adds immediate character and personalises the bedrooms for each of the family's three teenage boys.

The home provides excellent year round comfort including during the summer months—no active cooling is required. This has been achieved in part due to modest amounts of glazing on the eastern and western walls and well-sized overhangs to the north.

PROJECT TEAM

Architecture & Passive House Design
eHaus/Cad Viz
www.cadviz.co.nz/www.ehaus.co.nz

Interior Design
Terry Lobb – *www.terrylobb.nz*

Builder
eHaus – Baden Brown & Craig Alderton

Engineering
Peter van Grinsven – *www.pvgdesignltd.co.nz*

Certifier*
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	6.2 kWh/m²/yr
Heating Load	9 W/m²
Frequency of Overheating	0 %
TFA	134.5 m²
Form Factor	2.9
Air leakage @ 50Pa	0.47 ACH
PER demand	33 kWh/m²/yr
Renewable Energy Generation	45 kWh/m²/yr

* Initially certified as a Passive House by BRE UK in 2014. Sustainable Engineering subsequently certified it as a Passive House Plus in 2017

WAIKATO EXPOHAUS

Hamilton

Jon Iliffe and Baden and Glenda Brown formed eHaus in 2010 and from its base in Whanganui, the firm has been instrumental in establishing the Passive House concept in New Zealand. eHaus is designing houses around the country and to date the firm has licensed 15 partner construction companies who are trained to build them.

Ross Brown has headed his own construction company since 1997 and in 2014 his company, Brown Construction, secured the eHaus license for the Waikato area. Ross and two of his employees are Certified Passive House Tradespersons and with several Passive Houses built (including the Brown residence, see page 38) and more underway, they have developed their understanding of and skills in this methodology.

Brown Construction purchased a beautiful 6200 m² lifestyle block in Taupiri—north of Hamilton and within reach of Auckland—in order to build an "expoHaus". The high-end four bedroom, two bathroom home is currently open to the public by appointment and also houses the firm's office.

Its modern design, use of familiar materials and luxury features are equal to any executive home. When it comes to function, it's streets ahead.

PROJECT TEAM

Architecture
Edwards White Architects/eHaus
www.edwardswhite.co.nz/www.ehaus.co.nz

Passive House Design
eHaus – *www.ehaus.co.nz*

Construction
eHaus Waikato – Brown Construction
www.brownconstructionltd.co.nz

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	15 kWh/m²/year
Heating Load	13 W/m²
Frequency of Overheating	0 %
TFA	187.6 m²
Form Factor	3.7
Air leakage @ 50Pa	0.41 ACH
PER demand	42 kWh/m²/year
Renewable Energy Generation	21 kWh/m²/year

SHOTOVER PASSIVE HOUSE

Queenstown

Certified Passive House
Passive House Institute
classic | plus | premium

Queenstown is one of New Zealand's more challenging climates yet Passive House methodology can deliver a warm, dry, healthy home. This home is a family residence in one of the city's newest suburbs, nestled below the Remarkables.

The interest in making this build a Passive House came from the owners. The original brief was for a simple but dramatic design that overlooked the park to the north and contrasted with the more conservative dwellings around it. The form was simplified during the design process, while the facade elements outside the thermal envelope, especially those to the north, gained depth and complexity to provide shade from summer sun.

As planned from the outset, the house was built using SIPs for the roof and walls, and a small amount of thermally isolated steelwork. This facilitated swift construction and the open plan design.

The concrete slab is sandwiched with 250 mm of EPS foam insulation below and 90 mm of polyurethane insulation above to achieve R11. The high-performance, triple-glazed windows were imported from Germany.

PROJECT TEAM

Architecture & Passive House Design
Energy Architecture NZ
www.energyarchitecture.co.nz

Contractor
Climate House
www.climatehouse.co.nz

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	13.3 kWh/m^2/yr
Heating Load	10.8 W/m^2
Frequency of Overheating	6 %
TFA	174.6 m^2
Form Factor	3.16
Air leakage @ 50Pa	0.5 ACH
PER demand	36 kWh/m^2/year

LAKE TARAWERA HOUSE

Rotorua

PHI Low Energy Building

This two-storey bach overlooks the spectacular Lake Tarawera. It is a low-maintenance, durable house, with carefully chosen materials and facade textures that help the building meld into the landscape. The building takes advantage of the solar aspect and view.

The walls are constructed with Ecoblock insulated concrete forms (ICF); the reinforced concrete layer provides both structural strength and the air control layer. It is quick to build with and incredibly robust.

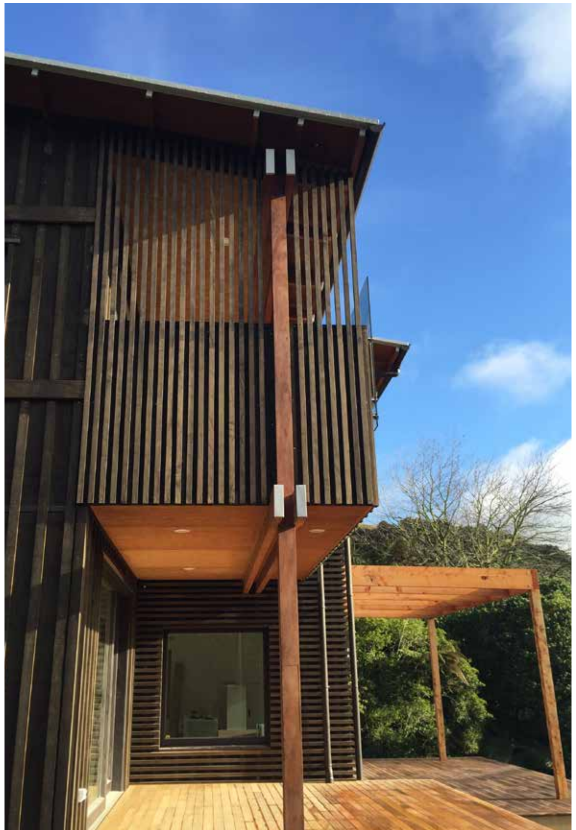
PROJECT TEAM

Architecture & Passive House Design
TAWA architecture
www.tawaarch.co.nz

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	19.6 kWh/m²/yr
Heating Load	14.3 W/m²
Frequency of Overheating	2 %
TFA	122.1 m²
Form Factor	3.4
Air leakage @ 50Pa	0.61 ACH
PER demand	72 kWh/m²/yr
Renewable Generation	61 kWh/m²/yr



WAIKANAE PASSIVE HOUSE

Waikanae

This project was a melding of like minds. The clients told their architectural designer that they wanted a Passive House. They had already chosen their builder, who had experience in building to the Passive House standard.

This beautiful house stunningly illustrates how Passive House standards can be met without constraining architectural creativity. It features curved ply ceilings and a subtle yet impressive internal plastered feature wall. The garage is clad in handcrafted 2 mm printed aluminium panels, a colour reminiscent of weathered green copper. This contrasts with the vertical cedar cladding on the house exterior.

SIPs were chosen for the wall and roof for their multiple benefits: speed of construction, reduced thermal bridging and ease of air sealing. Insulation was laid on top of the concrete slab (underneath the floating floor) because of the challenging geo-technical conditions. The poor soil would have potentially compromised efforts to insulate under the concrete slab.

Timber framed triple-glazed windows were imported from Germany. The solar orientation and lack of eaves bring with it a risk of overheating but this is managed by the use of external blinds.

The principle challenge lay in achieving the required thermal performance given the expansive floor plan and the resulting higher form factor.

PROJECT TEAM

Architecture & Passive House Design
Energy Architecture NZ
www.energyarchitecture.co.nz

Contractor
Mike Craig Builders
www.mcbuilders.co.nz

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	14.9 kWh/m²/yr
Heating Load	11 W/m²
Frequency of Overheating	0 %
TFA	254.5 m²
Form Factor	3.57
Air leakage @ 50Pa	0.3 ACH
PER demand	48 kWh/m²/yr

Construction went smoothly, thanks to the contractor's experience. The only hitch was floor insulation. The insulation originally specified wasn't available in New Zealand and a lower-performing, locally sourced product needed to be substituted. Happily, there was sufficient performance margin in the design to absorb this change.

Blower door testing produced an outstanding airtightness result of 0.27 ACH_n50, the best result in New Zealand at the time of build.

BISHOP STREET PASSIVE HOUSE

Christchurch

The owners previously lived in a pristine 1930s-built character home, which was damaged beyond repair in the Canterbury earthquakes. A protracted settlement with their insurers gave the couple years to consider the type of house they wanted to live in.

They chose a design that echoed the era of the previous home and suited the vernacular of their neighbourhood. The initial design was then revised by Theca Architecture to meet the Passive House standard.

This home is built from prefabricated Theca timber wall and roof panels with blown high-density fibreglass insulation installed at the factory. It sits on an insulated concrete slab—an excellent example of a waffle pod slab done correctly, with the concrete ribs insulated fully from the ground and proper edge insulation.

The design team selected a Wolf ventilation system due to the high level of local support. Windows are locally manufactured uPVC from NK Windows with triple glazing units manufactured in New Zealand. Having the garage separate from the home—as was typical with older homes—made the Passive House design process easier.

One of the owners has meticulously documented their process, from initial thoughts and planning through to final appliance choices, in a blog at www.ourpassivehouse.co.nz.

PROJECT TEAM

Architecture
MCD Architecture – *www.mcd-architecture.co.nz*

Passive House Design
Theca Architecture – *www.theca.co.nz*

Construction
Ethos Homes – *www.ethoshomes.co.nz*

Structural Engineer
Engco – *www.engco.co.nz*

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	22.3 kWh/m²/yr
Heating Load	9.4 W/m²
Frequency of Overheating	6 %
TFA	223.4 m²
Form Factor	2.9
Air leakage @ 50Pa	0.4 ACH
PER demand	59 kWh/m²/yr

KAPITI EXPOHAUS
Waikanae

This three-bedroom home was built by eHaus licensee QBuild in 2015 as a show home. It was the first certified Passive House in the Wellington region and successfully catalysed Passive House developments in the area. It has now been sold into private ownership.

It's an appealing contemporary-style home with a solar photovoltaic system that powers a heat pump that supplies both the hydronic underfloor heating system and domestic hot water.

It sits on an insulated concrete slab and features triple-glazed, tilt-turn uPVC windows manufactured in New Zealand by Advanced Windows.

PROJECT TEAM

Architecture & Passive House Design
eHaus – *www.ehaus.co.nz*

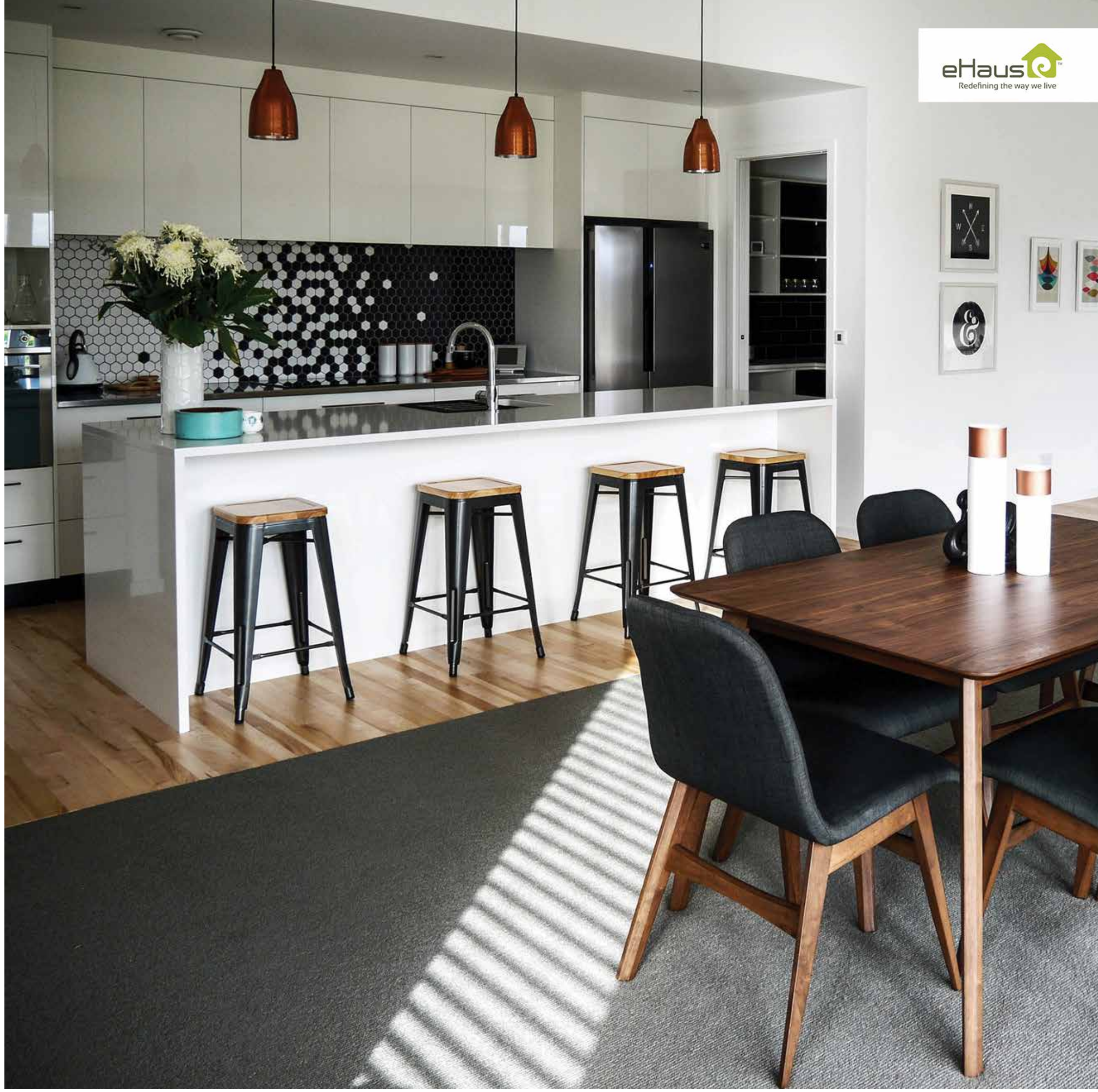
Construction
eHaus Kapiti
www.ehaus.co.nz

Structural Engineer
Ian Person

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	14.3 kWh/m²/yr
Heating Load	13 W/m²
Frequency of Overheating	3 %
TFA	144.7 m²
Form Factor	3.78
Air leakage @ 50Pa	0.5 ACH
PER demand	46 kWh/m²/yr



PASSIVE HOUSE TAUPO

Taupo

Passive House Taupo is notable because its owner also designed and built it himself. Kim Feldborg is an experienced NZCB-certified builder who apprenticed in Denmark and has built timber homes around Europe, as far north as Greenland.

This four bedrooms plus office, 260 m^2 family home blends into a new sub-division and offers majestic mountain views to the south across Lake Taupo. The other striking feature is a double height entranceway and hand-made spiral staircase. Conventional construction materials were employed: timber framing, brick cladding on the ground floor and timber weatherboards on the upper storey.

Unlike most New Zealand Passive Houses, this home has a concrete slab set directly on the ground, with XPS insulation added above the slab providing R4.5. Walls are insulated with fibreglass batts and an Intello air control membrane.

High performance glazing is a feature of any Passive House; here Kim chose low-E, triple-glazed timber windows from Denmark. The windows are R1.5 including the frame and thermal bridging losses related to installation. (This last detail is neglected by NZ Building Code calculations.)

The result is a character-filled home built to the highest standards of craftsmanship, which is a pleasure to live in. The only heating needed to maintain a comfortable, year-round interior temperature is provided by an old-fashioned 2kW oil-fin heater, rolled out for just a week or two each winter.

It stands in marked contrast to the Feldborgs' experience when they first arrived in New Zealand in 2007. The new home they lived in was freezing cold. This rude shock prompted Kim to investigate the Passive House standard. His own was the first Passive House he built; his company is focused on building more.

PROJECT TEAM

Architecture
Kim Feldborg, Valhalla Living – *valhallaliving.co.nz*

Passive House Design
Sustainable Engineering
www.sustainableengineering.co.nz

Construction
Kim Feldborg, Valhalla Living
www.valhallaliving.co.nz

Certifier
MEAD: Energy & Architectural Design
www.meadconsulting.co.uk

PASSIVE HOUSE METRICS

Heating Demand	12 kWh/m^2/year
Heating Load	8 W/m^2
Frequency of Overheating	4 %
TFA	257.2 m^2
Form Factor	2.61
Air leakage @ 50Pa	0.30 ACH
PER demand	41 kWh/m^2/year

COATESVILLE EHAUS

Auckland

This imposing residence in a French style was built for three generations, with two homes connected by a very large kitchen and pantry. It also includes office space for the young couple who work from home. It is testament to the flexibility of the Passive House standard, which can accommodate different aesthetics.

This is a very high quality build that performs as well as it looks. ICF construction was used for walls, which were finished with plaster inside and out. It sits on a concrete slab with a generous 200 mm of insulation, carefully integrated so that it is continuous at the wall/floor junction.

Glazing has been strategically placed; it only makes up 18 % of the wall area, but is used where it counts. Glazing has been minimised on the west wall; along with external shading, this helps prevent overheating in summer. Double-glazing is sufficient in this northern climate and the frames are uPVC.

Solar thermal hot water and a 6.75 kW solar photovoltaic array produce 75 % of the home's energy needs. There's provision for more than 112,000 litres of potable water storage.

The home's performance is exceptional, with heating demand and air leakage both being half that allowed by the Passive House standard.

PROJECT TEAM

Architecture
CADVIZ
www.cadviz.co.nz

Passive House Design
eHaus
www.ehaus.co.nz

Construction
eHaus Auckland Rodney – Terry Bryers

Certifier
BRE UK – *www.breuk.com*

PASSIVE HOUSE METRICS

Heating Demand	7 kWh/m²/yr
Heating Load	9 W/m²
Frequency of Overheating	3.1 %
TFA	370.3 m²
Form Factor	2.85
Air leakage @ 50Pa	0.3 ACH
PE demand	100 kWh/m²/yr

GEORGE HOUSE
Queenstown

This stunning new build on a quarter acre section with views of the hills and lake in Wanaka was the first Passive House for its architect and builder and the first certified Passive House in the South Island. It won a 2016 NZIA New Zealand Architecture Award and thrilled its owners, who say it's even more comfortable than they expected. The house easily meets Passive House standards for energy use, despite one of New Zealand's coldest climates.

Its Auckland-based owners wanted a base to enjoy winter sports and the 1940s bungalow that sat on this prime site was freezing; colder inside than outside. It prompted a decision to "bowl-and-build". They already knew they wanted a Passive House when they fortuitously came across Wanaka-based architect Rafe Maclean. He had completed his Passive House training and was looking for the opportunity to design one.

Triple-glazing is crucial to reaching Passive House performance in this climate, where it can drop to -10° C overnight. This house features German Visolux windows in composite frames: FSC-certified spruce inside and aluminium outside provided by Ecowindows.

SIPs have been used, with external cladding in western red cedar. Walls and roof boast an impressive R-value of nearly R8. The house sits on an insulated concrete slab and features solid oak flooring.

Inside, this home stays at a comfortable temperature year round; in winter a freestanding 2kW electric heater is run for a couple of hours in the afternoon/evening and this is sufficient to keep the indoor temperature comfortable around the clock.

The owners remain based in Auckland, and make the home available to rent for short stays. This has enabled many visitors to experience the comfort of a Passive House for themselves: the reviews are glowing.

PROJECT TEAM

Architecture & Passive House Design
Rafe Maclean Architects
www.rafemaclean.co.nz

Construction
Davidson Building

Certifier
MosArt
www.mosart.ie

PASSIVE HOUSE METRICS

Heating Demand	12 kWh/m²/year
Heating Load	11 W/m²
Frequency of Overheating	0 %
TFA	141 m²
Form Factor	3.7
Air leakage @ 50Pa	0.6 ACH
PE demand	94 kWh/m²/year

CRUMP HOUSE
Dunedin

The clients had returned to New Zealand with three young children. Unable to find a suitable, warm home in Dunedin, they bought a derelict 150-year-old villa—and demolished it. The site has spectacular views and is close to the city centre.

The five-bedroom, three-storey home was already designed before a decision was made to build it as a Passive House. That led to some changes—the fireplace became unnecessary and was deleted before construction—and some complications, like the junction where the insulated slab met the uninsulated foundation of the garage.

However, the design team could be confident that the house would meet certification standard because they could test variations of the design and the effect of different components in PHPP software. Specific thermal bridging challenges were carefully quantified using two-dimensional thermal modelling.

The house's form is more complex than typically seen in a Passive House, creating a higher surface-to-volume ratio (a high form factor). This was overcome by specifying additional insulation. Thermal bridging issues with the slab were elegantly resolved by placing a thick layer of XPS insulation between the slab and a timber floor.

High performance windows and doors (low-E tripled-glazing with argon fill in timber/aluminium frames from Germany) ensure quiet inside the house, despite the busy four-lane road outside.

The home won Architype the 2018 Southern Architecture Award.

PROJECT TEAM

Architecture & Passive House Design
Architype NZ – *www.architype.co.nz*

Structural Engineer
Nigel Harwood Consulting / eZED
www.nigelharwood.co.nz / www.ezed.co.nz

Builder
Caldwell & Highsted – *caldwellandhighsted.co.nz*

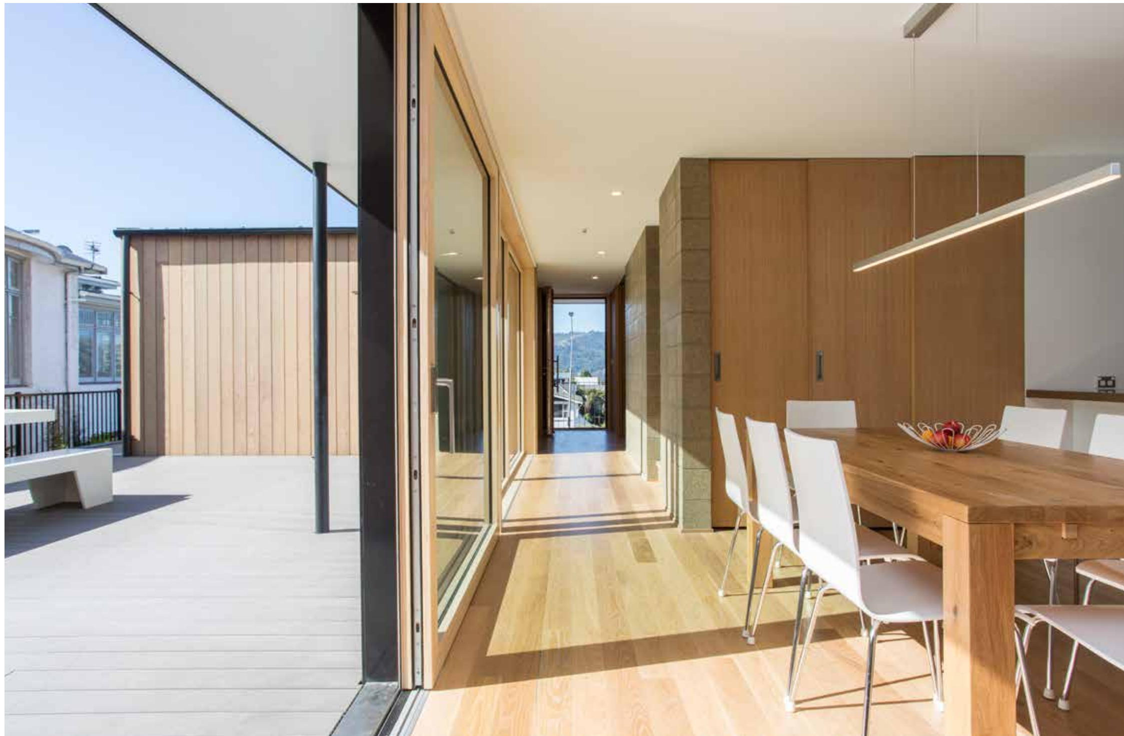
Building Services Fantech NZ / Architype
www.fantech.com.au / www.architype.co.nz

Certifier MEAD – *www.meadconsulting.co.uk*

PASSIVE HOUSE METRICS

Heating Demand	15 kWh/m^2/yr
Heating Load	10 W/m^2
Frequency of Overheating	0.2 %
TFA	179.2 m^2
Form Factor	3.38
Air leakage @ 50Pa	0.58 ACH
PE demand	120 kWh/m^2/yr



VAUCLIN RESIDENCE

New Plymouth

The clients came to eHaus with clearly-thought out requirements: simplicity without compromise on performance or construction. They wanted a Certified Passive House with quality, low maintenance and, durable construction.

While energy efficiency was important, other performance standards were required. The house needed to be readily secured plus resilient to high winds, storms and earthquakes. Air quality and environmental considerations were also a concern, with low-VOC and natural materials being required.

The clients perfectly understood the trade off between size, budget and quality and their instructions to the designer were clear: to stay within the budget, shrink the house rather than skimp on quality.

The design team delivered a Certified Passive House with two bedrooms, an office, two bathrooms, a spacious laundry and a reception area, all within a TFA of 121 m^2—plus a double garage.

The house is notable for its very high quality windows: wood/aluminium, German made, tilt turn frames with low-E coating and argon filled double-glazing. It has also a very low heating load and when heating is required, this is provided by a 1 kW portable heater and a heated towel rail.

PROJECT TEAM

Architecture & Passive House Design
eHaus
www.ehaus.co.nz

Construction
eHaus Taranaki – Steve Hofmans

Certifier
BRE UK
www.bre.co.uk

PASSIVE HOUSE METRICS

Heating Demand	9 kWh/m^2/year
Heating Load	5 W/m^2
Frequency of Overheating	3 %
TFA	121.1 m^2
Form Factor	3.4
Air leakage @ 50Pa	0.46 ACH
PE demand	88 kWh/m^2/year

MARRIOTT HOUSE

Christchurch

This Fendalton residence, a large family home and office, won the Sustainable Lifestyle Award at the 2016 Registered Master Builders' House of the Year Competition.

The clients are both consulting engineers who moved to Christchurch to assist with the rebuild. They knew they wanted a low-energy house; and when the architect they approached invited them to go on a Passive House adventure with him, they happily agreed.

The two-storey house does not overheat; even when summer temperatures spike into the mid-thirties, it stays a comfortable 23° C inside without any air-conditioning.

The foundation is a standard MAXRaft system with additional 50 mm perimeter insulation. The 200 mm hyJoist wall frames are filled with blow-in insulation. The Peine window systems were imported from Germany and feature timber frames, deep reveals and triple glazing. Considered placement of doors and windows provide abundant natural light without compromising performance.

Ventilation is provided by a Zehnder ComfoAir 350 unit, in combination with a recirculating carbon filter rangehood.

The clients and architect alike are full of praise for builder Glenn Harley and the blower door test results confirm the quality of the construction.

PROJECT TEAM

Architecture
Brewer Davidson Architecture & Urban Design
www.brewerdavidson.co.nz

Passive House Design
eZED – *www.ezed.co.nz*

Construction
Harley Builders
www.harleybuilders.co.nz

Certifier
Passivhaus Institut – *www.passiv.de*

PASSIVE HOUSE METRICS

Heating Demand	21 kWh/m^2/yr
Heating Load	8 W/m^2
Frequency of Overheating	0 %
TFA	248 m^2
Form Factor	2.9
Air leakage @ 50Pa	0.4 ACH
PER demand	62 kWh/m^2/yr
Generation RE	39 kWh/m^2/yr

BRASELL RESIDENCE

Greytown

Certified Passive House
Passive House Institute

This comfortable, contemporary three-bedroom home is modestly sized and won a 2015 South Pacific Passive House Design Award in the cost-effective category.

The home combines functionality and form, with visual appeal from the street and sympathetic siting toward the south boundary that creates space for gardens and indoor/outdoor flow. The more complex shape means a higher form factor. The mono-pitch roof efficiently sheds the strong Wairarapa winds.

Construction employs ICF walls on top of an insulated concrete slab. Triple-glazed windows are a feature, with this house being the first New Zealand certified Passive House to specify uPVC frames from Energate in Germany. (uPVC construction can meet Passive House standards and it is more affordable than timber or thermally broken aluminium frames with the same performance.)

The house features solar hot water (with an internal storage tank) and a rain water tank. The only heater required is a small freestanding unit.

PROJECT TEAM

Architecture
S Naus Architecture for eHaus
ehaus.co.nz

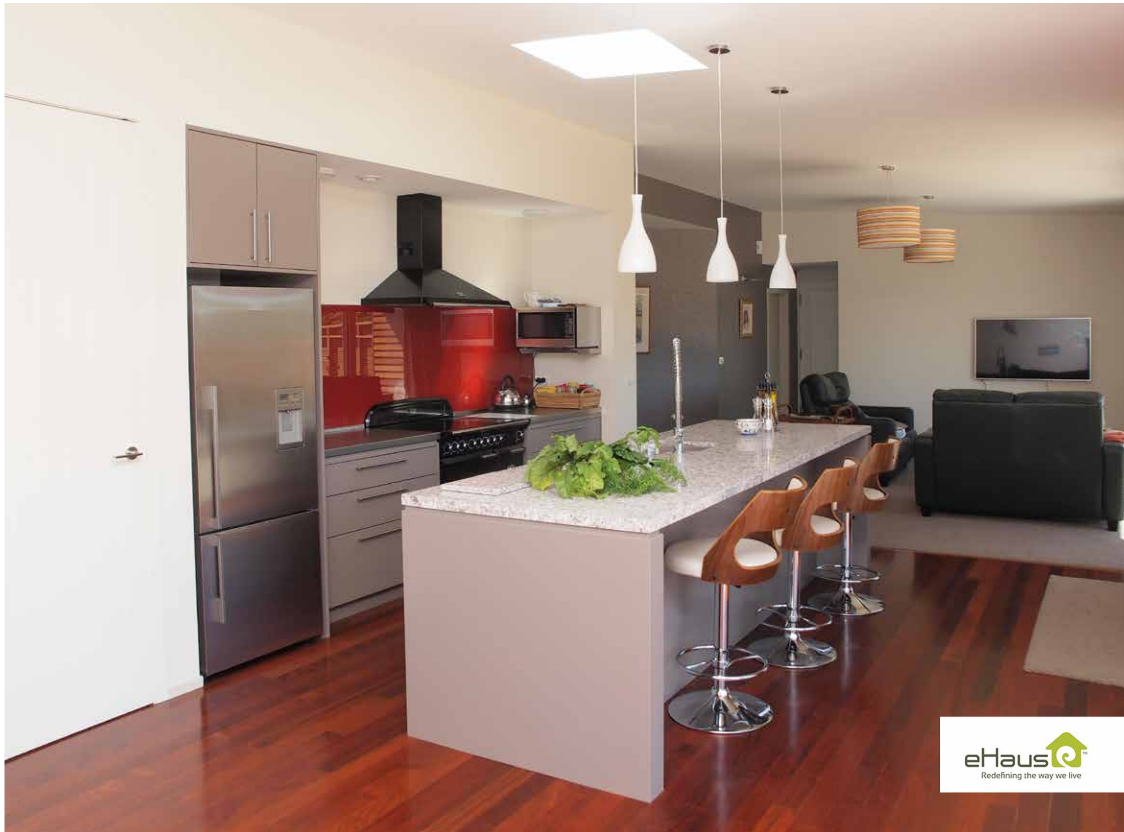
Passive House Design
eHaus - *www.ehaus.co.nz*

Construction
eHaus Wairarapa
www.ehaus.co.nz

Certifier
MosArt – *www.mosart.ie*

PASSIVE HOUSE METRICS

Heating Demand	15 kWh/m^2/yr
Heating Load	14 W/m^2
Frequency of Overheating	2.7 %
TFA	150.2 m^2
Form Factor	3.61
Air leakage @ 50Pa	0.6 ACH
PE	109 kWh/m^2/yr



eHAUS ON THE PRAIRIE

Whanganui

Certified Passive House
Passive House Institute

It's remarkable how much fits inside this two-storey 151 m² (TFA) home for an extended (and expanding) family. The clients wanted a functional and compact home, a place that was both "dignified and comfortable". It includes a self-contained flat, gym, library and 3.5 bathrooms.

The designer opted for Ecoblock ICF for the walls, which offers an insulation value of R3.8. Half the walls have an additional 150 mm of EPS insulation; combined this amounts to R10 for these sections and yields R5.2 overall.

European uPVC tilt-turn joinery features and the lounge contains a large picture window that takes in the beautiful views over the property and to distant mountains. New Zealand-made motorised external roller blinds provide shade when necessary and prevent overheating from solar gain.

A 5 kw solar photovoltaic array is grid-tied and the home also has a solar thermal system for hot water. Wind generation is planned. In addition, more than 22,000 litres of rainwater can be harvested and black and grey water is sustainably treated on site.

PROJECT TEAM

Architecture
Black Pine
www.blackpine.co.nz

Passive House Design
eHaus – www.ehaus.co.nz

Construction
eHaus Whanganui District, Baden Brown
ehaus.co.nz

Certifier
BRE UK – *www.bre.co.uk*

PASSIVE HOUSE METRICS

Heating Demand	11 kWh/m²/yr
Heating Load	10 W/m²
Frequency of Overheating	0 %
TFA	151.3 m²
Form Factor	3.06
Air leakage @ 50Pa	0.6 ACH
PE demand	100 kWh/m²/yr

RAGLAN PASSIVE HOUSE
Waikato

The owners were among the first to choose to build to the Passive House standard in New Zealand and everyone involved in the project broke new ground. The owners discovered the concept through their own research and specified it to their architect, Brooke Cholmondeley-Smith. He promptly undertook training and qualified as one of New Zealand's first Passive House Designers in 2011.

There were no certified Passive Houses in New Zealand when design began. At the time, there was no certified climate data for New Zealand and this caused considerable delay. Likewise, there was no-one in New Zealand qualified to certify the project then, so this was done by a certifier in the UK.

Lots of work was required to determine the right materials and building assemblies for the house to ensure they would meet the performance criteria. Key components like windows were checked with the certifier before ordering to make sure they would comply. Windows were imported from Germany because no-one could supply them in New Zealand. (How things have changed since 2011!)

The three bedroom, two-storey home is built using Ecoblock ICF walls. Construction was extremely quick using this material: walls were erected in two days and filled with concrete on the third. The truss roof is insulated with fibreglass batts above an Intello air control layer.

The home's heating demand is massively below the Passive House maximum, a laudable achievement all the more impressive given the timing of the project.

PROJECT TEAM

Architecture & Passive House Design
MOAA Architects
www.tawaarch.co.nz

Certifier
MosArt
www.mosart.ie

PASSIVE HOUSE METRICS

Heating Demand	4 kWh/m²/year
Heating Load	5 W/m²
Frequency of Overheating	< 10 %
TFA	125 m²
Form Factor	(not available)
Air leakage @ 50Pa	0.4 ACH
PE demand	89 kWh/m²/year

PH1NZ
Auckland

The very first Certified Passive House in New Zealand (indeed, Australasia) was built in Glendowie, Auckland in 2012. This pioneering project was designed by Jessop Architects and built by Chris Foley and team from Construction Luxury Living. Preliminary design of the environmentally friendly home was already complete when the client discovered the Passive House methodology. eHaus stepped in to provide Passive House modelling, with subsequent changes to design details.

Being first has its challenges, with the build making use of many components unfamiliar to building inspectors and planners. However, Auckland Council's urban design champion Ludo Campbell-Reid got behind the project and helped ease its regulatory progress.

In fact, the Council's building inspectors took a keen interest and grasped the opportunity to see something new. Other builders also turned up wanting to see what was happening.

The split-level 249 m² home sits on reinforced concrete floors that were poured over Expol 100 mm thick EPS polystyrene insulation, laid on top of a continuous layer of polythene. Concrete block masonry was also used and Laserframe timber framing went up very quickly, arriving on site as pre-cut and pre-nailed fabricated panels. Cladding is shiplap cedar weatherboard.

PROJECT TEAM

Architecture
Jessop Architects
www.jessoparchitects.co.nz

Passive House Design
eHaus
www.ehaus.co.nz

Construction
Luxury Living

Certifier
MosArt – *www.mosart.ie*

PASSIVE HOUSE METRICS

Heating Demand	7 kWh/m²/yr
Heating Load	7 W/m²
Frequency of Overheating	0 %
TFA	249 m²
Form Factor	3.33
Air leakage @ 50Pa	0.46 ACH
PE demand	107 kWh/m²/yr

Windows were supplied by Ecowindows from profiles imported from Germany.

The inward-opening, tilt-turn windows are standard in many European countries and meet much more stringent EU standards. Nevertheless it was challenging to prove to Auckland Council that the windows met New Zealand's Building Code. (Such are the burdens shouldered by those who go first.) Enormous lift-slide doors fully open up the back of the house to the private outdoor living area.

The house features rainwater collection, uses an external heat pump for hot water heating and has a photovoltaic array. A Zehnder heat recovery ventilation system was imported from Germany.

Initial estimates put total heating and cooling energy costs at just $20/month.

IV. The Future

The next phase for Passive House in New Zealand

This year, 2019, could be a tipping point for building quality, health and performance in New Zealand. The pioneering phase for Passive House construction of single family homes is over. The technology, design and construction has been proven throughout New Zealand.

Now it's time to apply all that has been learned to larger projects, like multi-family dwellings and commercial buildings. The case studies that follow highlight four different types of projects that are in the pipeline, from design to construction. Their owners, developers and design teams understand the value a Certified Passive House brings to their project.

All the components are now in place

Design teams. As 2019 begins, there are 26 Certified Passive House architects, designers and consultants from Auckland to Dunedin. That's a growth of 400 % in just six years.

Builders. Passive House certified builders have got their feet under them. Builders who have built their first couple of houses have the experience they need to confidently take on larger, more complex projects. Take Otago firm Stevenson & Williams Ltd: Master Builders since 1955, the firm has successfully completed two Certified Passive House single-family dwellings in Dunedin and is now at work on a 24-unit cohousing complex (page 88).

Components. Back in 2011, the pioneering Passive House in Raglan (page 80) was plagued with delays because of the difficulties in sourcing key components like windows. All that has changed. If clients want European or locally made high-performance windows, there are options to choose between. More affordable New Zealand-made uPVC windows are now also available.

Technological innovation continues at pace, with products morphing into systems that make construction faster and more resilient. Take Izodom's approach to insulated concrete forms (ICF): it doesn't just create highly insulated, durable walls but easily integrates with foundations and midfloors to eliminate thermal bridging.

Regulators. More planners and building inspectors in local government are familiar with Passive House methodology, recognise the quality of the build and its components and are supportive of its goals.

Economy of scale. Counter intuitively, the bigger the building, the cheaper and easier it is to reach Passive House performance levels. Multi-storey, larger volume buildings like apartments or office buildings have a lower form factor (page 34), so less insulation is typically required. This can simplify design details so that construction techniques are more like those used for conventional buildings. This reduces the learning curve for construction crews.

The holy grail is certifiable Passive House performance that doesn't cost any more to build than conventional construction. This has already been achieved in the US and other markets. In New Zealand, commercial buildings or apartments will likely be the first projects to achieve this realisable goal.

All that is needed now is a wider understanding of the importance of quantifiable energy efficiency, health and comfort in our built environment—and the will to build it.

Not just a house *"Passive House" is a direct translation of the German word Passivhaus, where haus means "building". In English, "Passive House" suggests a focus on residential homes, but this is misleading. Any type of building can and is being built to the Certified Passive House standard internationally: office buildings, kindergartens, supermarkets, apartment buildings, warehouses and factories.*

HIGH STREET COHOUSING PROJECT
DUNEDIN

In 2014, a small group of Dunedin locals came together with a vision to create a different kind of residential development. They wanted to create a far more sophisticated housing project than the typical New Zealand subdivision made of up large, detached homes walled off from their neighbours.

Their vision is now being realised. An affordable, sustainable and sociable cohousing neighbourhood is being constructed on a central Dunedin site formerly home to a school. Twenty-four units of varying sizes will stand around a central green common. All houses have freehold unit titles and will be fully self-contained. Residents can also use a large number of shared facilities, including a dining room, large kitchen, workshop, laundry, guest rooms, social space and meeting rooms. These will be housed within the re-purposed school building which remains on the site.

Construction has begun and High Street will almost certainly be New Zealand's first multi-family Certified Passive House project.

The apartments are housed in two multi-level buildings, one facing High Street and another on Alva Street. Although the construction is similar, the difference in orientation and form factor makes for different Passive House metrics and the two buildings will be individually certified. The Alva Street building has a higher form factor (2.4) compared to High Street (1.9). High Street will easily meet Passive House energy requirements, while Alva Street will just meet them. The Passive House metrics detailed below relate to the more challenging Alva Street building, although these may shift during construction.

The buildings sit on a fully insulated concrete slab. Thermally isolated concrete piles also feature, the first time this system has been used in a project targeting Passive House certification. The walls will be constructed from Formance SIP panels.

Domestic hot water is centralised. Each building has its own large heat pump plus storage tank and circulation loop, which delivers hot water nearly immediately to the taps in each apartment. Fire safety requirements for multi-occupant dwellings shaped several design decisions: each unit has its own heat recovery ventilation unit and there are fire walls between units that required special detailing to meet Passive House performance levels.

PROJECT TEAM

Architecture
Architype NZ – *architype.co.nz*

Passive House Design
eHaus
ehaus.co.nz

Construction
eHaus Otago, Stevenson & Williams

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	20.9 kWh/m^2/yr
Heating Load	9.9 W/m^2
Frequency of Overheating	0 %
TFA	626.5 m^2
Form Factor	2.4
Air leakage @ 50Pa	0.6 ACH
PER demand	42 kWh/m^2/yr
Not yet certified	

ROYS PEAK LODGE

Wanaka

From a holiday home to a luxury lodge; this Auckland couple are convinced of the benefits of the Passive House standard. The Georges own the first Passive House certified in the South Island (page 68) and are now working with the same architect again to develop a luxurious 11-room lodge. It will primarily be used for residential coaching clinics for small groups of sportspeople and will also host intimate weddings. The lodge is built in an outstanding natural landscape beside Lake Wanaka.

Roys Peak Lodge is easily the most complex Passive House project underway in New Zealand at time of writing. Each bedroom will have its own bathroom and fire-resistant materials must be used between each room. The heat recovery ventilation system, which will deliver fresh, filtered air to each room, will be powered by a central unit but each room will have individual temperature control.

It is also the first Passive House project to contain a commercial kitchen. The cooker will require a large rangehood, but this needs to be carefully designed so that it doesn't unbalance the ventilation system in the rest of the building.

Walls will be of a timber construction, with the climate zone dictating 190 mm stud framing for the exterior walls with blown fibreglass insulation behind the air control membrane. The 45 mm service cavity is insulated with TerraLana Wool and finished with gypsum wall board. The roof is constructed from XLam Cross Laminated Timber (CLT) with 150 mm of fibreglass insulation between the CLT and the roofing assembly.

The concrete slab foundation is a sandwich with rigid foam (PIR) above and EPS foam below. Combined, this achieves a high R8.1 insulation value and eliminates any thermal bridging at the edges; it's a similar floor system to that proven in the George House.

PROJECT TEAM

Architecture & Passive House Design
Rafe Maclean Architects
www.rafemaclean.co.nz

Construction
TBD

Structural Engineer
TBD

Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	14.5 kWh/m²/yr
Heating Load	11 W/m²
Frequency of Overheating	1 %
TFA	599 m²
Form Factor	2.3
Air leakage @ 50Pa	0.6 ACH required
Primary Energy demand	72 kWh/m²/yr
Not yet certified	

LEGACY MULTI-FAMILY APARTMENTS
Auckland

The developer's environmental and social conscience is driving this project, which is currently in its detailed design phase. The three-storey building houses four units; well-designed, comfortable yet modestly sized between 60-120 m² of TFA. It will sit alongside detached family homes in a newer Auckland suburb, an example of the densification urban planners are urgently calling for.

The developer is passionate about the benefits of targeting Passive House certification, citing health, energy efficiency and comfort: "I am very motivated to make my project a legacy, that shows how it is possible to build homes that are cost-effective, environmentally sustainable, comfortable, healthy, low-maintenance and which create minimal waste during the construction process.

"My vision is New Zealand building social housing that meets Passive House standards. We all deserve a healthy, dry home to live in."

The building is a long term investment. Its form factor is a low 2.5, more readily achievable as buildings get larger and the ratio of building surface area to floor area decrease. It means Passive House performance can be achieved with less insulation compared to a smaller or more complex shape.

PROJECT TEAM

Architecture & Passive House Design
Sang Architects – sangarchitects.com

Construction
TBD

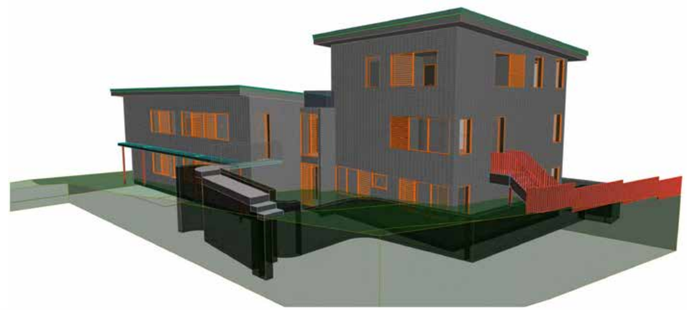
Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	13 kWh/m²/year
Heating Load	10 W/m²
Cooling Demand	6 kWh/m²/year
Cooling Load	10 W/m²
TFA	172.1 m²
Form Factor	2.5
Air leakage @ 50Pa	0.6 ACH required
PER demand	53 kWh/m²/year
Not yet certified	

As halves of the block will be separated by a central stairwell that is open to the environment, it is being certified as two separate buildings. The construction details will be identical but due to the difference in windows, orientation and form factor the Passive House metrics will differ slightly.

Construction will make use of the Polish Izodom system launched in New Zealand in 2018. It is a new generation of ICF blocks that offers improved thermal performance and is easy to join to floors and roof. The hollow blocks click together like giant Lego; while it's not strictly a prefabricated approach, it enables extremely fast construction, which saves on labour costs. The hollow, lightweight blocks are placed around steel reinforcing bars, then filled with concrete. It can be plastered, or interior walls can be fitted with gypsum wallboard and painted. It's extremely durable and low-maintenance and has excellent seismic strength.



SILVERSTREAM OFFICE

Wellington

Commercial buildings consume nearly 10 per cent of New Zealand's total annual energy use and many people spend a significant portion of their adult lives inside them. Making offices and factories more energy efficient and more healthy would have widespread benefit.

Design is almost complete for this small commercial building about 30 km north of Wellington. If it successfully reaches the performance targets, it will earn the distinction of being the country's first commercial building certified as a Passive House.

The climate zone doesn't present undue difficulties but the building does face some intrinsic challenges. It is a small, with a TFA of 115 m². Although the footprint is a simple shape, the form factor sits at a very high 4.1 due to its size. Higher levels of insulation are accordingly required.

The client's brief was for a durable, quality, low-energy building. Acoustic insulation was also very important because of the noise levels outside. Izodom Homes Ltd was awarded the construction on the basis of the cost, quality and durability of the Izodom system (page 93).

Given all this, the design team proposed targeting Passive House certification in order to receive third party assurance of performance. Because of the brief and the decision about construction materials, the additional cost will be minimal. The clients enthusiastically agreed; they are supportive of innovation and look forward to demonstrating how office buildings can perform. All involved hope this project will catalyse more commercial buildings being built as Certified Passive Houses.

The overall construction will be Izodom ICF block external walls and insulated concrete slab. The slab uses a special high-density EPS foam below and around the edges of the slab, plus 100 mm of standard EPS above the slab to reduce the amount of concrete required. This completely isolates the building's concrete structural shell from the ground and prevents any cold spots. The roof construction is a more typical timber-framed roof with fibreglass insulation over the air tightness membrane.

PROJECT TEAM

Architecture
Nature Homes – *www.naturehomes.co.nz*

Passive House Design
VIA Architecture
www.via-architecture.net

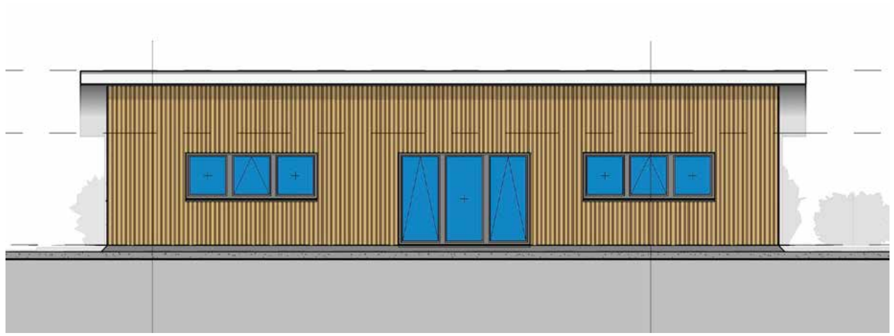
Construction
Izodom Homes – *www.izodom.nz*

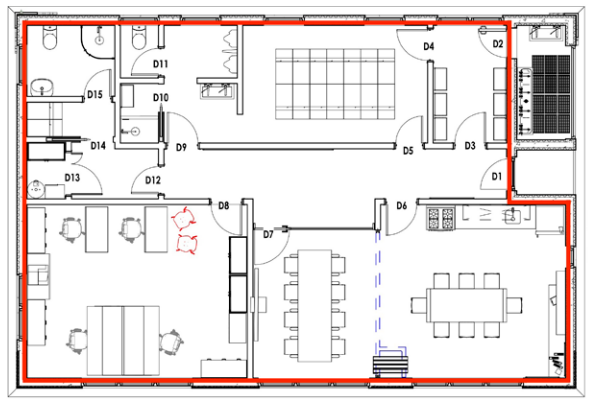
Certifier
Sustainable Engineering
www.sustainableengineering.co.nz

PASSIVE HOUSE METRICS

Heating Demand	15 kWh/m²/year
Heating Load	14 W/m²
Cooling Demand	10 kWh/m²/year
Cooling Load	11 W/m²
TFA	114.8 m²
Form Factor	4.1
Air leakage @ 50Pa	0.6 ACH or less required
PER demand	60 kWh/m²/year or less required

Not yet certified





PHINZ is an incorporated charitable trust with the following aims:

To advance education through:

- Educating the building industry and members of the public about improved energy efficiency in New Zealand buildings;
- Promoting the Passive House standard
- Researching the performance of built Certified Passive Houses in New Zealand and making such research publicly available;
- Researching the New Zealand housing industry in order to promote energy efficient building options;
- Providing a platform for the building sector to gain knowledge of highly energy efficient buildings;
- Educating building professionals and lay persons about Certified Passive Houses.

To benefit the community by:

- Improving public health and well-being and relieving fuel poverty of the people of New Zealand through the promotion of healthy and highly energy efficient homes and public buildings;
- Working with the public sector of New Zealand to improve the energy efficiency of New Zealand homes and public buildings.

PHINZ hosts the South Pacific Passive House Conference in NZ on alternate years, holds a national gathering every year to share and learn from fellow members. Local chapters hold regular informal gatherings also. Technical guidance and news is available from the website and electronic newsletters.

Please join PHINZ and help us work towards our charitable purposes.

Members are part of the movement behind the rapidly growing international standard, help grow the market for energy efficient products and services, get advertising opportunities with PHINZ and get discounts on PHINZ events and products. PHINZ membership also comes with complementary membership to the International Passive House Association (iPHA) along with the extensive online resources and the technical forums

To learn more about PHINZ visit ***www.PassiveHouse.nz***

Passive House Academy is a project of PHINZ set up to disseminate the knowledge needed to design and build highly energy efficient buildings. It is the only institution in Aotearoa/New Zealand to offer preparation courses for the examination for Certified Passive House Designer/Consultant or Tradesperson.

To learn more about the Passive House Academy visit ***www.phanz.ac.nz***

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This work is referenced at www.sustainableengineering.co.nz/PH4NZreferences

Download this book and find updates at www.warmhealthyhomes.co.nz

Jason Quinn

Born and raised in Massachusetts in the US's north-east, Jason's boyhood dream was to be an astronaut. Less than perfect vision scuppered that plan, but he went on to forge a stellar career at NASA anyway as an aerospace engineer. He is happiest solving tough technical problems and has particular expertise in advanced data modeling.

Jason and his family immigrated to New Zealand in 2009. His interest in housing began as a little boy "helping" his father build houses. He bought a dilapidated art deco house in Whanganui order to bowl-and-build. That was, until he discovered the cost of building houses in New Zealand. He spent hundreds of hours retrofitting the 1940s house for energy efficiency, a Sisyphean task that sparked a new career as a building scientist.

Jason was one of the first qualified Passive House designers in New Zealand. He is an in-demand speaker at Passive House conferences in Australasia and has taught courses for PHINZ and the NZ Green Building Council. His work focuses on the intersection of physics and building design and he has outspoken views on New Zealand housing.

Jason's work is driven by concerns about the future we are creating for our children. His commitment to the Passive House concept springs from its potential to significantly reduce carbon emissions and its rigorous measurability. He is deeply concerned about fuel poverty and childhood illness in New Zealand and the impact of poorly designed buildings on the health of individuals and society.

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Our homes should be a safe haven.

In this succinct, fiercely argued book, building scientist and Passive House designer Jason Quinn reminds us of all the ways New Zealand housing fails. He takes aim at the Building Code and the high cost of building average (or worse) homes.

Most of all, this is a book concerned with how to do better. It makes an impassioned argument for much wider use in New Zealand of the Passive House building performance standard. Jason Quinn demolishes myths about Passive House concepts and demonstrates its relevance for New Zealand conditions. The theory is backed up with concrete examples of New Zealand's first 24 Certified Passive Houses and concludes with the more diverse projects—apartment buildings, offices and tourist accommodation—that are being planned.

Of interest to architects and architectural designers—and those among their clients who are interested in how their new home will work and feel, not just how it will look—Passive House for New Zealand is also an important read for anyone involved in the building industry and in making policy on health and housing.

This timely book ... will spark lots of thought, funding and effort into energy-efficient and healthy housing.

—from the foreword by Professor Robyn Phipps, Massey University

ISBN 978-0-473-46903-0

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www.warmhealthyhomes.co.nz