Climatic Conscience for Dwelling Design

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In New Zealand, our residential architecture is built off the pragmatic approach of the instinctive farmer, and the desire to dissolve the boundary between architecture and landscape. In the search to create the dream home, many have packed up their beach houses to set up camp in the alpine environment surrounding Queenstown, causing the population and construction demand in the area to rise rapidly. As a result the building’s thermal envelope is put under pressure to perform both pragmatically and poetically as it faces one of New Zealand’s most extreme environments to live in. However, when put into action a pragmatic approach, to create a warm, dry and healthy home, often confronts conflict with a poetic approach that priorities the building’s relationship with the landscape through high amounts of glazing to dissolve the boundary.

In response, ‘Climate Conscience for Dwelling Design’ focused on the potential to exceed the minimum thermal envelope requirements, whilst actively engaging with the relationship between architecture and its environment. Quantitative and qualitative research methods were used to explore the dialectic between pragmatic and poetic approaches to design. The theoretical framework, background research and a systematic investigation into design precedents aided in sculpting a series of strategies and criteria that were refined throughout the design process. A series of cabins simulated and tested the strengths and weaknesses of the methodology and early design investigations to streamline the overall design investigation.

The developed design proposal builds off the aesthetic of an external structure to integrate the building within its landscape, whilst removing the load-bearing requirements from the building’s thermal envelope. As a result the predicted amount of heating energy was reduced. The process of resolving the design continued to constructively build off both poetic and pragmatic approaches to develop critical building elements to the appearance, experience and performance. As a speculative and simulated design, it hopes to become an example of how much potential there is for designers and architects to push boundaries with aesthetic and performance-based design decisions.
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INTRODUCTION

New Zealand residential architecture, as a discipline, retains a bond with its pragmatic origins of sheep farming, and poetic aspirations to dwell within the landscape. However, when these desires are considered as an architectural approach, a dialectic is formed between the argumentative reasoning behind pragmatic and poetic points of view. On one hand, pragmatism urges consideration of the consequences of design decisions on the performance and physical capabilities of architecture. On the other, poetics engage with the possibility that moments can be created when the architecture transcends beyond the sum of its parts, psychologically allowing the occupant to view it as more than just a physical space. Both sides present equally valid arguments in the search for evaluating the truth behind ‘great architecture’. This research proposes to engage with the dialectic between pragmatic and poetic approaches to design, to further pursue the role of a residential building’s external envelope and its impact on the interior and relationship between architecture and landscape.

Further, the research also seeks to respond to the current issues within architectural practice around calculating the performance of buildings. To do this, a simulation methodology, which evolves around software packages already being used by architects, is investigated to see if it can enable the architect to think both poetically and pragmatically.

Therefore the question the research will respond to is;

How can architects engage with both poetic and pragmatic opportunities through design to ensure a better quality built product?
AIMS AND OBJECTIVES

Prompted by recent research into the thermal performance issues of our current building system and the ‘New Zealand Dream’, to dwell in the landscape, this thesis addresses the consequences of building a home in one of the country’s coldest climates. As attention to climate change grows, and architectural typologies, driven by environmental ethics (pragmatic) and environmental aesthetics (poetic), drift apart, it can be difficult to take advantage of the wide range of complicated solutions to a relatively simple problem. As an architectural issue, design decisions have the opportunity to actively create a building that expresses its performance features through poetic gestures.

The aims of this thesis are firstly to critically develop a simulated theoretical design to identify factors of the building’s envelope that contribute to thermal performance and poetic relationship to the landscape. Secondly, to test a methodology that can be integrated into architectural practice workflow.

The key objectives of the research therefore are;

Focus design decisions on engaging both pragmatic and poetic opportunities to benefit the building’s thermal envelope, interior, and relationship with the landscape.

Review the development of thinking and strategies around pragmatic and poetic design considerations.

Systematically analyse pragmatic and poetic precedents to understand how different values and strategies have been applied internationally and within New Zealand.

Investigate the climate conditions throughout New Zealand to give context to the environmental considerations faced in the Southern Lakes District.

Identify strengths and weaknesses of using energy and thermal simulations to achieve poetic and pragmatic outcomes.
Figure 0.1: Morning Sun on the Southern Alps
SCOPE

The central focus for the research was the design of a high performance and environmentally influenced thermal envelope of a rural residential building. The research addressed issues around: accurately calculating the thermal and energy performance of a building’s envelope, applying inspiration from external influence precedents, and engaging the relationship between architecture and landscape. This process is limited by narrowing its focus around the condition of thermal performance and thermal qualities of space. The project can be used as a guide for how to approach designing for both practical and poetic opportunities in the central and lower regions of the South Island in New Zealand.
**Result**

"Designing off a hunch"

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**Problem**

The issue here is that any method of compliance - schedule, calculation, or modelling, is not usually completed until this point.

**Factors**

- Time
- Training
- Out-sourcing

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**BIM**

Within a Building Information Model

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**Analysing Site Conditions**

**Wholistic Analysis**

**Detailed Analysis**

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**BEM**

Converting to a Building Energy Model
METHODOLOGY

The approach to research through design as research, aims to explore a mix of pragmatic (largely quantitative) and poetic (largely qualitative) approaches to design generation and appraisal. From the outset of the research the intention was to explore thermal simulation and performance, alongside an investigation into a challenging climate within an inspirational landscape, to iteratively develop a speculative design that could be used as an example to inspire others to exceed the minimum. The methodology outlined in the following paragraphs weaves the pragmatic and poetic approaches together with the goal of demonstrating the evidential basis for the conclusions.

AGILE & ITERATIVE DESIGN & SIMULATION PROCESS

To reflect the pragmatic and poetic intentions of the research, a design-led methodology was formed around an agile and iterative workflow to actively test the performance of different design decisions through simulation. The methodology responds to the need for architects to explore more thoroughly the thermal consequences during the design process that could impact the energy requirements of the built product. A process of evaluating the existing literature, climate conditions and influential precedents generated a quantitative and qualitative criteria that was applied to a series of design investigations.

Figure 0.2:
Diagram of the issue with H1 compliance calculation being at the end of the design process

Figure 0.3:
Diagram of BIM to BEM simulation methodology
To streamline the quantitative investigation into the performance of different construction systems and the qualitative investigation into the thermal consequences of different aesthetic decisions, the design investigation shifted scales. The smaller scale design investigation, 'cabin series', was based around what type of building can be built without a building consent. The findings from these investigations were then applied to the larger scale building that tested the findings in the context of a functional residential programme. The purpose of shifting scales was to decrease the amount of time it would take to set up a simulation. Additionally, to make the results comparable, a consistent unit of kWh/m².a was used.
Figure 0.5: Illustration example of types of thermal bridges
THERMAL BRIDGE
IDENTIFICATION &
SIMULATION

To extend the quantitative investigation and more closely measure the thermal consequences of poetic design decisions, an analysis of thermal bridges was applied to the detailed design. As a simulation method it responds to the need for architects to have a deeper understanding of the performance of a building so that they are more empowered to 'design-out' potential threats.

A thermal bridge is where two (or more) materials, side by side, have a significant difference in insulative properties. There are many different ways of categorising thermal bridges but within the context of this research, three main categories will be explored, including 'repeating', 'linear' and 'point'. A 'repeating' thermal bridge, such as studs or joists, occurs regularly in the envelope and is accounted for in the R-value calculation of the building. A 'linear' thermal bridge, such as a lintel, occurs in a single location and is often a few meters in length. A 'point' thermal bridge, such as a steel beam penetration through a wall, occurs in a single location and is often under 500mm in length. Instances of the last two types of thermal bridges will be simulated to explore ways to improve the building's thermal envelope.

Simulating thermal bridges is a well-recognised form of performance evaluation in European and North American energy efficiency standards. It is important to analyse thermal bridges as they show how heat flows at building junctions and/or penetrations. These junctions can either add or reduce the energy demand of the building and in simulating their performance, a more comprehensive analysis of the building’s performance can be completed.

"It has been recognised that thermal bridging at the junctions between the various plane building elements - walls, roofs and floors - of a building can add significantly to the fabric heat loss. The higher heat flows that occur, because of complex geometries or the use of materials with a high thermal conductivity, can cause localised reduction in the internal surface temperatures, which in turn can lead to condensation and mould problems" (BRE 497)

The simulations were completed using the EcoDesigner Star plugin for Archicad. This plugin is not commercially available in New Zealand, however, approval for its use was kindly given by Central Innovation for its pilot use within the country.
“The men of old were born like wild beasts, in woods, caves and groves, and lived on savage fare. As time went on, the thickly crowded trees, in a certain place, tossed by storms and winds and rubbing their branches against one another, caught fire, and so the inhabitants of the place were put to flight, being terrified of the flames. After it subsided, they drew near, and observing they were comfortable standing before a warm fire, they put logs on, and while keeping it alive, brought other people to it, showing them by signs how much comfort they got from it.”

- VITRUVIUS
THEORETICAL FRAMEWORK
The following chapter fulfils the research objective: review a development of thinking and strategies of pragmatic and poetic design considerations. To provide context for the dialectic between pragmatic and poetic design approaches, a brief review of the original motivation to control our environments is explored. The two approaches are then explored separately (figure 1.3) to develop an understanding of the development of literature and the relevant strategies, which have the potential to benefit the design element of the research. The chapter concludes with a critical reflection that discusses the two sections in relation to residential architecture.
Figure 1.3: ‘House’ by Vlad Sargu
Figure 1.4: ‘Fire’ by Lidia Adriana
Charles Darwin, well-known for his work on the science of evolution, attributed core factors of the success of humans to their ability to control fire. He theorised that the “discovery of fire, probably the greatest ever made by man, except for language, dates from before the dawn of history” (Darwin 1871, p.23). This proposition challenges other competing evolution contributors, such as the use of tools to craft weapons, build boats and construct buildings, which all stem from having a higher intelligence level when compared to other animals. Professor Richard Wrangham and Dr Rachel Carmody argue that one of the largest effects of controlling fire was on altering our diet, “accounting for the unique pattern of human digestion”, allowing us to digest a wider range of food to survive (Wrangham and Carmody 2010). In regard to architecture, Becci Taylor, a building services engineer, suggests that our first motivations to control our environment were drawn from attempts to shelter and protect the fire (Taylor 2014). Early examples of vernacular architecture, designed for cold climates, where buildings designed around a central fireplace as the fundamental form of heating and light.
In our industrialised world, our obsession with productivity, software updates and hardware upgrades, lead to a rapid rise in the population with “an insatiable appetite for material goods and benefits” (Berleant 2005, p.17). Due to this development, we have “ignored the imperative of balance” with mindful aspects of our lives that slow it down and encourage us to disconnect (Berleant 2005, p.17). The loss of balance, due to favouring a technology-focused environment, is especially prevalent in the early mid-20th century thinking around controlling the indoor thermal environment.

In the last few decades the benefits around creating an artificial and mechanically controlled environment for people to work in has been questioned (Brager and Baker 2009; Arens et al. 2009; Zhang et al. 2007). However, the focus is on the typology of the work environment, as there is an obvious cost benefit in increasing the productivity and satisfaction of employees. The following sections will cover the pragmatic literature category. The focus is on scientific studies that look at the thermal environment of workplace typologies and other building typologies, outside the residential context of this research, to gain a perspective of how the broader field of thermal comfort research is changing. Specifically, three topics will be explored: natural ventilation, occupant control and thermal excitement.
Figure 1.5: ‘Office Buildings’ by Phil Desforges
In the 1970's the landmark research of Ole Fanger created the Predicted Mean Vote (PMV), a framework “necessary to determine a set of design temperatures for engineering mechanically controlled environments” (Candido and Dear 2012, p.82). This framework has been widely used in many climates, cultures and building types, even though its original purpose was for the heating and ventilation and air-conditioning (HVAC) industry to produce artificial indoor environments (van Hoof and Hensen 2007). Alongside this framework, the Predicted Percentage of Dissatisfaction (PPD) emphasised the ideal comfort zone as maintaining occupants within a ‘neutral’ state. Paul Tuohy argued that a result of placing emphasis on creating a ‘neutral’ state was “taking the power from the architects to service engineers” in the “wholesale commoditization of the building design process” (Tuohy et al. 2010, p.78). These theoretic frameworks have had a large influence over the thermal comfort field for many decades, including heavily shaping standards such as ASHRAE Standard 55, a standard that is continuously widely referenced.

However, like any influential piece of research, its presence in the field has been widely critiqued. Three key criticisms have been developed in research surrounding the topic. First, the PMV model was developed through laboratory experiments and requires careful consideration for the application using temperatures hotter than those used in the lab (Candido and Dear 2012). Secondly, and arguably the most important criticism is the prescribed ‘neutral’ state, essentially flatlining the body’s reactions to any temperature stimulation. Thirdly, the significant energy consumption used by HVAC units to maintain a warm, or slightly cool, still air environment
(de Dear and Brager 1998). From these critiques, the ‘adaptive comfort model’ was born, and the realisation of the unsustainable energy and carbon consumption to facilitate these indoor environments became common knowledge by the end of the 20th century. As a result, buildings began to be categorised into those that included HVAC systems and those that ventured down a more passive route by implementing natural ventilation (NV).

Essentially taking a step backward, the shift in thinking moved towards the fundamental strategies derived from vernacular architecture, to reconsider the heavy energy use of artificially controlled environments. In other words, it was reconsidering natural airflow, that Fanger had defined as a ‘draft’ and classified as ‘uncomfortable’ through laboratory experiments, to classify it as a ‘breeze’ which has the potential to broaden the range of accepted comfort temperatures. In cool climates, still air was still desirable, but in hotter climates, or environments with high solar gains, increased airflow allowed these temperatures to be tolerated. Considering comfort to being adaptive and that the occupant has the ability to acclimatise is a revenant development in the literature for this research as the southern New Zealand microclimates flux above and below ASHRAE’s definition of thermal comfort.
Aside from the obvious mechanical versus passive ventilation difference between the two, another noticeable difference was the control the users had over their environments. In HVAC equipped buildings, the occupants are considered passive recipients to predetermined thermal set points, however, with a shift towards the adaptive model and naturally ventilated buildings, occupants became active inhabitants of the space with the ability to alter the conditions as needed (Candido and Dear 2012). It has been found that the body has sensitive thermal comfort responses to environmental stimuli, depending on the architectural context in which it is experienced (Raja et al. 2001). Combining this physical response with a psychological one, a study looking at providing control of the indoor environment found that control is linked with reduced stress levels (Leyten, Kurvers, and van den Eijnde 2009). Additionally, the ‘forgiveness effect’ has been found in occupants in user-controlled environments who tolerate higher amounts of minor malfunctions in their work environment due to an increased amount of freedom in adapting their immediate indoor conditions (Taylor 2014).

On the other hand, studies have also recorded the negative impacts of automatically controlled environments on occupants. A field study of 47 English office buildings found a relationship between occupant control and sick building syndrome, where complaints of symptoms such as dry eyes, itchy throat and stuffy nose were more frequently recorded in indoor environments where occupants had the least amount of control (Hedge 1989). These results have similarities to a study in Germany that also showed a correlation between environmental control and sick building syndrome (Zweers et al. 1992).

Based on these results from studies around office and commercial environments, the clear takeaway is the
relationship between control and satisfaction. However, an office building is not the same as a home environment because in a normal office the occupant is fixed to sit in one location or zone, and in a normal home the occupant is free to move around as they wish. In spite of this, the results from the occupant control studies can still hold relevance to this research, as a lesson for residential environments could be viewed as providing control outside of normal conditions has the ability to increase satisfaction.

Figure 1.6: ‘Window’ by Chris Barbalis
To excite the thermal senses in the body, a contrast of hot and cold is required. The body can be thermally stimulated in two ways. Firstly, as explored by Lisa Heschong, a visual contrast of environments, where architecture acts as a form of shelter from an external thermal extreme, creates a sense of “thermal delight” (Heschong 1979). For example, an alpine villa provides shelter from the snow through a rich wooden interior and fireplace. Alternatively, the Israeli courtyard provides shelter from the hot desert by creating a lush cool oasis of plants and fountains. As a visual form of thermal excitement, this strategy is well-used in much of New Zealand’s rural residential architecture. Here, the buildings’ often adopt the role of creating shelter from a cold coastal storm, achieved by placing rooms perceived to have the highest amount of comfort, i.e. the lounge or bedroom, alongside this view, framed by the window.

Moving beyond “thermal delight” the extreme end of the spectrum is to create “thermal sacredness” through ritualistic and symbolic experiences (Heschong 1979). In a residential setting, this is commonly achieved through the presence of a fireplace because patterns of behaviour around them extend beyond simply using them to provide heat. The element of fire in many ways is associated with a spiritual experience, as a symbol of purification, fire aids in creating a connection between the spiritual and physical world (Heschong 1979). Another element with similar connotations is steam. In association with the sauna, the practice of pouring hot water over hot rocks to create steam originally stemmed from a method to worship the dead, through to defining an architectural typology when combined with the log building techniques in Northern Europe (Heschong 1979).

Secondly, another method of being thermally stimulated is
through the nerve endings, or thermoreceptors of our skin that respond to the temperature and air velocity and send signals to the hypothalamus at the base of the brain (Zhang et al. 2007). In other words, our bodies are making a comparison between the body’s temperature and the data from the environment to judge how comfortable we feel within a space. In naturally ventilated indoor environments that are experiencing a higher temperature than the body’s core temperature, the skin’s cold thermoreceptors can be triggered through increased airflow (De Dear 2011). This means that pleasure is felt by creating a natural cooling effect in hotter environments (De Dear 2011). This feeling of pleasure, moving beyond comfort, is considered thermal alliesthesia, a concept used to describe the conscious experience of pleasant and unpleasant thermal stimulation to the skin (Cabanac 1971). An example of thermal alliesthesia is the feeling of wrapping cold hands around a warm mug or touching cold metal on a hot day.

In the context of residential architecture, creating thermal excitement can enhance the experience of living within a space, enriching the routine of daily patterns. Both methods of creating thermal excitement have the potential to be widely applied, however, within a home the application is likely to impact the material selection, elemental control to create thermal contrast and stimulus. Further, a ‘one size fits all approach’ is likely to be unsuccessful within a house, and so programme specific would be more appropriate. For example, a hot and humid environment is likely to create a pleasant experience in a bathroom, based on the sauna example above, and a cooler, dry and still air environment is likely to be pleasant in a bedroom. Overall, being sensitive and aware of the specific environmental conditions relative to the spatial function is the most important prerequisite before applying the methods to create thermal excitement in the context of residential architecture.
Many lessons can be found from reviewing literature on vernacular architecture all over the world. People have a strong ability to be innovative, especially in highly restrictive and limited conditions faced when building homes to survive the many climate conditions and weather events (May 2010). Both climate and weather have had a strong influence over the design process. The difference between the two can be defined as simply a measure of time. Banister Fletcher suggests that architecture “must have had a simple origin in the primitive efforts of mankind to provide protection against inclement weather, wild beasts, and human enemies” (Fletcher 1954, p.1). The idea of architecture as an active form of protection is taken a step further by Jonathan Hill who argues, whilst reflecting on a history of architecture, that weather has been a significant contributing author of architecture (Hill 2012).

Considering weather as a contributing author of architecture is a concept that has been slowly developing in New Zealand as architects have been seeking to create a national architectural identity. In the manifesto by The Group architects, they argue against adopting international solutions, stating that “New Zealand must have its own architecture, its own sense of what is beautiful and appropriate to our climate and conditions” (Gatley and Gus Fisher Gallery 2010, p.21).

Today, some of the most well-known homes in New Zealand are awarded for not only their dialogue with their setting but their influence from it. However, New Zealand is a country with many climate conditions and different frequency of extreme weather events. NIWA, the National Institute of Water and Atmospheric Research (New Zealand) has long been publishing reports on the wide
variety of climate patterns and extreme weather events, from high temperatures in the north and the heavy rainfall along the west coast of the South Island (NIWA 2009). Therefore, to follow Jonathan Hill’s theory on the weather being an contributing author in design, would mean that the influence of weather should be different across the country.

However, whilst architects responding to older societies are able to use a critical understanding of the past as a catalyst to create the future, New Zealand’s architectural history is limited by ‘time’ when attempting to understanding the impact of climate and weather on the built environment. Yet in reflecting upon the book ‘Weather Architecture’, Hill explains that;

“The relationship between architecture and the environment is one of mutual dependence which requires the architect to develop a subtle and complex understanding of time and context, accept the inevitability of unexpected change and acknowledge weather’s creative influence”. (Hill 2012, p.5)

A New Zealand example of residential architecture that acknowledges the weather’s creative influence is the Wind-Rain Houses by Nigel Cook. These houses recognise that our lifestyle habits are similar to people in Australia and California, yet our climate restricts the ability to use outdoor spaces as much as they do. In reaction to this, these houses use the weather to inspire an innovative type of dwelling that fulfils this desire by utilising roof vents controlled by a computer connected to sensors that measure the weather. Overall, by responding to the specific weather conditions of this country, a building typology was created that is unique in aesthetic and function compared to the typically New Zealand home that has adopted influence from international precedent.
The concept of immortality, being untouchable by time, has been a fantasy conjured by humans which is self-projected onto themselves and surrounding objects, including architecture. To understand the relationship between architecture and time, this section will provide a discussion on how time is shown through weathering on architecture and the consequential attitudes towards this effect in both a global and local context.

In the design and construction industry, it can be simpler to assume that the completed constructed state of the building will be its final form to be relentlessly maintained to stand the test of time. The concept that a house must show its age is entertained by Mohsen Mostafavi and David Letterbarrow who argue that “no matter how maintenance-free the construction, weathering still occurs” (Mostafavi 1993, p.5). This idea that architecture, like people, will never be immortal, is not an idea that is commonly favoured by architects, builders or clients. The conservation of heritage architecture demonstrates the application of immortal values on buildings. Antrim House in Wellington is a prime example of pristine heritage preservation, with an exterior that is regularly being repainted from an approved colour scheme. Paint enables these immortal idles and is commonly used to ‘fix’ signs of weathering in all types of buildings.

However, the idea of weathering throughout time in architecture doesn’t have to be only perceived as a negative or something to ‘fix’, where “newly finished corners, surfaces, and colours are taken away by the rain, wind and sun” (Mostafavi 1993, p.6). The impact of weather is measurable and predictable in the marks that it will leave on the building, and there is potential for these marks to be perceived to add value in the aging process. The addition of value can be seen in the way specific products are artificially weathered to achieve a rustic...
aesthetic. For example, furniture is painted and then sanded to look like it came from an old French country house, or silver wood stain to be applied to cladding to give the appearance of perfectly even weathering. These examples support the conclusion by Mostafavi and Letterbarrow, who argue that the “sense of weathering is often associated with a romantic appreciation of the appearance of buildings that have aged” (Mostafavi 1993, p.6).

This argument is resonated in Jonathan Hill’s reflection on the picturesque romanticism’s influence on architecture. Hill states that in this period “architecture became temporal” in an effort to increase aesthetic appreciation as the “weathering and decay were acknowledged and even celebrated” (Hill 2012, p.4). This encouragement for buildings to coexist with their immediate environment lead the relationship between architecture and weather to be built off an acceptance of “time, decay and [inevitably] change” (Hill 2012, p.4).

These arguments could be also be used to reflect on the way we, as a country, have romanticised the image of a decaying farm shed. A form of architecture that is deeply correlated to the identity of rural life. In pursuit of defining the motivations behind this form of romanticism Ray Grover records John Scott’s statement; “the woolshed acts as a symbol for all New Zealanders … having grown out of the New Zealand farmer’s needs, it represents our total income … whether or not we’re involved in farming. It’s important because it was generated here.” (Grover 2005, p.187)

Furthermore, Susanna Stevenson states that our pragmatic approach to architecture was “embedded in New Zealand tradition”(Stevenson 2007, p.9). These statements on New Zealand’s origins for architectural identity combined with the literature on the romantic qualities gained from allowing the building to weather, provide a reason to why we have glorified the idea of poverty in local rural communities. The example of the woolshed is one of a few examples of how our buildings have been left to weather and settle into the landscape.
1.8 RETHINKING ENVIRONMENTAL AESTHETICS

The idea of architecture weathering and evolving to coexist within its environment leads to the theory of environmental aesthetics. This section will build on the previous two sections by exploring how philosophers have traditionally defined environmental aesthetics. It will then move into how this theory is being rethought during a time when the world is becoming increasingly more aware of its impact on the environment due to climate change. Finally, it will reflect on how rethinking environmental aesthetics can change the way we think about the aesthetic experience we create through our architecture.

A traditional or formal way of defining the theory of environmental aesthetics is outlined by Allen Carlson, whose argument is centred on two points of view; a ‘subjectivist’ or ‘objectivist’ which are both focused around the appreciation of the environment as an object in space and time (Carlson 2000). Yet, more recently as there has become an increased global awareness of the impacts of climate change and the effects of human actions, there has been a shift in theory towards how we approach the concept of environmental aesthetics. Arnold Berleant, an author with a long published history on writing about environmental aesthetics, developed an argument around the coexistence of both natural and human environments. He argued for a phenomenological standpoint where “one can only speak of the environment in relation to human experience” (Berleant 2005, p.3). In other words, using our experience with the land and the response from the landscape to build a mutual understanding of the impact of our design decisions.

To break this down further, historically visual terms have been used to describe aesthetic perception. Berleant points out that frequently “we are given
not an aesthetic of experience but an aesthetic of appearance” (Berleant 2005, p.3). In a study outlining a model for measuring aesthetic judgments, the author points out that aesthetic appreciation of appearance can be made by using the sense of sight almost instantly, whilst to achieve an aesthetic experience more time is required to engage more senses (Leder et al. 2004). In architecture, the immediate judgment of aesthetic appearance through the sense of sight can be “seen clearly in the standard stock of visual metaphors that provide the usual vocabulary for denoting acts of thought and cognition” (Berleant 2005, p.3). In particular, metaphors relating to the environment and one’s experience within it are commonly used in New Zealand to describe remote examples of residential architecture.

In building off the heightened awareness of our environment due to the increased amount of research on climate change, “environmental perception offers an exceptionally rich opportunity for illuminating aesthetic experience” (Berleant 2005, p.4). The environment, on top of being a visually exciting medium, has the ability to engage the body’s other senses such as; hearing, through the sound of wildlife and wind through trees, smell, through the natural sent produced by plants, and touch, through the different textures and surfaces. The least considered sense when designing for aesthetics is touch, due to only being present in the experience of the environment and difficult to acknowledge in the appearance of a space. In an earlier section, *Thermal Excitement*, methods including stimulating the thermal receptors on the skin to achieve thermal alliesthesia were discussed. This method involves using thermal strategies to activate the sense of touch to improve the experience of space. For this reason, the literature from that section also applies here, where the goal is to create an aesthetic experience.
Pragmatically, residential architecture can learn a lot from the literature surrounding the environmental control of office buildings. Firstly, enhancing natural ventilation to reduce the energy demands of mechanical systems. New Zealanders tend to open windows and doors to cool residential buildings intuitively over resorting to automatic mechanical systems. However, enhancing natural ventilation not only has an impact on temperature, but on air quality and humidity too. During the winter months in Queenstown, people struggle to keep their homes warm from the cold environment outside and in turn are less likely to open windows to supply natural ventilation. In the absence of a mechanical ventilation system, the indoor air quality will be reduced as a consequence of this behaviour. Further, drying laundry indoors in the winter can increase the humidity in the air, making it increasingly harder to heat and resulting in higher energy demands. Therefore, in residential architecture, encouraging a higher use of natural ventilation all year round has the ability to improve the temperature, air quality and humidity.

Secondly, providing occupant control over the indoor environment can decrease stress levels and increase satisfaction. As discussed in the section Occupant Controlled Environment, a key difference between a normal office and normal home environment is the occupant’s ability to move freely within the space. However, the finding from the studies on office environments can still be applied to residential environments when considered as providing control beyond the normal scope. In combination with the previous takeaway, an element of unique ventilation or window function could encourage the occupant to more frequently naturally ventilate the home whilst making the occupant feel as if they had a higher level of control over their environment. The opportunity to create a unique form of environmental control, in turn, is also an
opportunity to create a design feature that is integrated with the aesthetic of the building.

Thirdly, using thermally contrasting environments and the concept of thermal allesthesias to create thermal excitement. In the context of residential architecture, these two methods provide a range of opportunities to create interior spaces that engage and enhance the thermal experience of specific spaces within a home. In turn, the strategy of creating thermal excitement also contributes to the theory explored in the poetic section, *Rethinking Environmental Aesthetics*, that suggested creating an aesthetic experience must engage with multiple senses over just relying on sight and sound. The creation of an aesthetic experience combined with the methods to induce thermal excitement opens up the possibility to compose a journey through the building that is inspired by the environment and referenced through thermal spatial qualities.

The investigation into poetic theory has enriched the understanding of how to utilise the inspiration from the environment to further develop the relationship between architecture and landscape, a key consideration in achieving the ‘New Zealand Dream’. Specifically, the topic of Architecture and Time shone light on the romantic qualities’ architecture can possess through aging. The example of the weathered farm shed embodying our pragmatic past has provided a path for architects such as The Group in Auckland to rethink our architectural identity as a country. However, in a country with vastly different weather conditions, our architectural identity cannot be static, or neutral like a mechanically controlled office, but instead, it must allow for adaption. Therefore, examples such as the Wind Rain Houses by Nigel Cook provide insight into how buildings can take inspiration from the local weather and climate to author a piece of architecture that fits uniquely into its environment without compromising on the desired function or behavioural patterns of the occupant.

Overall, through exploring both pragmatic and poetically orientated literature, the research has been provided with many theories to consider, strategies to apply and opportunities to explore.
CONTEXT & ENVIRONMENT
2.1 OVERVIEW

In order to explore, through design, the dialectic between the poetic and pragmatic design approaches, a building site from a challenging New Zealand climate and context has been selected. The following sections place this specific site into the broader New Zealand context.

The purpose is to enable the research conclusions to reach beyond the specifics of the individual site to a broader level of knowledge about the dialectic itself.
It is unquestionable that New Zealand’s identity is interlinked with its wide range of landscapes. From white sand beaches to the snow-covered Alps, our landscape is our brand. As an attraction it drew in a visitor population of 3.79 million people in the last year, of which 1.99 million, 52%, were people visiting for a holiday (Tourism New Zealand 2018). However, perceiving the land as something to label, own and sell is a perception strongly linked with the views of the early settlers who came to New Zealand seeking to command the landscape.

In contrast, this perception is not shared by Maori, the indigenous people of New Zealand. Their observations of the landscape are deeply rooted in their cultural values of family and survival. Many of their myths and legends portray this relationship visually through metaphors, and it is not hard to see the correlation between the name of the country, Aotearoa, ‘Land of the Long White Cloud’, and their values.

In time these two perspectives have grown to create a mutual sense of respect, and much of the more recent architecture reflects this. In comparison to Australia, Anna Johnson and Richard Black state that “the respect and engagement New Zealanders have with Maori cultural attitudes to landscape is a more integrated relationship than the one Australians have with their own Indigenous people” (Johnson and Black 2017). This integration between cultural attitudes has been critical to the development of our architectural identity, one that will forever be linked to our landscape.

Figure 2.3: ‘Queenstown’ by Aaron Sebastian

Figure 2.4: ‘New Zealand Beach’ by Petr Vyshlid
The traditional timber construction system in New Zealand has long been criticised for “its conservatism and lack of innovation” (Urban Research Network 2019). However, a study report published by BRANZ showed that timber framed construction was 93.1% of new construction in 2015 and has held a strong 90% (+/-5%) of the market for the last decade (Rosevear and Curtis 2015). A clear benefit of the current system is its ability to have the framing elements prefabricated off-site, reducing the delays due to weather and human ability, as well as improving the quality and consistency due to mechanically manufacturing techniques. As many reports have recognised, there are more benefits and opportunities in continuing to prefabricate building elements, components or entire buildings (Buckett 2014; PrefabNZ 2013).

However, rating a construction system on its ability to be quick and cheap to build are only factors that involve the building’s life cycle. By prioritising these values, factors that affect the building’s performance after it is built go either unconsidered or judged with heavy assumptions. Furthermore, a recent research report revealed that the amount we account for based on ‘clear wall’ assumptions, is a significant underestimate (Bakshi, Gjerde, and Donn 2019). This underestimated amount of timber led to an increase in thermal bridging within wall elements and a large reduction in elemental R-values. This means that whilst there is a well-known identified potential to increase prefabricated timber production in New Zealand, there is also an opportunity to create a building system that has less thermal bridging to improve the thermal performance of the building after it is built.
Figure 2.5: ‘Wood’ by Dorelys Smits
2.4 New Zealand’s Climate and Building Code

This section analyses a sample of weather files from the three climate zones in the building code to evaluate the distribution of our regulations on minimum performance. To put this into perspective a comparative analysis is undertaken that gathered minimum building code standards from countries responding to similar climate conditions.

In regards to climate, the country is broken down into three zones in an attempt to recognize that a wide variety of microclimate conditions across the two main islands. These climate zones are reflected in the minimum thermal resistance values (R-values) for different building elements shown in Figure 2.6. However, the distribution across these minimums is 5% in the wall elements, 13% in the roof and 0% in the floor. This implies that there isn’t a large distribution in climate conditions that they are responding to.

To check how well these code minimums reflect the distribution in the country’s climate, a sample size of weather files were gathered from the National Institute of Water and Atmospheric Research (NIWA) database. In each file the heating degree days were recorded at a set point of 18°C to create a comparison. The results from this investigation (figure 2.8) showed that the distribution range across climate zone three, where the site for this thesis is located, was 18.2 times larger than the distribution across climate zone one.

Moreover, the heating degree days analysis was extended across the globe (figure 2.9) to gather appropriate building codes relating to similar climates to the lower central South Island. In doing so a comparison was made between the minimum building regulations from North American and the minimum building regulations in New Zealand. This revealed that our existing minimums are up to 3.4 times (floor value) lower than what is considered barely legal in another country.

Furthermore, in comparison to our Australian neighbours, who face the opposite problem of keeping the heat out rather than in (same principles of heat transfer apply), it becomes apparent that their standards are also significantly higher. In New South Wales the minimum
R-value for a roof is R6.3 and a wall is R3.8. This means that New Zealand is getting by with relatively low building minimums compared to the rest of the world.

A perception study by the Building Research Association of New Zealand (MacGregor and Jaques 2017) found that in the construction industry builders/installers and building officials had the highest perceptions that our current housing quality was ‘Good to Excellent’, whilst architects had the lowest perception in the same category and more frequently rate the housing quality as ‘poor to very poor’ (MacGregor and Jaques 2017). This study also revealed that one of the biggest restrictions in building beyond the minimum was clients not willing to invest (MacGregor and Jaques 2017).

A motivation for this thesis is to design a building beyond the existing building code minimums for thermal performance, to more adequately meet the conditions of one of New Zealand’s coldest climates (zone three). In designing beyond the minimum, building systems that utilize relatively simple or similar construction techniques will be prioritised, as theoretically they hold higher potential in being integrated into the New Zealand construction market, over a system that performs well in an international market.
Figure 2.7: Sample size of NIWA weather files
Figure 2.8:
Heating and cooling degree day analysis
Quantitative Goals

R 3.6  Walls  R 2.0
R 5.46  Roofs  R 3.3
R 4.4  Floor  R 1.3


Figure 2.9: Global heating degree day analysis
This section briefly explores the history of people inhabiting the place with the objective of gaining an understanding of their mark on the landscape and the landscape’s mark on them. This understanding will contribute and inform the phenomenological standpoint this thesis has taken on viewing and designing for the relationship between architecture and landscape.

The small resort town of Queenstown is located at the outlet point of Lake Wakatipu, New Zealand’s third largest lake, which gets its ‘Z’ formation from over 15,000 years of glacier movement. The town, as a humble sheep farm, only ran uninterrupted for two years before gold was discovered in the Shotover River in 1962. The town that quickly appeared, blossomed on the site of the original sheep farmer’s homestead, which still remains as the centre of town. After the gold ran thin the town’s population dwindled to 1000 people which was consistent throughout the first half of the 20th century. In 1981, with a population of 3,500 people, the region began to become recognised for its natural beauty and that year marked the tipping point of a tourism industry that is still growing today. (New Zealand History 2018)

In building a phenomenological understanding of people within the Queenstown Lakes District, it can be seen that the mark people left on the landscape was a short period of mining, a form of extraction. However, the imprint the landscape left on the people was much deeper. The landscape that provided a source of income, begun in simple beginnings of sheep farming. These simple beginnings are strongly linked to the ideology behind the search for a vernacular identity (Gatley and Gus Fisher Gallery 2010). This is reinforced with a quote that was referenced in a literature review by John Scott: “the woolshed acts as a symbol for all New Zealanders ... having grown out of the New Zealand farmer’s needs, it represents our total income ... whether or not we’re involved in farming. It’s important because it was generated here.” (Grover 2005, p.187).
A takeaway to contribute to the design exploration in this thesis is the opportunity to reference these simple beginnings, in not only the country’s history but in the history of this specific region. The reference to farming runs prominently through New Zealand’s current architectural style throughout the country. Yet, the unique, even though brief, gold mining history offers potential inspiration that will allow the design to focus on being specific to climate and environment of this specific part of New Zealand, over contributing a design to the identity of the country as a whole.

Figure 2.10: ‘Sheep in a brown field’ by Branislav Belko
This section investigates the current and future predictions for the Queenstown Lakes District to evaluate the potential risk of continuing to build in our current form to our existing code minimums.

It is well known that the Queenstown Lake District is the tourism capital of the country, with a wide range of attractions and activities available throughout the year. In a published growth scenario by the District Council, the permanent resident population is expected to inflate by an average rate of 2.6%, from 38,000 in 2018 to 74,700 in 2058 (Jones 2017). Moreover, the peak tourism population per day is expected to rise from 77,300 in 2018 to 138,700 in 2058 (Jones 2017). In other words, a town with a current permanent population of 38,000 is expected to build a city that has the ability to hold a maximum capacity of 213,400 people.

In turn, it is therefore not surprising that the company Airbnb has been so successful in flooding the market with short term rental opportunities to the average homeowner. This service has been so popular that the available listings grew 65% from 2016 to 2017 (Infometrics 2017). In proportion to the available commercial accommodation units, which were 10,383 in 2017, Airbnb has created an additional 4,226 units (Infometrics 2017). This means that Airbnb holds 28.9% of the accommodation market without physically owning any property.

The rise in homeowners tapping into the additional income that can be earned from renting out any spare bedrooms or unoccupied holiday homes lead to an increase in the demand for the home and income model in the residential market. The resulting producted has created semi-detached or fully detached guest houses in many of the newly constructed homes. The typology of a guest house, especially if it is detached, weakens the thermal envelope of the building. This is because it commonly creates a more complicated form (if semi-attached) or has a higher ratio of the external envelope to internal volume (if detached). This results in making the building harder to heat and more expensive to run. To address this problem, this thesis will explore ways of reducing thermal stress on the buildings envelope whilst still adding the flexibility of creating a temporary rental in a residential home.
Figure 2.11: Mountains around Moke Lake
The exact site selected for this thesis is Moke Lake, a 15-minute drive from the centre of Queenstown. The site was selected for its elemental qualities, aligned with the New Zealand Dream, including; a body of water, views down a valley, different types of terrain to build on and native vegetation. Additionally, as access was limited to the region during the thesis time frame, the site was also selected due to the author's pre-existing familiarity with the area, which allowed the design to also be built off a personal relationship with the landscape.

Figure 2.12:
Camping

2.7 MOKE LAKE
Figure 2.13: 
Map of the Queenstown Region
This section explores strategies from the local weather file (figure 2.15) to describe the conditions the design will be exposed to and ultimately protecting its inhabitants from. Extending on from the literature review, which identified that there has been a shift in research relating to indoor temperature and ventilation comfort ranges in naturally ventilated buildings, this section specifically analyses the temperature and wind patterns over an annual cycle.

Temperature
The maximum temperature recorded is 30°C and the minimum is -6°C, giving a range of 36°C in a year-long period. Furthermore, when comparing the temperature cycle to the ASHRAE comfort criteria, which states that the lowest temperature acceptable in winter is 20.3 degrees Celsius, only 5 months of the year have ranges that partly cross this line. This means that at least 7 months of the year are considered uncomfortable according to this criteria. However, other research has questioned this criteria, as discussed in the Theoretical Framework review of literature, which suggested that people will acclimatise to given climate if they spend a significant amount of time there (Brager and Baker 2009; Arens et al. 2009; Zhang et al. 2007). This research suggests that permanent residents will likely accept lower temperature as comfortable and only the tourists may feel the cold at temperatures lower than 20.3°C.

Wind
Specifically looking at a map of the site for this thesis, Moke Lake, it can be seen that the wind coming from the east or west will likely be reduced due to the large hills that closely border the valley. However, even though the hills provide a potential benefit of shelter, they also provide a potential threat. In the event that the wind is coming from either the north or south, in line with the path of the valley, the large bordering hills will likely funnel the wind and accelerate it. This means that during a northerly or southerly, any unsheltered outdoor spaces will be uncomfortable.
Figure 2.14: Map of Moke Lake
Passive Strategies
From Climate Consultant

Orientate windows north for solar gain

Use double glazed low-E on windows facing south, east and west.

Use clear double glazing on north facing windows for solar gain

Use heavy weight materials on the interior to provide thermal mass
Snug floorplan with central heat source
Lower nighttime temperature to conserve energy
Use high insulation

Protect outdoor areas from the wind to extend the annual comfort period
Arrange daytime space to make the most of winter sun
Use small skylights to reduce the requirement for lighting

Use low-mass, tightly sealed construction to provide heat build-up in overcast climates

A high effciency fireplace can be the most aforable heat source
Keep floor area low to avoid heating uneccessary space
Avoid trees infront of key windows for solar gain
Steep pitched roof to avoid snow buildup on roof

Basement should be installed below frost line and well insulated

Any form of shading on the windows should be avoided in winter
Extra insulation will help improve occupant comfort

Use a simple floorplan and multiple stories to reduce heat loss from the envelope

56

Heavy drapes or blinds will help reduce heat loss
Locate storage areas on the south to help insulate

Figure 2.15:
Pragmatic climate
strategies


2.0 | Context and Environment

Figure 2.16: Axonometric model of Moke Lake

Figure 2.17: Section through the valley
Figure 2.18: Sun on the hills
Figure 2.19: View from the tent
Figure 2.20: Morning sun
Figure 2.21: Sheep country
Figure 2.22: Sheep
Figure 2.23: Southern Alps
Figure 2.24: Still water in the morning
Figure 2.25:
Bridge over the water
Figure 2.26: Looking towards the valley you enter through
Figure 2.27: Reeds that grow on the edge of the lake
SYSTEMATIC PRECEDENT STUDIES
3.1 OVERVIEW

Four precedent studies were systematically explored in order to inform the application and inspiration of pragmatic and poetic approaches on the design methodology. Unlike standard precedent studies, this chapter draws upon both large samples and individual cases to explore the basic premise of the research: that the conflict between poetic and pragmatic approaches to design might uncover a common or singular design ‘solution’. The logic of the selection was therefore to seek examples of residential architecture that were awarded or claimed to be successful examples of either a high performing or poetically beautiful building.

The first part of this chapter investigates large samples of pragmatic and poetic precedents to gauge key praised features to generate strategies that can be applied to the design methodology.

The pragmatic sample is taken from international sources as many countries overseas are seen to be more advanced due to having a larger economy. The poetic sample is taken from a New Zealand source to isolate the specific qualities of poetic beauty that contribute to the ‘New Zealand Dream’.

The second part looks more closely at the thermal envelope of individual cases to identify strengths and weaknesses. The pragmatic example is taken from within the Queenstown Lakes District to investigate the claim of high performance used to advertise the property. The poetic example is taken from the architect, Peter Zumthor, whose approach to design is driven by a phenomenological approach, which ties into the environmental aesthetics discussion in the Theoretical Framework chapter.
Figure 3.2:
Precedent Studies included in this chapter
### 3.2 Passive House Descriptions

**Purpose**

The purpose was to evaluate a range of existing passive house projects from all over the world to explore the different strategies and systems used. Ultimately, the main goal was to control the influence of these strategies and systems on the design.

**Sample Size & Scope**

56 projects were analysed from 16 different countries with the objective of using a systematic analysis to tackle a larger sample size. This systematic analysis included recording down the project information and any mention of strategies and/or systems that were used to achieve a passive house status. All houses were taken from the book, “Passive Houses” by Chris van Uffelen, to ensure an equal representation of each sample.

**Research Method**

The focus was placed on how each ‘Passive House’ was represented in the book and specifically what sustainable/passive features were mentioned. Specific strategies or systems were given closer attention if they were considered more relevant to the context of this research. This was done by simply cross-checking the heating degree days from the location of the sample against the heating degree days from the Queenstown weather file. All weather files were sourced through the EnergyPlus website. The results were recorded in a spreadsheet to map patterns in the data.
Figure 3.3:
Sample Size of Passive Houses with general project details.
Figure 3.4: Raw data of passive and low energy strategies and systems.
### Figure 3.5:
Raw data of passive and low energy strategies and systems
Figure 3.6:
Insulation, Passive Heating/Cooling, and Solar in relation to the origin
FINDINGS & OBSERVATIONS

This investigation revealed patterns in the strategies and systems used in this sample of passive houses. These patterns are from the full set of data and take into account houses from warm and cool climates, which is useful for this research as the Queenstown climate experiences both cold winters and warm summers. Key observations from this data include:

- Categories that collected a high frequency of results were; High Insulation, Passive Heating, Passive Cooling, and Solar. This suggests that there is a high benefit in designing-in strategies to store heat, whilst also avoiding overheating, as well as, generating on-site electricity.

- There were a number of categories that only had a few mentions. This suggests that these systems could be bespoke or only available in a specific country. In many cases, these mentions came from projects that had many different systems and strategies listed. These projects stood as a reminder to look at the quality and effectiveness more closely, over simply being impressed by the number of different items the client was able to afford.

- Projects located in colder countries included a Geothermal heat-pump as a low energy, more efficient form of heating. This is because regular heat-pumps lose their efficiency when the temperature drops below zero.
### 3.3 Home of the Year Awarded Houses

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To explore the New Zealand Dream through the representation of ‘great architecture’ in architectural media, to understand factors that could be influential on clients and architects.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size &amp; Scope</td>
<td>The last 23 years of Award Winning Houses from New Zealand architectural media were systematically explored. A single source, HOME Magazine, was used as it is specifically marketed towards architects and clients, and is commonly found in local supermarkets. Other sources that advertise a similar home of the year award were ignored due to being targeted at a different audience. For example “Master Builder Home of the Year” is aimed at advertising different building companies and has award criteria focused on the built product over the design.</td>
</tr>
<tr>
<td>Research Method</td>
<td>Prior to the investigation, a spreadsheet was set up to streamline the collection of information. The key categories of information included; general project details, materials used, descriptions of the envelope’s performance, metaphors describing the architecture’s relationship with the landscape, and photographs.</td>
</tr>
</tbody>
</table>
Figure 3.7: Sample Size of Award-winning Houses
Figure 3.8: Sample size organised by location
It is well-known that New Zealand’s population is more heavily distributed in the North Island, 3.75 million people, compared to the South Island, 1.04 million people. However, the distribution seen in figure 3.8 shows a far heavier than expected cluster of awarded houses in the North Island than the South Island. Further, many of the North Island homes are located towards the upper area. As there is a clear difference in the climate and even environment between the two islands, this distribution could suggest a preference for a house within a warmer, more comfortable setting, and the aesthetic that comes with it. This aesthetic commonly includes high amounts of glazing and thin elegant structural elements.
Interior Photographs

Exterior Photographs

Content on this page has been redacted: Please refer to the physical copy

Figure 3.9: 1998
Figure 3.10: 2001
Figure 3.11: 2003
Figure 3.12: 2014

Figure 3.13: 1997
Figure 3.14: 2003
Figure 3.15: 2008
Figure 5.16: 2018
FINDINGS & OBSERVATIONS

In analysing the photographs included in the articles on each award-winning home, a pattern began to emerge that reflected the literature findings from Lisa Heschong’s book, “Thermal Delight in Architecture”. Specifically, the chapter on “Delight” which speaks to thermal sensation and how humans are attracted to thermal extremes, i.e. cold exteriors and warm interiors (Heschong 1979). This theory can clearly be seen in the way each home has been photographed from both the interior and exterior.

This pattern is interesting because even though the practical thermal performance was rarely mentioned in an article, the desire to feel warm is still strongly expressed in the photography. The repetition of this thermal expression shows that there is value in creating an aesthetic around the idea of feeling warm.
Content on this page has been redacted: Please refer to the physical copy.

Figure 3.17: 2001
Figure 3.18: 2003
Figure 3.19: 2005
Figure 3.20: 2009
Figure 3.21: 1996
Figure 3.22: 1998
Figure 3.23: 2018
The ideal New Zealand home is well connected to the concept of an outdoor 'holiday'. Likely because our seasons aline with western holidays but in an opposite formation. Unlike the northern hemisphere, where they have Christmas and family time corresponding to the winter and being cold, New Zealand has this time of year during the summer. Therefore, the holiday that celebrates family, and the home as the place of the family, is linked to summer and the outdoors. As a result, many residential clients/ house designs are credited for their connection between the indoor and outdoor conditions.

Further, these photographs capture the relationship between the building and its environment and show that the influence of context, including weather and climate, plays a strong role. This pattern resembles the argument by Jonathan Hill in his book, “Weather Architecture”, where he states that weather can be seen as an author of architecture. Therefore, as many of the award-winning homes are from warmer parts of the country, it comes as no surprise that the buildings are heavily glazed, dissolving the boundary between inside and out to bring the occupant closer to the warm weather.
3.4 High-Performance Airbnb House

| Purpose | To explore the claim of ‘high performance’ made by a residential property that is built to also function as a short term rental. |
| Sample Size & Scope | A single case study was explored to allow a more detailed exploration to be conducted. The house was found through the popular Airbnb site. It was advertised as having a higher than minimum performance but without reference to any accreditation system. To investigate the building’s performance, building consent documentation and H1 compliance calculations were obtained through the district council. The focus was on the envelope and the structural systems that makeup or penetrate the building’s thermal envelope. |
| Research Method | Instead of recording the insulation product that this building used to increase its performance, elements of the building were explored that could weaken the performance of the building. This includes:  
- assumptions made in the H1 calculations  
- linear thermal bridges in the thermal envelope  
- point thermal bridges in the thermal envelope |
Figure 3.24:  
Floorplan of AirBnB Case  
Study House
(For a more detail refer to  
the physical copy)
Figure 3.25: Section A-A with Thermal Analysis Overlay
(For a more detail refer to the physical copy)

Figure 3.26: Section B-B with Thermal Analysis Overlay
(For a more detail refer to the physical copy)
In the envelope calculations, the building was listed as being primarily constructed out of timber. This meant that the repetitive thermal bridging from the timber was accounted for in the calculations. However, the building also included steel portals to accommodate the larger spans required from the design. These steel portals were considered negligible in the calculations, as NZS 4214 & 4218 do not require linear or point thermal bridges to be accounted for in the performance of the whole building. This means that the linear thermal bridges of steel and all junctions went unaccounted for. Further, as steel is a highly conductive material, not calculating its performance places this building at risk of condensation occurring on a cold internal surface.
## 3.5 Mining Museum

<table>
<thead>
<tr>
<th><strong>Purpose</strong></th>
<th>To explore the motivations behind a poetic design precedent to inform the design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample Size &amp; Scope</strong></td>
<td>The Mining Museum project by Peter Zumthor is a cluster of several small buildings within a steep landscape. This project was chosen because of its similar mining background to the Queenstown region.</td>
</tr>
<tr>
<td><strong>Research Method</strong></td>
<td>Explore information on the project and interviews with the architect to further understand how the history of the people and landscape has been applied to the design of a building.</td>
</tr>
</tbody>
</table>
Figure 3.27:
Mining Museum by Peter Zumthor

Figure 3.28:
Mining Museum by Peter Zumthor
Content on this page has been redacted: Please refer to the physical copy

Figure 3.29:
Plans and Sections of the Mining Museum buildings
Inspired by the philosophy of Martin Heidegger, Zumthor’s work embodies phenomenological principles through privileging the experiential qualities of all of his buildings. As an overarching purpose, he states “I try with my buildings to stimulate, to provoke a feeling for the place” (Zumthor 2016). In his description of the mining museum, he personifies the buildings, speaking as if the architecture made the choice, “The buildings try to be simple. They try to be very straightforward in their construction” (Zumthor 2016).

The unique intention of the Mining Museum buildings, is the coming together of two worlds, one belonging to the miners and the other to the contemporary people. The miners’ world is created through “scaffolding, which speaks of simple industrial architecture, which has to do with a simple construction that the miner needed to do” (Zumthor 2016). The box begins to reference both worlds, with contemporary program and fittings within a dark interior that resembles the dimly lit tunnels the miners worked in.
Evidence from pragmatic and poetic precedent investigations revealed a common motivation to increase the warmth within a house. Although both were executed differently and in reflecting on the findings from the Theoretical Framework chapter, have different possible issues;

1) Pragmatically executed through increased insulation in the building’s thermal envelope to increase the temperature indoors (measured as a quantitative value). An issue of this approach could be by only achieving a ‘neutral’ indoor state that prevents the occupant from feeling physically uncomfortable.

2) Poetically executed through warm-toned materials and yellow-toned artificial lighting to increase the psychological perception of warmth (measured as a qualitative value). Triggering the perception of warm resembles the strategy of achieving thermal delight through the thermal qualities of space. However, these qualities are purely visual qualities of an aesthetic appearance and could fall short of creating an aesthetic experience if the interior didn’t engage a physiological response, as per the theory of thermal alliesthesia.
3.6.2 PART TWO

The issues with the pragmatic precedent were caused by the creation of large interior spaces that exceeding the span capabilities of the structure, which resulted in the inclusion of steel portals that ultimately weakened the performance of the thermal envelope. A solution to this pragmatic problem was unintentionally found in the poetic precedent, where an external structure was used to reference the mining history of the area. Whilst the reference has parallels with the mining history in the Queenstown Lakes District, the inclusion of an external structure could solve the spanning issues in the pragmatic precedent by removing the load bearing requirements from the walls. Even though the poetic precedent did not do this, it could be achieved, without compromising the aesthetic, by running additional support beams through the floors to take the gravitational load.
Cabin Series
The following chapter tests the energy simulation method within a Building Information Model (BIM) to Building Energy Model (BEM) workflow to identify strengths and weaknesses that contribute to the findings of the research. As ArchiCAD, and other similar software packages, were developed in other countries, attention was placed on the accuracy and appropriateness of semi-automated assignment and calculation of essential inputs. To streamline the process, a small 10m² cabin was used to focus the analysis on the building’s envelope.

Test 01 analysed the performance of thermal resistance values (R-values) of the New Zealand Building Code minimums and initial improvement options. Test 02 investigated further into the automated assignment of weather data based on the location input. Test 03 explored preliminary aesthetic responses to test the thermal consequences of different aesthetic decisions.
01 THERMAL CONSEQUENCES OF CONSTRUCTION

02 THERMAL IMPACT OF CLIMATE

03 THERMAL CONSEQUENCES OF AESTHETICS

Figure 4.2: Chapter Structure
### 4.1 THERMAL CONSEQUENCES OF CONSTRUCTION

**CABIN TEST 01**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>R-Values of different building elements.</td>
</tr>
<tr>
<td></td>
<td>Roof</td>
</tr>
<tr>
<td></td>
<td>Wall</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
</tr>
<tr>
<td>Constants</td>
<td>Wall area</td>
</tr>
<tr>
<td></td>
<td>Window area and thermal resistance (R-value)</td>
</tr>
<tr>
<td></td>
<td>Floor area</td>
</tr>
<tr>
<td></td>
<td>Roof area and angle</td>
</tr>
<tr>
<td></td>
<td>Orientation of the building</td>
</tr>
<tr>
<td></td>
<td>Surrounding vegetation for shading</td>
</tr>
<tr>
<td></td>
<td>Weather file/Project location</td>
</tr>
<tr>
<td>Output</td>
<td>Annual Cooling Energy</td>
</tr>
<tr>
<td></td>
<td>Annual Heating Energy</td>
</tr>
<tr>
<td>Sample Size</td>
<td>Construction systems available in New Zealand.</td>
</tr>
<tr>
<td></td>
<td>Beginning with the most commonly used, NZS 3604 and popular upgrades</td>
</tr>
</tbody>
</table>

**Purpose:** To conduct a preliminary test into the performance of building code minimums and initial improvement systems. As well as, examine the accuracy of the built-in R-value calculator.
Figure 4.3: Cabin floor plan
A fixed design for a cabin was used to control simulation inputs that would affect the results. By controlling specific simulation inputs and making them constants, the input of thermal resistance (R-value) was isolated and applied to each building element (walls, floor, and roof). This input is the primary variable in these simulations and the results that are produced are looked at to examine the comparative performance of the different systems selected.
01 Code Minimum  
- Non Solid Construction

02 Code Minimum  
- Solid Construction

03 Code Minimum  
- High Thermal Mass

04 Typical Upgrade  
- 3604 Construction

05 Battens on the Inside  
- 3604 Construction

06 Battens on the Outside  
- 3604 Construction

07 Lockwood  
- Solid Construction

08 Formance  
- Structurally Insulated Panel

09 NZSips  
- Structurally Insulated Panel

Figure 4.5: Graph of wall, floor and roof construction R-values
Figure 4.6:
Wall framing layout of 3604 construction system
Figure 4.7:
Site plan
ANNUAL COOLING ENERGY

KEY

- 01 Code Minimum - Non-solid
- 02 Code Minimum - Solid
- 03 Code Minimum - High Thermal Mass
- 04 Typical Upgrade - 3604
- 05 Battens on the Inside
- 06 Battens on the Outside
- 07 Lockwood
- 08 Formance
- 09 NZSips

Figure 4.8: Annual cooling energy
Figure 4.9: Annual heating energy
In figure 4.9 the three construction systems requiring the most heating during the winter all had higher thermal mass and lower R-values. As a passive heating strategy, this should result in lower amounts of heating due to the higher amount of mass storing heat and slowly releasing it. The results suggest that the given design is not allowing for enough solar exposure to heat up the thermal mass, meaning that it remains at a cooler, uncomfortable temperature. The cooling energy results reinforce this finding, as the same three construction systems perform far better, indicating that the solar mass is in enough shade to keep it cool.

All of the non-solid construction systems with lower thermal mass and higher insulation required less heating during the winter (figure 4.9). Improvements in insulation were reflected in the results and due to the same thermal mass input, they all followed the same pattern.

An interesting observation in assigning values for solid and non-solid construction was the limitation of only being able to assign one material per construction layer within the built-in R-value calculator. To investigate in more detail, a conference paper was written alongside the research and published by PLEA in December 2018. The findings from this paper identified that the built-in R-value calculators in ArchiCAD and Revit were inaccurate when calculating the thermal resistance value, R-value, of any building component that was built using New Zealand’s traditional timber-framed construction system. The calculator was inaccurate because it was built on a homogenous calculation method, meaning that only a single material could be accounted for per layer. However, much of New Zealand’s residential construction is built with insulation and timber within the same layer, making it a heterogeneous system that requires an iso-thermal planes calculation method, as identified in NZS 4214. The conference paper further identified that a seed file could be created to account for this, or the override function should be used for externally calculated R-values.

To account for non-solid construction systems, R-values were externally calculated, as per NZS 4214, and manually input using the override function in the tool. This method was applied throughout the research.
# 4.2

## THERMAL IMPACT OF CLIMATE

**CABIN TEST 02**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>Location/City simulation input - Weather file assigned from ArchiCAD through selecting a city.</td>
</tr>
<tr>
<td>Constants</td>
<td>All building geometry Simulation inputs Building systems (Same building from Test 01)</td>
</tr>
<tr>
<td>Output</td>
<td>Annual Energy Use Annual heating energy Annual cooling energy</td>
</tr>
<tr>
<td>Sample Size</td>
<td>Weather files assigned from the ARCHICAD city input. Sample size is larger than the previous weather file sample size looking at heating degree days to gauge distribution across climate zones. The increase in size aims to explore how reasonably the software generates results across the country and the effect of climate on performance</td>
</tr>
</tbody>
</table>

Purpose: To examine the effect of climate on performance and to validate the accuracy of the automatically assigned weather data file.
Figure 4.10: Sample size of locations, climate zones, and the automated sources used to assign weather files
Figure 4.11: Impact of different climates and weather file sources.
4.2.1 CRITICAL REFLECTIONS

Compared to the first analysis of the effect of climate in the Context and Environment chapter, the results across the three different climate zones reflect a similar distribution in annual heating energy. However, half of the annual cooling energy didn’t calculate an expected result relative to its climate zone. For example, a simulation in climate zone 1 is expected to have a higher cooling load than simulation in climate zone 3. Upon closer examination, it was found that the software was automatically assigning weather data from two different sources (NIWA and Strusoft Server) based on the manual location input from the provided city list.

Weather data sourced from NIWA, National Institute of Water and Atmospheric Research was explored in the Context and Environment chapter in a heating degree days analysis and the introduction of a second data source was unanticipated. Going into this investigation it was expected that the additional locations offered in ArchiCAD would be matched with the closest weather file produced by NIWA. However, in collecting the sample size, over half of the locations were being assigned weather data from the Strusoft Server, which is a service sold by a company based in Sweden and Denmark.

In looking closer at the heating energy, the results from the Strusoft Server whether files are consistently higher across all climate zones. This suggests that the weather data may be attempting to compensate for not being capable to measure cooling energy, by overestimating the heating energy to get a similar total annual energy. However, because a deeper analysis into the data within the weather file would be required to make more definitive conclusions, it is observed that there is a significant inconsistency in ArchiCAD’s automated approach to selecting weather files.

As the Queenstown weather file is sourced from NIWA, a local government funded institution, it is considered reliable. It is noted that any further climate comparative simulations in this research are run with NIWA weather files only.
# Thermal Consequences of Aesthetics

CABIN TEST 03

## Type

<table>
<thead>
<tr>
<th>Description</th>
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<tr>
<td><strong>Variables</strong></td>
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<tr>
<td><strong>Constants</strong></td>
</tr>
<tr>
<td><strong>Output</strong></td>
</tr>
<tr>
<td><strong>Sample Size</strong></td>
</tr>
</tbody>
</table>

Purpose: To investigate a range of different aesthetics that explore different extremes in design decisions.
Figure 4.12: Overview of tested cabins
This concept explores a typical aesthetic commonly applied to houses that build with a traditional NZS 3604 structure.
This concept explores the metaphor of creating a ‘bunker’, to shelter its inhibitors from the weather.
This concept explores the software’s ability with simulating a morphed roof. Unfortunately, as shown in the thermal block illustration, the roof could not be translated for simulation.
This concept explores the software ability with simulating a complicated roof. Unfortunately, as shown in the thermal block illustration, the roof could not be translated for simulation.
This concept explores the impact of walls completely made of glass on the energy requirements for heating and cooling.
This concept explores how a typical NZS 3604 timber structure could be altered to become something that is expressed rather than hidden.
This concept explores the impact of ‘green washing’, by focusing the aesthetic on design features that made the building look sustainable.
This concept explores the metaphor of ‘floating’ by creating an elevated structure with a line of windows to make the roof look like it's floating above the walls.
4.3.1 INITIAL RESULTS

The initial energy profiles represent the reference model, as per Modelling Method requirements in NZS 4218, as they are all run with code minimum values for all thermal envelope inputs. At a glance, the results show what any architect should expect, that increasing the glazing percentage will decrease the performance and cause negative effects on the heating and cooling consumption. This is reinforced by simulations 05 and 06, which demonstrate the extremes of this design decision, through high cooling loads in the summer and high heating in the winter. Simulation 06 is the highest as it extends the level of transparency to the roof.

On another note, simulations 03 and 04 appear to have reasonably comparable heating energy results considering there were issues in generating a full thermal block due to complex roof geometries. This suggests that an architect could still generate a series of comparable results without having to thoroughly error check the generation of an energy model.

[Note: In the context of this research, the error of incomplete thermal block or energy model generation is accepted due to the preliminary nature of the investigation. For a final simulation if the generation of an element is not possible, simplification of the element will be made]
ANNUAL ENERGY PROFILES

Figure 4.45: (Opposite Page)
Explanation diagram to aid in reading energy profiles

Figure 4.46: (Above)
Energy profiles of cabins in test 03
4.3.2 EVALUATION

This evaluation expands and categories the criteria for measuring the thermal consequences due to aesthetics to further explore, beyond just the energy results. The criteria are created to reflect positive aspects so that the consequences can be measured in absence. From the total score, the top three were re-simulated with more accurate thermal envelope inputs, relative to the aesthetic.

Figure 4.47: Evaluation Matrix
Figure 4.48: Energy profiles of cabins in test 03
4.3.3 CRITICAL REFLECTIONS

To the left, the ‘Proposed Building’, as per Modelling Method requirements in NZS 4218, is modelled with closer values to the materials likely used in the construction of the building, determined by its aesthetic.

Simulation 02 was modelled with concrete walls with the R-value and thermal mass assumption input into the tools override function. The results reflect the same pattern found in ‘TEST 01’, where higher mass materials perform poorly in winter due to less sun exposure.

Simulation 06 was modelled with 50mm thick polycarbonate walls and roof, R3. This material doesn’t let in as much light as glazing due to being slightly opaque. However, as it has an R-value 10 times higher than minimum glazing requirement, the solar gains received are trapped far more effectively, causing it to overheat further.

Simulation 07 was difficult to assign values for the walls and roof as there is a significant amount of scientific debate around how to accurately account for the fluctuating water content in the soil from watering and rain. The data for this was gained from a study that measured the performance of four different soil types (Kotsiris et al. 2011).

The takeaway knowledge from this investigation includes;

- Increased amounts of glazing have a severe impact on the performance of the buildings envelope due to the extreme flux in climate conditions over a year period.

- Accounting for systems that advertise themselves as ‘green’ or ‘sustainable’, such as green walls/roofs, will likely require a significant amount of additional insulation to ensure that the envelope meets code.
Figure 4.49: Illustration of the difference between a homogeneous and heterogeneous wall.
4.4
SUMMARY OF KEY OBSERVATIONS

1. In Queenstown, it is important to ensure that any high thermal mass construction elements have sufficient sun exposure to be effective.

2. Due to the built-in R-value calculator within ArchiCAD only being able to account for a single material per-layer and timber framed construction having both timber and insulation on the same layer (figure 4.49), R-values should be externally calculated and input using the override function.

3. Even though the automatic assignment of simulation inputs is attractive due to the ability to save time, one should always be careful with any semi-automatic software, especially products developed overseas. In this case, the assignment of weather files should be double checked for any further examination of the effect of climate on performance.

4. Design decisions have a large impact on energy performance due to altering ratios of building elements, i.e. glazing area. As this is efficiently measured once the simulations inputs are set up full-scale design concepts should have regular simulations completed.
CONCEPT DESIGN
5.0.1 DEVELOPMENT DIRECTION

As the placement of a building within a site significantly impacts both pragmatic and poetic design decisions, this chapter begins with a massing exploration to test different building volumes within samples of the landscape.

The following section is based on the observations from the systematic precedent analysis of award-winning homes in New Zealand. Qualities associated with these building envelopes from the ‘New Zealand Dream’ will be applied to the first set of concept designs. The purpose is to measure the effect of climate to determine how appropriate these aesthetic ambitions are in the Queenstown Lakes District.

The second set of concept designs responds to the issue of thermal bridging occurring due to the inclusion of steel portals placed to support large voids, such as open plan kitchen, living, and dining. The critical reflections from part two of the Systematic Precedent Study suggested that this issue could be resolved by removing the structural requirements from the thermal envelope. The aesthetic style of Zumthor’s mining museum, chosen for its parallels with Queenstown’s own mining history, is explored through iterative concept designs to test the application of an interior programme within a strictly regular grid.
5.0 | Concept Design

Figure 5.2: Chapter Structure

MASSING STUDY

PRECEDENT STUDY PART 1
1 - THE LOOKOUT
2 - FLOATING ON AIR
3 - SITTING QUIETLY
4 - BUNKER DOWN

CRITICAL REFLECTION

PRECEDENT STUDY PART 2
5 - THE LOOKOUT
6 - FLOATING ON AIR
7 - SITTING QUIETLY
8 - BUNKER DOWN

CRITICAL REFLECTION

MODEL MAKING
This section explores the relationship between architecture and landscape, through systematically applying a building volume to three different terrain samples taken from the Moke Lake site. Each site has a different vegetation arrangement that includes a mix of low and high plants so that it is quick to gauge what part of the environment the architecture is likely to respond to.
Figure 5.4:
Three sample landscapes from site
Figure 5.5: Massing investigations
Figure 5.6:
Massing investigations
Two sets of concept designs are generated based on the inspiration from architectural media and a key design precedent. In each concept the spatial design principles will be documented over the top of the floorplan and the specific influence will be briefly described. Floor plans and a section, showing the thermal building envelope highlight any ‘at risk’ areas for having point or linear thermal bridges. These types of thermal bridging have been selected as they are commonly assumed negligible by architects and designers who are following the guidelines in the standard NZS 4214.
Figure 5.7: ‘Queenstown Mountains’ by Phil Botha
Figure 5.8: Floor plan
5.2.1 THE LOOKOUT

Designed as a lookout, this concept was inspired by Home of the Year Finalist “Happy Camping”, in Hanmer Springs. The inspiration of form was paired with the idea of organising the layout based on the inversely proportional relationship between metabolic rate and room temperature. In other words, as heat rises, rooms where occupants are likely to have low metabolic rates (sleeping) are placed higher, and rooms that require more movement (cooking) are placed lower. A study of New Zealand homes showed that the average bedroom temperature is during the night is 13.6°C (French 2006). This is below the minimum recommended temperature range of 16 - 18°C (Thomas 2018). By placing the bedroom above the living and kitchen it, in theory, will benefit from the heating of the spaces below.

Figure 5.9: The Lookout digital model
Figure 5.10: Floor plan - Thermal Bridge Identification

Figure 5.11: (right) Section - Thermal Bridge Identification
THERMAL ENVELOPE EVALUATION

A key weakness of the floorplan arrangement is the stairwell being placed on the exterior. This weakens the thermal envelope because the construction of stairs require additional blocking to fix the treads and risers to the wall. In this concept the stair is only supported by its connection to the wall, which means that a large amount of additional structure would be require to achieve this. In turn this creates a series of point thermal bridges throughout the envelope at the connection between the stair and wall.
Figure 5.12: Floor plan
5.2.2 FLOATING ON AIR

The concept, Floating on Air, was inspired by the 2016 winning Home of the Year, “K Valley” in the Coromandel. Inspiration was taken from the idea of combining two spatial design qualities; light and dark, and applied to achieve a similar ‘floating’ effect. The purpose was to investigate what type of thermal impact this influence could have on a building built in Queenstown, with a climate dramatically different to the Coromandel.

Figure 5.13:
Floating on Air digital model
Figure 5.14:
Floor plan - Thermal Bridge Identification

Figure 5.14:   
Floor plan - Thermal Bridge 
Identification

Linear Thermal 
Bridge  
Point Thermal  
Bridge ‘at risk’  
areas
THERMAL ENVELOPE EVALUATION

Aside from being significantly compromised by a large amount of glazing on the lower level, the thermal envelope is also weakened by the large number of internal to external wall intersections in the upper level. Furthermore, the envelope is also weakened by the issue of placing a staircase on an external wall.

Figure 5.15: Section - Thermal Bridge Identification
Figure 5.16: Floor plan

Private: Night time

Occupancy Proposal

Shared: Daytime

Fire
5.2.3 SITTING QUIETLY

The concept, Sitting Quietly, was inspired by “Castle Rock House”, another by the multi-award winning architectural firm, Herbst Architects. The inspiration was drawn from the aesthetic of the exterior and how the building was placed within its landscape. This inspiration was paired with a program organisational concept of creating two thermal envelopes by separating daytime and nighttime occupancies.

Figure 5.17: Sitting Quietly digital model
Figure 5.18: Floor plan - Thermal Bridge Identification
THERMAL ENVELOPE EVALUATION

By creating two separate envelopes the ratio between floor area and envelope is increased, making the two volumes more vulnerable to thermal bridging. In this concept, linear thermal bridges have been created very close together due to creating lines of sight from entry points to the view of the landscape.

Figure 5.19:  
Section - Thermal Bridge  
Identification
Figure 5.20: Floor plan
5.2.4 BUNKER DOWN

The concept, Bunker Down, was inspired by the 2018 Home of the Year Finalist, “Square One”. Like the previous concept the approach was to draw influence from the building’s exterior aesthetic and its placement within its environmental context. The organisation of the program also applies the same approach, where two envelopes are created to separate day and night, this time in the context of a single bedroom home.

Figure 5.21: Bunker Down digital model
Figure 5.22:
Floor plan - Thermal Bridge Identification
THERMAL ENVELOPE EVALUATION

Similar to the previous concept, this design is made more vulnerable by creating two envelopes. Furthermore, the placement of plumbing fixtures on exterior walls means that additional framing structure would need to be added to accommodate additional piping and fixtures. This means that a significant amount of point thermal bridges have been added to the envelope.

Figure 5.23: Section - Thermal Bridge Identification
Figure 5.24:
Summary floor plans of the first set of concept
5.2.5 CRITICAL REFLECTIONS

SPATIAL QUALITIES

Creating light spaces, that are open to the landscape are beneficial to the relationship between architecture and environment, as they make the inhabitants feel like they are connected to the outdoors, whilst still maintaining control of the indoor environment. However, it comes as no surprise that, in such a cold climate, it becomes very expensive to heat the space during winter and to stop it from overheating during summer.

Ultimately a lesson learnt here was to be careful applying influence from projects that have different climates. This can be difficult in New Zealand, a country that continues to search for its own architectural identity. These concept explorations suggest that there shouldn’t be a single answer to the question of identity as a single aesthetic can be difficult to apply across significantly different climates.

THERMAL ENVELOPE

Creating two thermal envelopes within one building has the appeal of only having to heat one space at a time. However, when the occupancy increases to the point where two or more bedrooms are required, this idealistic theory becomes flawed, as both envelopes are likely to be occupied at the same time. This results in a building that will be more expensive to run compared to if it was a single envelope.

Furthermore, patterns started to emerge in floor plan and section evaluation that resulted in an increase in point and linear thermal bridges. These include:
- Internal to external wall intersections, mainly present in bedroom layouts that include built-in wardrobes.
- Window placement that is close to other intersections will likely result in the wall in between becoming close to completely solid timber, increasing the impact of the thermal bridge.
Figure 5.25: Floor plan

Dark & Sheltered
The concept, Mining History, was inspired by the well-known mining museum by Peter Zumthor. Investigated in the Systematic Precedent Studies chapter, the museum was chosen for its potential to use the poetic relationship the aesthetic has with the mining history of the region to remove the pragmatic load-bearing requirements from the buildings thermal envelope.

Figure 5.26:
Mining History digital model
Figure 5.27:  
Floor plan - Thermal  
Bridge Identification
THERMAL ENVELOPE EVALUATION

By creating a simple box form, the geometry of the building creates very few linear thermal bridges, only those in the four essential corners. However, due to the long thin nature of the building, the staircase again finds itself along an external wall, increasing point thermal bridges in their connection.
Figure 5.29: Floor plan
5.2.7 THE ENTERTAINER

Continuing the influence from Zumthor’s Mining Museum, this concept explores shifting two separate volumes to create elevated outdoor space. Additionally, the ends of the building have been twisted to make the building appear to be stretching out, looking over the landscape. However, this design decision created issues with the proportion of the building and awkward floor plan arrangement.

Figure 5.30: The Entertainer digital model
Figure 5.31:  
Floor plan - Thermal Bridge Identification

Figure 5.32: (right)  
Section - Thermal Bridge Identification
THERMAL ENVELOPE EVALUATION

By creating a shift in the building’s geometry, the area of the building envelope significantly increased. In other words, this design decision will make it harder for the building to stay warm. Furthermore, the placement of long thin windows, doors and built in wardrobes has increased the frequency of linear thermal bridges.
Figure 5.33: Floor plan
5.2.8
FLIGHT

The concept, Flight, begins by correcting the proportional issues of the previous. It continues by exploring a different roof shape and to create a lifting effect around the upper outdoor area, providing the perception of luxury through additional perceived volume over area. This concept also begins to create a rhythm around irregular placement of windows within an orthogonal external structure.

Figure 5.34: Flight digital model
Figure 5.35: 
Floor plan - Thermal 
Bridge Identification

Figure 5.36: (right)  
Section - Thermal Bridge 
Identification
THERMAL ENVELOPE EVALUATION

Similar to the previous concept, this design is made more vulnerable by the visual shift between two box-like volumes. Furthermore, the same issues from floor plan and window composition have caused clustered of linear thermal bridges.
Figure 5.37: Floor plan
The concept, Alpine House, pushes the idea of expressing an external structure by combining it with the traditional European form of an ‘alpine house’ to suit its location within the Southern Alps of New Zealand. The spatial qualities of combining light and dark, explored in an earlier concept, are also applied through the use of a polycarbonate envelope in the upper story.

Figure 5.38: Alpine House digital model
Figure 5.39: Floor plan - Thermal Bridge Identification

Figure 5.40: (right) Section - Thermal Bridge Identification
THERMAL ENVELOPE EVALUATION

Through creating an A-frame external structure, there are less connection points to the thermal envelope. However, few connection points could result in the requirement for larger metal fixings that would create a significant point thermal bridge. Moreover, although visually attractive, having a second level completely enclosed by polycarbonate and glass creates issues for the thermal envelope. An increase in solar gain results in an increase in cooling requirements.
Figure 5.41:
Summary floor plans of second set of the concept designs
CRITICAL REFLECTIONS

RELATIONSHIP BETWEEN ARCHITECTURE AND LANDSCAPE

Through expressing the primary structure in the form of a post a beam structure, the aesthetic of the building shifted away from the aesthetic commonly awarded in Home of Year houses that are frequently located in the upper parts of the North Island. Proportionally, the long thin timber members fit in well within a site that is surrounded by trees. The height of the building also allows it to sit above the hill, without have to excavate heavily into it.

Furthermore, the addition of a second roof, provides the overall building composition with a strong horizontal line before meeting the sky. Phrased in phenomenological terms, the building stands with strength, like the mountain guarding the lake. A potential weakness in developing this concept further, is the restrictions around organizing the program around a strict grid.

THERMAL ENVELOPE

By removing the load bearing requirements from within the wall elements, the amount of timber required will be reduced. This means that there will be more room for insulation. There are risks that the connection between the thermal envelope and the primary structure could become a thermal bridge, but there are many strategies that can be used to reduce its impact.

Moreover, in comparing the evaluation of the second set of concept designs to the first, the issue of the interior walls connecting with the exterior, and the use of tall thin windows, continues to cause clusters of linear thermal bridges. As this would be difficult to avoid through design, further investigation will explore how to minimize its impact on the thermal envelope.
“Buildings can have a beautiful silence”

Peter Zumthor

Figure 5.42: Collection of concept physical models
5.3 MODEL MAKING

Physical model exploration into five selection concepts to further investigate the relationship between architecture and landscape. Built at 1:200

Figure 5.43: Top view of physical models
Figure 5.44:  
'The Lookout' concept  
physical model

Figure 5.45:  
'The Lookout' concept  
physical model
Figure 5.46: ‘Floating on Air’ concept physical model
Figure 5.47: ‘Floating on Air’ concept physical model

Figure 5.48: ‘Floating on Air’ concept physical model
Figure 5.49: ‘Mining History’ concept physical model
Figure 5.50: ‘Flight’ concept physical model

Figure 5.52: ‘Flight’ concept physical model
Figure 5.51: ‘Flight’ concept physical model
Figure 5.53: 'Alpine House' concept physical model

Figure 5.54: 'Alpine House' concept physical model
Figure 5.55: ‘Alpine House’ concept physical model
DEVELOPED DESIGN
Quantitative and qualitative evidence suggested that the use of an external post and beam structure was the most successful solution to creating a house with a higher performing envelope and responsive relationship with the landscape. Benefits included reducing the requirement for additional timber in the wall elements by removing the load bearing requirements, and creating a regular and repeating pattern on the facade to act as a form of a measurement tool against the landscape. The addition of a small gap between the post and beam structure and the building’s envelope also reduced the risk of water penetrating the envelope through a vertical join. The external nature of the structure suggests the potential to add further passive and poetic features to the building’s envelope, as they won’t be cantilevered off the envelope, therefore removing the risk of large metal fixings creating thermal bridges.

Figure 6.2:
Sketch of the developed design
Prior to the developed design phase of the research, there were significant concerns around the placement of a building within a cube formation structure, the integration of the building's relationship with its environment to inform the program and interior of the house, and the integration of more passive design features. The concerns stemmed from the concept designs that tested the application of a residential programme fitting within cube structures and regular and repetitive structures, which resulted in awkward circulation or dead space. Further issues occurred with overheating or over-shaded spaces that caused a higher energy consumption due to the envelope not taking full advantage of the sun. These issues are identified as weaknesses of the previous phase and are considered opportunities for the developed design to improve upon.

Further, the key aims of the developed design include:

- Refine the form of the external structure to optimally fit the functions of a residential floor plan.
- Create interior spaces within the building that reflect experiences within the landscape.
- Integrate passive design features with the poetic aspirations of the research, to control the sun and enhance ventilation.
- Achieve lower heating and cooling energy requirements.
- Improve the performance of the building’s thermal envelope.
- Test the performance of linear thermal bridges.

Figure 6.3: Sketch of the developed design
6.0.3 REVIEW OF CRITERIA & STRATEGY

Figure 6.4 illustrates the refinement process of the criteria and strategies gathered from the Theoretical Framework and Systematic Precedent Study chapters. The hierarchy is organised by approach, followed by criteria, and the respective strategies, to provide an overview.
In response to the critical reflections from the *Cabin Series* and *Concept Design* chapters, specific strategies have been eliminated that no longer apply to the design, and priority has been given to more important strategies, shown through a larger black dots. These refined criteria and strategies will be used to evaluate and critically reflect on the developed design.
To quantify the potential benefit of an external post and beam structure, an analysis of the timber framing within the envelope was undertaken. Two concept designs, The Lookout and Flight, were used to understand how much structure would be required in a building built to NZS 3604 with and without load-bearing walls. The idea for the analysis of framing emerged out of previous research which identified that additional, unaccounted for framing, added to the built product, significantly impacted the thermal resistance (R-value) of wall elements over any other building component (Bakshi, Gjerde, and Donn 2019).

Figure 6.5: Framing model of ‘The Lookout’ concept

Figure 6.6: Framing model of ‘Flight’ concept
The Lookout is constructed with the traditional timber framing solution most commonly used in New Zealand. Gravitational loads are transferred through load-bearing walls and lateral support is provided through braced sections of the building, usually completed with more frequent fixing requirements of a plasterboard product. As an integrated solution, all of the structural elements are concealed behind interior and exterior finishes. To support the gravitational load of the building, framing is placed closer together to increase the strength. Further, to accommodate a window or door in the envelope, additional framing is added either side. The additional framing is considered a weakness as it reduces the area that can be filled with insulation.
The concept design, Flight, is constructed with all load-bearing requirements of the structure removed. Gravitational loads are transferred from each element to the primary post and beam structure, which is also designed to absorb all lateral loads from high winds or earthquakes. As a two-part system, all of the primary structural elements are expressed externally, which enables the building envelope to be constructed with less timber. The reduced requirements of the framed elements, particularly the walls, means that there is more room for insulation in the thermal envelope.

Figure 6.8: Framing elevations of thermal envelope
Figure 6.9:
Framing physical models of the two concepts built at 1:100
The process of quantifying the amount of timber required to frame wall elements lead to the positive outcome of increased insulation. The amount of framing was reduced by 6.9% on average and created a noticeable difference in the ‘solid’ or ‘clear’ parts of the wall. However, using an external structure to remove the load-bearing requirement for the walls did not solve the issue of linear thermal bridges caused by junctions between building elements, as the framing and insulation remain on the same layer. A key concern would be the likelihood of these linear thermal bridges having a greater difference in thermal resistance compared to the rest of the wall, which now has the capacity to hold more insulation. Additionally, if any finishing products require large metal fixings there is a risk of creating a significant point-thermal bridge because the thermal envelope only consists of a single layer.

<table>
<thead>
<tr>
<th></th>
<th>The Lookout</th>
<th>Flight</th>
</tr>
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<tbody>
<tr>
<td>Average Timber Area</td>
<td>31.4%</td>
<td>24.5%</td>
</tr>
<tr>
<td>Average Insulation Area</td>
<td>68.6%</td>
<td>75.5%</td>
</tr>
<tr>
<td>Risk of Linear Thermal Bridging</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Risk of Point Thermal Bridging</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
6.1.4 WALL FRAMING INVESTIGATION

In the Cabin Series investigation, early tests were made into two alternative framing systems that would still allow for the wall to be load-bearing. As an external structure was introduced in the concept phases the Thermal Consequences of Construction investigation has been continued to test additional benefits from adjusting the framing composition within the wall.

A transition from conceptual full-scale investigations to an elemental investigation (Wall only) was necessary to quantify more effectively the benefit of different framing systems within the thermal envelope. This shift aimed to bring the investigation closer to achieving a higher performing thermal envelope, a core objective of this research. Brief tests of existing systems were completed on a sample wall before adjustments were made to enhance the performance of the framing.

Figure 6.10:
Plan of ‘Double Wall 01’

Figure 6.11:
Plan of ‘Double Wall 02’
6.1.5 ALTERNATIVE FRAMING OPTIONS

Reflecting on the success from removing the load bearing requirements from the envelope, four additional framing systems are used to quantify the area within the wall available for insulation. The framing systems have been selected on their potential to be prefabricated before being brought to site. A limitation of 200mm of the total wall thickness, or no more than roughly double the thickness of a typical NZS 3604 wall, is placed to restrict the system from performing better due to simply being thicker. Further, insulation with equal thermal resistivity will be used to ensure no advantage is given from the inclusion of a better performing insulation product.

Figure 6.12: Plan of ‘Z-Frame’

Figure 6.13: Plan of ‘I-Frame’

Figure 6.14: Plan of ‘Double Wall 03’
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**Figure 6.15:**
Evaluation of wall systems
6.1.6 COMPARATIVE CRITICAL REFLECTION

The process of quantifying the amount of timber present in each construction layer led to a pattern that suggested three construction layers would allow for the middle layer to have a smaller amount of timber. The addition of plywood, within the middle layer of the Z-frame and I-frame, reduced the amount of timber to 6.4%. However, it wasn’t as effective as using a timber packer, Double Wall 02 at 1.2%, because the wall only needed to be separated in the middle as they would be fixed at the top and the bottom. To completely remove all thermal bridging, the packer was replaced with plywood plates to remove the direct path through the wall and create a more complicated one to reduce energy flow through the wall.
6.2 DEVELOPED DESIGN OF A CLIMATIC DWELLING

The developed design of the research is a climatic dwelling that aims to create dialogue between pragmatic and poetic design decisions. The following sections break down this dialogue to explain how different parts of the building negotiated the different poetic and pragmatic strengths and weaknesses.
Figure 6.16: Approaching from the water
A physical model was built to communicate the relationship between architecture and landscape.
The model was built out of black card, birch plywood (interior), kauri timber (base), and frosted acrylic (lake).
6.2.1 SITE PLACEMENT

In response to the critical reflections from the digital massing models and physical model investigations in the Concept Design chapter, the developed design has been located on the seam between land and lake. Benefits of this placement included dual vehicle access, by boat and car, and the connection between bush path and jetty. Further, the poetic and romantic qualities are emphasised through the physical appearance of floating out into the water.

Figure 6.19: Site plan
Figure 6.20: Looking through the trees
Figure 6.21:
Entry Stairs from the driveway
Figure 6.22: Exploded axonometric of the primary and envelop structural systems
As identified, a key concern for the spacing of the structural system was the composition of a residential programme that wasn’t disadvantaged with awkward dead spaces. The proportions of the post and beam structure were critical in creating allowances for interior spaces and also in defining one of the most visible external features. The height of the grid was the first thing that was fixed and was specified at 3.5m, increasing the floor to ceiling height from 2.4m to 3.3m. A benefit of this move is a larger sense of space by creating a bigger volume over adding more area to each room.

Proportionally the distribution of the vertical elements was matched to the 3.5m, giving the north and south elevations a perfect grid, transforming the structure into a measurement tool to track changes in the landscape over the lifespan of the building. The original intention was to have the structure equal in proportion in every direction, however, 3.5m is a highly restrictive width for living, kitchen and dining spaces that require more flexible circulation. In response to this issue, the depth of the structure was changed to 4.7m. To express the difference in proportion the structural member was changed from a single beam to a double beam. To resist lateral loads the structure is considered as interconnected timber portals.

6.2.2 RESOLVED STRUCTURAL SOLUTION
Figure 6.23:
Structural model perspective
Figure 6.24: Structural model elevation
Figure 6.25: Structural model detail of separated frames
Figure 6.26: Diagram of the wall system

Figure 6.27: Structural model
6.2.3
ADDITION OF SCREEN

The refined proportions of the post and beam structure poetically can be viewed as two perfectly gridded walls, separated, to become host to a home. In plan view, these walls form two parallel lines which act as two stitches between the land and lake. To add emphasis to the parallel lines a timber screen was composed between the vertical posts, adding volume to the two walls that sit side by side. A weakness of having a continuous screen across the entire north and south facades of the building was the shading impact the timber slats would have over the windows. Although the shading would be a potential positive during the summer months when temperatures can reach 35°C, the shading would ultimately have a negative impact on the building as solar gains are an essential form of passive heating.

To combat the negative impact of over-shading, the screen was designed to retract over all windows on the north facade. To provide balance, selected windows on the south side also retract to let more light in. This design move allowed the building to physically transform and respond to the seasons as many of the plants do on site. The regular grid of the structure has become a measurement tool for the changing patterns of the retractable screen as well as the landscape.

As identified in the Theoretical Framework chapter, increased occupant control outside of the normal conditions can increase occupant satisfaction of their environment. To action this strategy in the design, a manual mechanism was designed to control the screen. To restrict penetrations into the thermal envelope of the building, all of these controls were located on the exterior, as shown in figure 6.29.

Finally, aesthetic adjustments were made to the screen to integrate the building within its landscape. Firstly, the screen was bent to suggest points of entry into the building from the water and land. Secondly, the screen was fractured out into the landscape to blend the building in with its landscape. Thirdly, small horizontal elements were added organically, in contrast to the very orthogonal composition of the rest of the exterior, to create a gradient effect as the screen came close to touching the ground. This was done to emulate the dappled shadows of leaves from a tree and in turn creating a more responsive relationship with the shrub/ground level of the landscape.
Figure 6.28: Retractable screen
Figure 6.29: Retractable screen manual system

Figure 6.30: Retractable screen section perspective
6.2.4 NATURAL VENTILATION

Another key takeaway from the Theoretical Framework chapter was the energy reduction benefits from enhancing natural ventilation within a space. Ventilation strategies that were incorporated into the developed design included, cross ventilation and a thermal chimney which services all three floors. The base of the thermal chimney, on the second floor, created a courtyard space that was placed between the living and kitchen/dining areas, creating a division of privacy between the two spaces. This placement also means that the living area borders two outdoor areas, which enhances the feeling of indoor-outdoor flow, a key quality that was mentioned frequently in the Home of the Year precedent study analysis.

Figure 6.31: Section perspective through the courtyard
Figure 6.33: Second Floor
Figure 6.34: Third Floor
Figure 6.35: Section perspective
Reflecting on the existing trend, within the Queenstown Lakes District, to build an additional guest house as a temporary Airbnb rental that generated a supplementary income, the developed design strives to rethink the level of privacy within a home. Traditionally, a three bedroom home is designed for a family with the areas to sleep clustered close together. However, when children grow up and move out of the family home, the left behind bedrooms become excess dead space unless they are rented or repurposed. To rethink how bedrooms fit into the programme of a house, bedrooms were first considered as a ‘place to sleep’ rather than a room to host a bed. This shift in thinking aided in connecting the rooms with qualitative trigger words that evoked a connection to the landscape. In turn, a ‘place to sleep’ became connected to the words “bunker”, “nested”, or “floating”, which had an implied sense of relaxation.

The result was two zones within the house that could be defined as a ‘place to sleep’, one above “nested” within the treetops, and the other below “floating” over the water. Both ‘places to sleep’ were incorporated into the programme of the building, creating two separate areas that provided the opportunity for one or the other or both to become a temporary rental at the occupant’s discretion.

A bunk room was incorporated into the layout of the ‘places to sleep’ on the third floor, with subtle privacy walls built-in to remove all lines of sight between beds. Long thin windows were added into the other two ‘places to sleep’ to provide a vantage position of the view only when a person was lying in bed. As heat rises, this design decision helped store heat within the space for longer.
Figure 6.36:
Third-floor front bedroom
Bathrooms were also rethought when being integrated into the programme of the building. Again, rather than thinking of them as a room to host a shower, bath or toilet, they were considered as ‘places to bathe’ and cleanse. As identified by Lisa Heschong, bathhouses and saunas have ritualistic and spiritual origins and have become sacred through the act of thermal rituals (Heschong 1979). A key component of these rituals is steam from hot water and a form of full immersion into a wet atmosphere. To create a space of thermal excitement, the experience of swimming in a lake was also reflected upon, where one descends into the water.

The idea of a sacred thermal space was combined with the concept of descent to compose a ‘place to bathe’ on the first floor, which was physically “anchored” into the landscape through a concrete slab foundation. The act of descending and the quality of being “anchored” was used as inspiration to design a bath sunken into the slab. To provide a connection to the landscape a long thin window was designed to rest on the junction between the wall and floor, allowing a person in the bath to peer out through shrubs towards the lake.

In contrast, another ‘place to bathe’ was designed to serve the people inhabiting the third level. As this space is higher, within the tree canopies, the sensation of rain was used as inspiration. In response, a long shower, with multiple shower heads, was placed against the polycarbonate wall that borders the thermal chimney, only providing a glimpse of a shadow to anyone walking down the hallway. Clerestory windows were placed on the other two walls that bordered the shower to provide the illusion that the roof was effortlessly “floating” above. Further, a hanging light feature was added to reinforce the experience of being suspended within the canopy during a storm.
Figure 6.37: Third-floor bathroom

Figure 6.38: First-floor bathroom
At full capacity, the house can sleep up to eight people within its three bedrooms. This means that the communal areas needed to be able to host large numbers of people at one time. In particular, the kitchen and dining spaces would likely experience the highest demand as daily patterns of cooking and eating would likely overlap. Instead of creating two large rooms, the area was made to function as either a large kitchen or dining area through built-in furniture merging the island into the dining table. Bifolding doors were also added to the core part of the kitchen that contained the stove, sink, and fridge so that it could be completely concealed, creating a more formal dining space.
Figure 6.39: Open kitchen

Figure 6.40: Closed kitchen
Finally, vertical circulation within the building also responded to its changing position relative to the landscape. Inspiration was taken from the experience of walking along different hiking trails within the area, where the relationship to the ground informs the type of structure implemented. The staircase connecting the first and second floors was influenced by tracks that are retained into the earth. Solid timber was used to reflect the sturdy and compact aesthetic of these tracks. The staircase connecting the second and third floors was influenced by tensile swing bridges that connect two tracks that have to cross a river or steep valley. Thin folded steel plates form the steps. An ephemeral wall, constructed from steel wire, which also acts as a balustrade, was used to reflect the fine and elegant aesthetic of these bridges.
Figure 6.41:
Second to the third-floor staircase

Figure 6.42:
First to the second-floor staircase
Reflecting on the simulation tests in the Cabin Series and Concept Design chapters, large areas of glazing threaten the energy and thermal performance of the design. Too much glazing meant that there was a risk of overheating in the summer and high heat loss in the winter. However, within a home, a window can provide many different types of spatial qualities, through filtering natural light, and providing access to views of the surrounding landscape.

As a building element, they help shape our interiors and attract focus to specific features. In the developed design, windows have been specifically designed to either frame the view or let light in. Two window materials were used: double glazed glass, R0.56, and 50mm thick polycarbonate, R3. The glazed windows draw attention to specific views on the landscape and allow direct sunlight into the room. Whilst the polycarbonate windows diffuse the light providing a softer glow. As the polycarbonate windows have a much higher thermal resistance value, they were specified for the large south-facing window, the entry window and door, and west and east facing walls around the courtyard.
Figure 6.43: Polycarbonate window in Timber wall

Figure 6.44: Double glazed window in a concrete wall

Figure 6.45: Double glazed window in a timber wall
6.2.10 LOCATION OF MECHANICAL SYSTEMS

1. Solar Panels for energy generation
2. Solar hot water heating
3. Rain water collection tanks
4. Geothermal heatpump
5. Any other systems use the carport as a substitute plant room
Figure 6.46: Long section
6.2.11 WHOLE BUILDING ENERGY SIMULATIONS

Energy simulations were used to quantify the performance of the building envelope and different mechanical systems and passive strategies. Each simulation was run using the Queenstown and Auckland weather file to explore the impact climate had on the building's performance. Due to all cooling needs being met through the incorporation of passive ventilation in the final design, the simulation input of ‘district cooling’ was disabled and the heating energy output was focused on. Key observations from the results included:

- Increasing the performance of the building’s thermal envelope made a significant impact on reducing the amount of heating energy consumed annually.

- The geothermal heat pump was effective throughout the year, which was expected as the buried exterior unit benefits from a more stable ground temperature compared to the fluctuating air temperature.

- Solar panels were ineffective during the winter months, likely due to the weather file recording a high number of overcast days during this time period. However, in practice it is unlikely solar panels would be completely non-functional during this period because newer models of solar panels can still generate electricity on overcast days.

- A limitation of the simulation process was only being able to assign one system at a time, regardless of if that system generated or consumed energy. This meant that energy demands needed to be measured independently.
01 Reference Building
02 Improved Envelope
03 Solar Heating
04 Heat Recovery System
05 Geo-thermal Heat Pump
6.3 DETAILED DEVELOPMENT OF THE DESIGN

To simulate a thermal bridge, a construction detail was drawn with the relative materials built as building elements before the detail is extracted (as the simulation will run from the information in the building elements not from the fills tool, which are typically used for drafting details). Specific points of interest are then identified and mapped on a diagram to show 'at risk' locations that could be vulnerable to condensation.

These points will record the temperature (in degrees Celsius) and energy flow (W/m²K). These results will correspond to data visualisations that also map temperature and energy flow across the detail. The overall result from the thermal bridge is given as a psi-value (pronounced 'si'), which is the rate of heat flow per kelvin per unit of length, which the R-value does not account for.
Figure 6.49: Internal floor to envelope

Figure 6.50: Window head

Figure 6.51: Window sill

Figure 6.52: Door to skylight

Figure 6.53: Skylight to courtyard
Simulation Notes

WH.DG.1 Window Frame Centered
WH.DG.2 Window Frame Exterior
WH.DG.3 Window Frame Interior
Figure 6.60: Diagram of measured points

KEY OBSERVATIONS

Placing the window frame within the centre of the wall provides a marginal improvement to the performance of the junction.
Simulation Notes
WH.DG.3 Glass Fibre Batt
WH.DG.4 Mineral Wool
WH.DG.5 PIR Rigid Foam
Figure 6.67: Diagram of measured points

KEY OBSERVATIONS

Measuring the change in thermal properties in a thermal bridging simulation has minimal impact on the results as the overall geometry of junction has not been altered.
Simulation Notes

WH.DG.1A Window Frame Centered
WH.DG.2A Window Frame Exterior
WH.DG.3A Window Frame Interior
KEY OBSERVATIONS

Due to aluminium being a highly conductive material, the scale on the energy flow simulation became 15 times larger compared to the timber simulations. As a result, I.1 and I.2 have a low surface temperature, increasing the risk of moisture.
Simulation Notes
WS.DG.1 Default Materials
WS.DG.2 Materials Re-defined
WS.DG.3 Aluminum Face to Window Frame
KEY OBSERVATIONS

Placing an aluminium front to the timber window frame caused the energy flow scale to increase by 410% due to having to account for a highly conductive material.
**Simulation Notes**

WS.DG.4 Thermal Break Option 1
WS.DG.5 Thermal Break Option 2
WS.DG.6 Aluminum Face to Window Frame 2
KEY OBSERVATIONS

All attempts to break the energy flow had little impact on the overall psi value which suggests that the design of the junction is still highly conductive. Based on these results a timber window is the best option.
Simulation Notes

F-E.1  No Thermal Break
F-E.2  Floor Structure Running Opposite Way
F-E.3  Bolt Connection: Primary & Secondary Structure
KEY OBSERVATIONS

The visual energy results are misleading as it appears F-E.1 and F-E.2 have a worse performance, where in fact F-E has the worst performance. It appears to have the least because the steel bolts are conducting at a faster rate than the timber around them causing the scale to increase by a factor of 9.
Simulation Notes

F-E.4 Add Thermal Break Between Structural Elements
F-E.5 Second Thermal Break Added
F-E.6 Structural Issue Fixed
**KEY OBSERVATIONS**

A polystyrene thermal break was effective in minimising heat flow through the envelope. The visual results here are comparable as the energy flow scale is relatively consistent compared to the jumps seen in other simulation results.
**Simulation Notes**

F-E.7  Acoustic Insulation Added
F-E.8  Insulation Packer Under Inner Frame
F-E.9  Bolt Connection Retested
KEY OBSERVATIONS

The addition of a thermal packer under and above the framing was not effective likely due to not being thick enough.
An improvement of 30% from F-E.3 to F-E.9 is accredited to the performance of the thermal break.
Figure 6.110: P-S.1

Figure 6.111: P-S.2

Figure 6.112: P-S.3

Temperature [°C]  Energy Flow [W/m²K]

Simulation Notes
P-S.1 Defaults/Base Model
P-S.2 Added Thermal Break
P-S.3 Thermally Broken Frames
**KEY OBSERVATIONS**

An improvement of 25% in the psi values is due to physically filling in the gap between the door and skylight, reducing the surface area exposed to the outside air and replacing it with an insulative material.
Simulation Notes
S-C.1 Defaults/Base Model
S-C.2 Added Thermal Break
S-C.3 Thermally Broken Frames
The performance was increased by using thermally broken frames, however, the raised geometry due to weathertightness restrictions has created a weakness that was not resolved.
Figure 6.124:
P-S.1A

Figure 6.125:
P-S.2A

Simulation Notes
P-S.1A Boundary Test 1
P-S.2A Boundary Test 2
Simulation Notes
P-C.1A Boundary Test 1
P-C.2A Boundary Test 2
Figure 6.129:
FULL.2

Simulation Notes
FULL.2 Boundary Test 2

KEY OBSERVATIONS

The cropped area of the detail has a large impact on the psi value/performance of the junction.
Figure 6.130: Energy performance results

- Heating Energy: +25.6%
- Cooling Energy: -47%
- Total Energy: +21%

Legend:
- ☐ Not accounting for thermal bridging
- ■ Accounting for thermal bridging
6.3.1 ACCOUNTING FOR THERMAL BRIDGING

Through accounting for the thermal bridges in the whole building simulation, the results got worse overall by 21%. The thermal bridges that were accounted for were the best option in each development set. The fact that the overall performance of the building decreased, proves that accounting for thermal bridges in the envelope has a significant impact on the overall performance. However, in the building, there was a total of 26.3m of window sills, which amplified the impact of the thermal bridge.

Thermal bridging has a large impact due to being applied over large lengths. For example, the window sill test above, as an isolated detail comes across as small and comparably insignificant to the overall performance. A limitation of this analysis is around what a minimum number or type of thermal bridges should be accounted for to achieve an ‘accurate’ result. This is difficult to give an answer due to the variation in the design of buildings.

A positive takeaway is the control this form of analysis gives architects in the process, as once a thermal bridge is simulated, it is largely up to the design of the junction to improve its performance.
CRITICAL REFLECTIONS
From the outset, the research aimed to engage with two design approaches that both have equally valid arguments for different design decisions. To reflect on the developed design, strengths and weaknesses around combining these approaches have been divided into two areas of investigation; structure, envelope and interior.

STRUCTURE
A key benefit of the external structure was the removed load-bearing requirements from the thermal envelope. The early identification of this benefit in the research allowed for iterative development into the aesthetic and an exploration into the opportunity to make more room for insulation by adjusting the framing. Even though it is likely an increased number of iterations would have resulted in even more sophisticated use of timber and plywood, the wall framing system applied to the developed design significantly reduced repetitive and linear thermal bridging. A key success of this system was that the middle layer became 98% free of timber, allowing for continuous installation of insulation and easy access for plumbing and electrical services. Further, an aesthetic benefit was the gained from the additional wall thickness providing a solid and protective appearance of the envelope.

ENVELOPE AND INTERIOR
Dissolving the boundary between inside and outside is strongly correlated with the New Zealand Dream, however, the application of heavy amounts of glazing heavily threatened the performance of the buildings envelope. A compromise was created by including polycarbonate windows to allow for more naturally lit spaces whilst still retaining a relatively high thermal performance compared to glazing. A key concern was that the interior would feel boxed away from the landscape, however, it also presented the opportunity to be more considerate and deliberate with the connection between the program of the space and the view. The low long thin windows in the bedrooms were considered as one of the more successful integrations of the pragmatic and poetic design considerations.
Figure 7.2: Physical model of the developed design

Physical model used warm lighting and a plywood interior to create the aesthetic appearance of warmth like how photographers use artificial lighting at twilight to achieve the same effect.
Identifying the strengthens and weakness of energy and thermal simulations was a key objective of the research. ArchiCAD’s built-in energy analysis tool was used as a representative of the semi-automated simulation engines built into BIM software packages, already purchased by architects throughout New Zealand.

The research found that the benefits of the tool included the interactive schedules and quick transitions between the information and energy models. Key weaknesses were identified in the Cabin Series chapter, which set out to test the simulation methodology. The weaknesses included: 1) a homogenous R-value calculator that could only account for a single material per layer, 2) inconsistent assignment of weather files from either NIWA or Strusoft Server. It is noted that through further investigation in a conference paper, the R-value issue was found in other BIM to BEM enabled tools, including Revit, whereas the weather file issue was isolated to the tool built-in to Archicad.

Through continuing to use the BIM to BEM workflow into the developed design, two additional issues presented themselves as the design became more detailed and resolved. These issues include:

**Building Systems Assignment**

In Archicad, a maximum of three systems can be assigned to a simulation to met heating, cooling and ventilation demands. However, a limitation was found when trying to assign a system to generate energy (solar) and consume energy (geothermal heat pump) to meet the heating demands.
To resolve this, individual simulations were completed to measure generation and consumption of energy. It is noted that a Building Energy Model, BEM, can be exported in the file formats of .gbxml (Green Building XML) or .phpp (Passive House Planning Package), which would allow for more advanced simulation.

**EcoDesigner Star Plug-in**

As an additional plug-in, not yet commercially available in New Zealand, the Eco Designer Star plugin for ArchiCAD has high potential to engage architects more effectively with the simulation workflow. The thermal bridging simulation function of the tool allows for an instant visual relationship between the performance and the drawing, quickly communicating any issues that need to be resolved. However, the results scale of the energy flow visualisations was a weakness, because it automatically adjusted itself, unlike the temperature scale which could be defined. As a result, the visual representation of data could appear misleading when attempting to compare results.
The wide scope of this research, set out to explore both pragmatic and poetic approaches to design, was made possible by the brief of a small residential house. The original proposal for the research was a commercial scale building which would have heavily restricted the detailed analysis within the developed design. Further, a larger scale building with a more complicated programme would have required a larger theoretical framework to adequately investigate the existing research within the field.

More significantly, however, time restricted the scope of the individual investigations that could have resulted in different findings if the time allowed for a larger sample size.

Further, a cost analysis of the construction systems and different aesthetic design decisions would have also provided a more holistic analysis of the different investigations.
In winter the exterior screens retract up to let in more natural light to increase solar gains.
8.0 CONCLUSION

With the demand for housing in colder parts of the country rising, the research explored the opportunity to engage with the dialectic between pragmatic and poetic approaches to design a building that not only exceeds the minimum but does so through exercising its relationship with its environment.

Designing a house involves complex decisions and in many cases, they are driven by two, often competing, objectives; poetic or pragmatic. Even in the way we award excellence in architecture, one is given more or complete priority over the other. In many ways, this makes sense because a firm’s aesthetic or primary service is their brand. However, to ignore or favour one over the other in the design phase places the built product at risk of either underperforming or becoming neutral and uninviting.

Leading by example, Climatic Conscience for Dwelling Design set out to demonstrate how architects can utilise semi-automated energy and thermal simulation software, to efficiently test and improve different aesthetic decisions through a systematic and agile design workflow. The result is a speculative, simulated design that proves pragmatic responsibilities can enhance poetic opportunities in the creation of a design that is unique to its climate and environment. As a process, it ensures that both the visible finishing elements and invisible construction elements of the architectural envelope are contributing constructively to the overall outcome. To ensure the effectiveness of each move, this research worked at multiple scales to streamline the investigation.

Firstly, a series of cabins were designed to test the simulation methodology through analysing the thermal consequences of construction and aesthetics, as well as validating assumptions made by the simulation tool, including R-value calculation and weather file generation. Secondly, two groups of concept designs were generated using an agile design process to
explore the building’s poetic relationship with its context and measure the impact of a challenging climate on its performance. The findings from these tests, along with the case study analysis and theoretical framework produced criteria and strategies, which were refined going into the developed design.

The developed design used the dialectic between pragmatic and poetic design approaches to reconsider the function of the envelope and the domestic spaces within a home.

The research not only set out to identify a potential workflow where poetic and pragmatic objectives are achieved but also to identify issues and opportunities with using a semi-automated simulation platform that stands as a viable method for complying with section H1 of the New Zealand Building Code.

All design investigations show evidence of how full-building simulation can be conducted iteratively to prove the minimum has been achieved. The construction detail investigation shows further evidence into how details can be simulated to provide a more interactive and visual understanding of the performance. These results present the opportunity for a stronger ability to correct and create solutions to performance issues without having to compromise the aesthetic.

Although the design outcome has been largely successful and well received, there is still significant potential in further research in low-energy/net-zero residential architecture as climate change action becomes more critical. A more thorough investigation into the tools, further refinement of the construction system, cost benefits, and a wider investigation into New Zealand’s climates and landscape, are just a few of the areas that could continue to strive to ensure we are designing better to ensure we are building better.
8.1 KEY CONTRIBUTIONS

1) **The identification of the benefits of removing the load-bearing requirements from the thermal building envelope.** Further, the identification of the potential to improve the wall elements within the envelope to allow for more insulation and less linear and repetitive thermal bridging.

2) **A speculative developed design that successfully incorporated both pragmatic and poetic design approaches to create a building unique to its landscape, and climate.** Additionally, considering the function of bedrooms beyond the use for raising a family created a programme composition which included the potential to host a temporary rental without encroaching the privacy of the permanent occupants.

3) **Identification of the limitations of the simulation software.** Currently, the ‘Modelling Method’ in NZS 4218 considers the use of simulations tools validated by ASHRAE Standard 140 as acceptable, provided a reference model is supplied with the compliance documentation. The findings from this research have identified simulation inputs that require careful consideration when preparing the Building Energy Model (BEM), even if they are automatically assigned.

4) **Pilot testing of thermal bridging simulation within a BIM software package.** Completing thermal bridging simulations and applying the results as an input to the whole building simulation found a difference of 20-30% in the total annual energy performance of the developed design. This proves that the thermal bridges can have a significant impact, especially when unaccounted for. Further, the visual display of the results over the detail drawing is promising for architects and designers as it clearly communicates what is causing an issue, and opens up the potential to be ‘designed out’.
5) A comparative analysis of the thermal envelope minimums in an equivalent climate to Queenstown. The comparison between New Zealand and North American minimums for thermal envelopes found that our minimums are almost half of what is considered acceptable overseas. In other words, much of what is built within the Queenstown Lakes District would be considered illegal in North America, due to having a poor performing building envelope.

Figure 8.2: Watching waves
The growing impact of climate change and population increase throughout the country makes the demand for high performing, low or net energy houses more critical, which suggests that there is potential for further research into this area. This includes:

- A more detailed analysis of the impacts of the different climates across the country.
- More appropriate code minimums for thermal envelopes or redistribution of the climate zones.
- Development of the built-in R-value calculators in BIM software packages
- Validation of other automated simulation inputs for the New Zealand construction industry.

- A qualitative analysis into the strategies to create thermal excitement within a home.
- A quantitative analysis of the energy consumption of houses within New Zealand’s extreme climates.
- Structural analysis of the timber-framed construction system used in the developed design.
- Cost evaluation of the different timber-framed construction systems that could be used as alternatives to NZS 3604 to allow more insulation in the building envelope.
Figure 8.3: Still water
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‘Fire’ by Lidia Adriana, Unsplash < https://unsplash.com/photos/v9kNO0JOR0c >

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Figure 6.83: WS.DG.5
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REFERENCES


Thomas, Yinka. 2018. “Get a Good Night’s Sleep.” Sleep Council UK.


Example of report produced from the energy simulations in Archicad.
Energy Performance Evaluation
[Project Number] [Project Name]

Key Values

General Project Data
- Project Name: 01 Parallel lines .1
- City Location: 45° 3' 0" S, 168° 39' 0" E
- Latitude: 0.00 m
- Climate Data Source: NZL_Queen...0_NIWA.epw
- Evaluation Date: 12/10/2018 at 10:23:47 AM

Building Geometry Data
- Gross Floor Area: 70.89 m²
- Treated Floor Area: 55.77 m²
- External Envelope Area: 463.03 m²
- Ventilated Volume: 392.10 m³
- Glazing Ratio: 18%

Building Shell Performance Data
- Infiltration at 50Pa: 6.35 ACH

Thermal Resistances
- Building Shell Average: 0.93
- Floors: --
- External: 3.30 - 1.30
- Underground: --
- Openings: 0.47 - 0.10

Specific Annual Values
- Net Heating Energy: 158.26 kWh/m²a
- Net Cooling Energy: 149.26 kWh/m²a
- Total Net Energy: 307.52 kWh/m²a
- Energy Consumption: 338.20 kWh/m²a
- Fuel Consumption: 338.20 kWh/m²a
- Primary Energy: 374.47 kWh/m²a
- Fuel Cost: -- NZD/m²a
- CO₂ Emission: 3.92 kg/m²a

Degree Days
- Heating (HDD): 2637.67
- Cooling (CDD): 1538.40

Energy Consumption by Sources

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<tr>
<th>Source Type</th>
<th>Source Name</th>
<th>Quantity kWh/a</th>
<th>Primary kWh/a</th>
<th>Cost NZD/a</th>
<th>CO₂ Emission kg/a</th>
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Energy Quantity

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Primary Energy

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Quantity by Source: [kWh/a] 0
Primary by Source: 20886
Energy Performance Evaluation
[Project Number] [Project Name]

Energy Cost
[Not Applicable]

CO₂ Emission
100 [\%] [83, 16]

Energy Targets
- Heating
- Service Hot-Water Heating
- Cooling
- Ventilation Fans
- Lighting
- Equipment

Energy Consumption by Targets

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<th>Target Name</th>
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<td><strong>20886</strong></td>
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<td><strong>218</strong></td>
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Energy Quantity
[44, 44, 5, 4, 46, 54, 47, 44, 54, 46, 47]

Primary Energy
[44, 40, 2, 12, 4, 42, 44, 44, 40, 12, 4, 44]

Quantity by Target: [kWh/a]
Primary by Target: [20886]
Energy Performance Evaluation
[Project Number] [Project Name]

**Energy Sources**
- Secondary
  - Electricity
  - District Heating
  - District Cooling

**CO2 Emission**
- 83%
- 16%
- 5%

**Energy Cost**
- Not Applicable

**Project Energy Balance**

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<td>Service Hot-Water Heating</td>
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</tr>
</tbody>
</table>

**Thermal Blocks**

<table>
<thead>
<tr>
<th>Thermal Block</th>
<th>Zones Assigned</th>
<th>Operation Profile</th>
<th>Gross Floor Area m²</th>
<th>Volume m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>001 House</td>
<td>3</td>
<td>Residential NZ</td>
<td>70.89</td>
<td>392.10</td>
</tr>
<tr>
<td>Total:</td>
<td>3</td>
<td></td>
<td>70.89</td>
<td>392.10</td>
</tr>
</tbody>
</table>

**Environmental Impact**

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Source Name</th>
<th>Primary Energy kWh/a</th>
<th>CO2 emission kg/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary</td>
<td>Electricity</td>
<td>3034</td>
<td>218</td>
</tr>
<tr>
<td></td>
<td>District Heating</td>
<td>9526</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>District Cooling</td>
<td>8325</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>20885</strong></td>
<td><strong>218</strong></td>
</tr>
</tbody>
</table>