DEPARTMENT OF MANAGEMENT AND MARKETING

The challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in older homes in New Zealand

Kim Chai

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The challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in older homes in New Zealand

BY

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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Business

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2016
Declaration

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This thesis entitled: “The challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in older homes in New Zealand” is submitted in partial fulfilment for the requirements for the Unitec degree of Master of Business.

Candidate's declaration

I confirm that:

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- The contribution of supervisors and others to this work was consistent with the Unitec regulations and policies.
- Research for this work has been conducted in accordance with the Unitec Research Ethics Committee Policy and Procedures, and has fulfilled any requirements set for this project by Unitec Research Ethics Committee.

Research Ethics Committee Approval Number: 2015-1080

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## Abbreviations

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<td>BRANZ</td>
<td>Building Research Association of New Zealand</td>
</tr>
<tr>
<td>CCANZ</td>
<td>Cement &amp; Concrete Association of New Zealand</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>CRESA</td>
<td>Centre for Research, Evaluation and Social Assessment</td>
</tr>
<tr>
<td>CSLG</td>
<td>Construction Sector Leaders Group</td>
</tr>
<tr>
<td>dB</td>
<td>Decibel</td>
</tr>
<tr>
<td>DGW</td>
<td>Double glazed windows</td>
</tr>
<tr>
<td>EECA</td>
<td>Energy Efficiency and Conservation Authority</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>Low-E</td>
<td>Low emissivity</td>
</tr>
<tr>
<td>MBIE</td>
<td>Ministry of Business, Innovation and Employment</td>
</tr>
<tr>
<td>NZBCSD</td>
<td>New Zealand Business Council for Sustainable Development</td>
</tr>
<tr>
<td>N₂O</td>
<td>Nitrous oxide</td>
</tr>
<tr>
<td>PVB</td>
<td>Polyvinyl Butyral</td>
</tr>
<tr>
<td>ROI</td>
<td>Return on Investment</td>
</tr>
<tr>
<td>SGW</td>
<td>Single glazed windows</td>
</tr>
<tr>
<td>SPF</td>
<td>Sun Protection Factor</td>
</tr>
<tr>
<td>STC</td>
<td>Sound Transmission Class</td>
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<tr>
<td>UREC</td>
<td>Unitec Research Ethics Committee</td>
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Abstract

Current building legislation (NZS4218:2009) includes requirements for energy efficient windows. This has resulted in most new homes in New Zealand being fitted with double glazed windows, improving the health, comfort and environmental efficiency of these buildings. Yet, a large number of the existing (older) homes built before the legislation, more than one million homes, have not adopted the new technology meaning most people are living in cold, mouldy and unhealthy homes across the country. This suggests barriers to the uptake of double glazed windows (DGW) in existing homes.

Therefore, this research seeks to identify and discuss the challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in older homes in New Zealand. The focus of this research is to analyse the data collected and evaluate the findings with information from the literature and provide recommendations to help deal with the challenges in retrofitting DGW. These recommendations can make retrofitting DGW more accessible to homeowners resulting in healthier and more comfortable homes as well as helping to protect the environment. In order to accomplish the purpose and objectives of this research, this study employed the unstructured interview as a data collection method with a qualitative approach. A total of 12 participants from homeowners and industry professionals related to the retrofitting of double glazed windows in older homes were interviewed in New Zealand.

Based on the empirical results, the study found a number of challenges in retrofitting double glazed windows. The main challenges are attributed to its high cost, lack of information, perceived low return on investment (ROI), difficulty in accessing trades people, uncertainty and length of time frame as well as complexity of regulation. The benefits such as comfort, health and safety and helping to address environment issues and the insignificant economic gains are not enough drive for most homeowners to retrofit their homes with DGW. Furthermore, homeowners find that it is difficult to access information and knowledge associated with retrofitting. It was found that based on the current understanding of benefits and environmental issues,
major factors identified as challenges, there is only limited interest demonstrated by most homeowners in retrofitting their existing homes with DGW.

This research provides recommendations that could increase the interest of homeowners in retrofitting their homes with DGW. Firstly, regulation could be introduced as a motivating driver to retrofit DGW in older homes. Secondly, stakeholders should also create a knowledge platform with detailed information on retrofitting DGW such as technology, cost, time frame, process, health, comfort and environmental issues. Thirdly, DGW with vacuum technology should be used as it can match SGW in terms of weight and thickness, retrofitted into existing joineries, saving retrofitting cost, time and possibly avoiding the lengthy and costly Council consent. Finally, the government should provide funding in their long term budget that could be utilised during an economic crisis to help owners retrofit DGW in their homes to help stabilise the ‘boom and bust’ economic cycles in the New Zealand construction sector.

Overall, the study shows multifaceted difficulties associated with retrofitting DGW including high cost, relatively low knowledge, low return on investment, uncertainty on the length of time frame as well as accessing trades people. These issues have driven down the homeowners’ interest level in retrofitting DGW in their homes. Therefore, future research should be conducted to increase homeowners’ interest by establishing an accurate cost for retrofitting DGW, expanding on the literature to establish a strong knowledge platform that is easily accessible by the consumers. In addition, New Zealanders should learn and collaborate with a country such as Japan that has successfully implemented retrofitting their homes with DGW and enjoyed the gains from doing so.
Chapter One: Introduction

1.1 Background

How many times have we read in the news that people are living in cold, mouldy and unhealthy homes? The New Zealand Herald reports that according to Energy Efficiency and Conservation Authority (EECA), many New Zealand families are facing winters in homes that fail to meet the global guidelines for healthy living (Edmunds, 2015). Similarly, Tapaleao (2016) highlights figures from Consumer NZ that showed 38 percent of people were not keeping their homes as warm as they would like them to be because they were restricting their energy use to reduce power bills. It is recommended that temperature in houses should be kept at a minimum of 18°C to 20°C in living areas and children's bedrooms, and 16°C in adults' bedrooms (Edmunds, 2015).

The negative aspect of space heating associated with keeping houses warm is that it can contribute to environmental harm. It is reported that energy sources used for space heating in New Zealand homes are mainly from electricity for heat pumps or electric heaters, solid fuel heating, gas heating and solar heaters (Level, 2015). Similarly, the New Zealand 2013 Census (Statistics New Zealand, 2014a) on occupied private dwellings, reports that 79.2 percent use electricity and 36 percent also burn wood to heat their homes. These energy sources used to warm up homes, with the exception of solar heating, contribute to global warming (Level, 2015). As highlighted by Skates (2011), global warming is now a generally recognized phenomenon and carbon-dioxide is one of the main culprits blamed for this issue. Porter (2015) adds that the least disruptive way to cut down carbon dioxide production is to reduce heat loss from houses.

Therefore, to improve living conditions as well as reduce space heating in homes, EECA proposes insulating houses (Edmunds, 2015). However, even with insulation, single glazed windows (SGW) are a poor performer in keeping homes comfortable as they allow cold air into homes during winter and during
summer, it allows warm air in (Wright, 2016, May 10). This negative performance is also supported by a study which showed that SGW are thermally a weak point that is responsible for between 26 percent and 48 percent of heat loss from a building (Smith, Issacs, & Burgess, 2010). Similarly, New Zealand Glass (2011) reports that up to 31 percent of energy used to heat up the homes is lost through SGW. However, DGW can prevent 73 percent of this heat loss (New Zealand Glass, 2011) which makes it important to retrofit SGW with DGW in older homes.

Furthermore, there are numerous benefits (EECA, 2015) associated with DGW that include:

- Reducing condensation build up in cold weather, with the air (dry or inert gas) acting as an insulation or barrier in between two pieces of glass, separating the warm inner pane and cold outer pane. DGW is also commonly used in refrigerators with glass doors to prevent condensation which is cold inside and warm outside.
- Reducing the heat loss through energy efficient windows, hence lower heating costs and indirectly helps to reduce global warming.
- Improving thermal comfort of any home.
- Reducing external noise through the windows.

Along with the comfort in homes and environmental issues, it is interesting to note that most of the homes built in New Zealand are fitted with DGW in line with the legislation of minimum standards for insulation in the building code (EECA, 2015), with the latest revision implemented from October 2008 (McChesney, Cox-Smith, Amitrano, & Branz Limited, 2008). Thus, the enactment of the building code has resulted in most new homes being fitted with DGW, which implies that the relevant authority recognises the importance of DGW based on its benefits and environmental issues.
1.2 Description of the Research

Even though the importance of DGW in homes has been recognised with legislation for insulation in the building code, many of the older homes in New Zealand are still not retrofitted with DGW (Edmunds, 2015). Therefore, this research seeks to find out the main challenges and the underlying factors in each of the challenges that are hindering homeowners from retrofitting DGW in their homes. The findings from homeowners and stakeholders’ perspectives linked with information from the literature review will be analysed for possible solutions to the challenges in retrofitting older homes in New Zealand with DGW.

The author has been unable to find any research carried out on the challenges faced by homeowners and other stakeholders in retrofitting DGW in older homes in New Zealand. However, a study by the Building Research Association of New Zealand (BRANZ) shows some similarities with this research on the section which describes the barriers to the adoption of energy efficient windows (Burgess, 2014). While there are similarities such as market awareness, capital cost and absence of improvement drivers, the objectives of the studies are different which can lead to different outcomes. The main aim of this research is to find out the main challenges faced by homeowners and other stakeholders that are hindering homeowners from retrofitting DGW in their older homes while the focus of BRANZ’s study is on the development of a window thermal performance rating tool.

This study involves interviewing stakeholders who are related to the retrofitting process such as builders of new homes, contractors and renovators of existing homes, the Windows Association, representatives from Auckland Council as well as owners of older homes. This is to enable the researcher to collect data from a vast body of knowledge, including experiences of those with different backgrounds. In analysing the data, the researcher would be able to identify some of the main factors to each challenge as well as some of its possible root
causes which can help the researcher to generate possible solutions to mitigate the situation.

This research is important as it will promote health and comfort in homes as well as help to protect the environment. As this is a major project with two-thirds of New Zealand homes that require retrofitting DGW, it is also a business opportunity. It could be undertaken with New Zealand authorities’ leadership, as corporate social responsibility for the people’s comfort and health, as well as to spur the economy in the event of another global financial crisis. Ultimately, retrofitting all the older homes in New Zealand with double glazing windows becomes both economical as well as an environmental challenge for all the stakeholders involved.

The biggest breakthrough that this study could achieve, based on analysing the data from the findings and the literature, is to make recommendations that can help to change the mind-set of New Zealand society, making insulation and particularly DGW a reality, a norm and a culture rather than a luxury in people’s homes. As explained by Sachs and Ruhli (2011), stakeholders are prepared to contribute beyond what might be considered normal, not only for monetary gains but also other motivating factors such as making a commitment to human health and comfort.

Therefore, all stakeholders such as EECA, homes builders, eco-advisors, manufacturers, Auckland Council as well as homeowners should collaborate to overcome the challenges in retrofitting DGW in older homes. As Ben Packard, Starbucks’ Vice President of Global Responsibility, emphasised through his experience of making Starbucks’ 100 percent recyclable iconic coffee cup, the project not only involves developing recyclable materials but also bringing together all the stakeholders and infrastructure to the new culture. Packard further says that it involves not only Starbucks but also engages the entire food packaging and recycling industries into the project (Allen & Klein, 2011).
This research aims to improve people’s lives by making their homes healthier and more comfortable as well as helping to protect the environment. Hence, the focus of this research is on the challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in older homes in New Zealand.

1.3 Research Questions

This research seeks to find out from the homeowners and other stakeholders the challenges they will face in retrofitting single glazed windows with double glazed windows for older homes in New Zealand. The main research question to explore the experiences, knowledge and perceptions of the homeowners and other stakeholders is:

**What are the challenges faced by the homeowners and other stakeholders in retrofitting single glazed windows with double glazed windows for older homes in New Zealand?**

To help with the main research question, the following sub-questions were designed:

1. What are the main challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in homes?
2. What are homeowners and other stakeholders’ interests in retrofitting double glazed windows?
3. What are homeowners and other stakeholders’ understanding of the benefits of using double glazed windows for homes?
4. What are homeowners and other stakeholders’ interests in reducing the impact of environmental issues, which is one of the benefits of using double glazed windows?

1.4 Research Aim

The aim of this research is to find out the main challenges faced by homeowners and other stakeholders that are hindering homeowners from
enjoying the many benefits that come with retrofitting single glazed windows with double glazed windows in their older homes.

1.5 Research Objectives

The objectives of this research are:

- To identify the challenges that are hindering homeowners from retrofitting single glazed windows to double glazed windows.
- To explore the level of interest exhibited by the homeowners and other stakeholders in this change that can bring many positive benefits.
- To find out whether or not homeowners and other stakeholders (builders of new homes, local authorities, manufacturers and importers of DGW, advisors and contractors) are aware of the benefits that can be gained with this modification.
- To find out the attitudes of New Zealanders in addressing the environmental issues through lower use of energy for heating that is made possible with the conversion.

1.6 Thesis Overview

The thesis comprises six chapters.

Chapter One - Introduction - provides the background and description of the conceptualisation of this research. It also highlights the research question, aim, and objectives.

Chapter Two – Literature Review - presents a critical approach to the review of the literature in order to provide a theoretical and practical foundation for this thesis. It outlines and discusses the benefits such as health and comfort as well as challenges in technology, regulation and lack of resources and time frame.

Chapter Three – Methodology - chapter discusses the methodological considerations and selection of a qualitative approach. Based on the qualitative
approach, the design of the questionnaire, data collection, data analysis and ethics issues are described.

Chapter Four - Findings - used thematic analysis on the data obtained from interviews. This was then structured into primary themes that emerged from the data and support the research’s sub-questions. The chapter presents the findings of this study with empirical evidence. The key findings are highlighted in each of the primary themes and summarised for discussion in the subsequent chapter.

Chapter Five - Discussion of the Findings - discusses the analysis of key findings in each of the primary themes linked to the information in the literature review. The discussion will provide some answer to the research questions.

Chapter Six - Conclusions and Recommendation - concludes by providing a summary of the thesis, recommendations and limitations of this study as well as suggestions for further research. The researcher’s personal reflection ends this research in the closing statement.

1.7 Chapter Summary

This chapter provided the background for the research by highlighting the poor living conditions in New Zealand due to lack of insulation in which DGW can play an important role in improving. It explained how this issue led to this research that seeks to discover the challenges that are stopping homeowners from retrofitting DGW in their homes. In addition, this chapter set out the research questions and sub-questions that were developed, and the aim and objectives that were established, to guide this research. It then provided the overview of the entire thesis comprising six chapters.

The next chapter, Chapter Two, is the literature review that provides an overview of the benefits such as health and comfort, challenges in technology, regulation and lack of resources and time frame that will provide a theoretical foundation for the discussion of the findings.
Chapter 2 - Literature Review

2.1 Introduction

This review of the literature uses a critical approach to examine the current knowledge about retrofitting double glazed windows (DGW) in older residential homes in New Zealand. As explained by Jesson, Matheson and Lacey (2011), a critical approach is a “critical analysis that you can back with evidence or examples” (p. 16). It focuses on a range of key issues for the Auckland environment and weather conditions for older homes with benefits associated with home insulation and the additional advantages in using double glazed glass windows to enhance home insulation. Other benefits are that it will provide comfort such as noise control and privacy as well as a healthy lifestyle. Retrofitting DGW will also reduce energy usage in older homes which will help to address environmental issues. Besides benefits, this review will look at the challenges that come with the DGW retrofitting process. Firstly, it will discuss the resources and time that are required for retrofitting DGW. Secondly, it will study related regulation and new regulation that must be put in place to ensure a proper and safe change process. The last challenge to be discussed is the associated economic impact of retrofitting DGW on individuals and the wider New Zealand economy.

There are many reasons for retrofitting double glazed windows in older homes. A major reason for the retrofitting process is that double glazed windows increases the effectiveness of insulation in houses. As the Energy Efficiency and Conservation Authority (EECA) explains, a well-installed insulation makes houses easier to heat and can improve living conditions. Furthermore, a study by Smith, Isaacs and Burgess (2010) demonstrated that windows are thermally a weak point responsible for 26 percent and 48 percent of heat loss from a building. New Zealand Glass (2011), a company that specialises in retrofitting SGW with DGW, highlighted that up to 31 percent of energy used to heat up the homes is lost through SGW and DGW could prevent 73 percent of this energy being wasted. According to Level (2015), an organisation developed for the construction industry by BRANZ to conduct research and testing and
provide consulting and information services, energy sources used for space heating in New Zealand homes are mainly from electricity for heat pumps or electric heaters, solid fuel heating, gas heating and solar heaters, which contribute to climate change and other environmental issues. Therefore, using DGW can reduce energy consumption and help to address environmental issues.

With the reshaping of the housing system to cope with the growing population in Auckland, comfort such as noise control and privacy as well as improved health are also critical factors to consider for retrofitting to DGW. As explained by Cement & Concrete Association of New Zealand (CCANZ, 2010), good insulation design with DGW can help to create an even, comfortable temperature within a house which contributes to a healthier living environment. Smarter Homes (2013a), owned by the Ministry of Business, Innovation and Employment, also reports that with DGW, no condensation will form on glass window pane hence reducing mouldy conditions so as to contribute to better health and lower health costs.

Alongside the benefits associated with retrofitting DGW are the challenges of the technology of double glazing, regulations, lack of resources and time frame. Learning about the current technology and future trends of double glazing will help homeowners understand and accept the concept of double glazing for homes. The challenge of regulations, as highlighted by Howell (2010), lies in the councils specifying and delivering effective methods to achieve policies set for DGW retrofitting process. This is to ensure a safe and effective implementation of DGW retrofitting process for New Zealand older homes. Resource challenges for the DGW retrofitting are high costs for the homeowners and increasing the number of contractors to meet the high volume of New Zealand older homes requiring this change. The time frame for getting approval from Council as well as the process of retrofitting DGW is another challenge for homeowners. This is highlighted by Burgess and Bennet (2006), the DGW retrofitting process is more expensive and time consuming than existing SGW and window frames needing to be replaced; in some cases, the walls may need to be rebuilt to fit the DGW.
2.2 Home Insulation and Double Glazed Windows

Edmunds (2015) reports in a *New Zealand Herald* article that an estimated two-thirds of New Zealand homes do not meet global guidelines for healthy living, and a key action that must be taken to address this issue is insulating the house. This section looks into the process of heat transfer, effective use of heat from the sun, measuring the effectiveness of insulation and heat losses from a home. Firstly, it will explain how heat transfer takes place through conduction, convection and radiation in a home. Secondly, it will explore the methods of gathering, storing and retaining heat from the sun. The third part will discuss the heat losses from homes through roofs, windows, walls, floors and air leakage. Finally, it will describe the two common methods, U-value and R-value, used to measure the effectiveness of insulation in reducing heat loss.

As Harley (2012) explains, heat transfer is the movement of heat from indoors to outdoors in the winter and from outdoors to indoors during the summer. Harley adds that if heat transfer does not occur, houses would always be warm in the winter and cool in the summer without the use of heaters or air conditioning (Harley, 2012). Johnston and Gibson (2010) explain that heat is transferred in three ways: by conduction, convection and radiation. Conduction is the way heat moves through a solid material and is measured by its resistance to heat flow. Convection is how heat moves through gas or liquid such as in a conventional home; air hits a relatively colder window, falls to the floor, pushing the warmer air up, and causes drafts and gives us cold feet in winter. Radiation is how hot bodies transfer heat to colder bodies. It is important to consider heat transfer from conduction, convection and radiation in building an energy efficient home (Johnston & Gibson, 2010).

Therefore, it is important to focus on three factors to maximize the use of free energy from the sun in designing comfortable energy efficient homes (Donn & Thomas, 2010):

- Glass – to gather heat from the sun
- Thermal mass – to store the heat accumulated
- Insulation – to retain the heat accumulated by preventing heat loss.
CCANZ (2010) explains that thermal mass of materials, such as stone and brick, require much more heat to warm up, making them more effective for heating and cooling a house as compared to timber or plastic since stone and brick store a greater amount of energy. Donn and Thomas (2010) add that although concrete and brick are good conductors of heat, they have poor insulation values. Therefore materials with better insulation values, such as fibreglass, polyester, wool or polystyrene, are used to cover the walls for retaining the heat in a house (Donn & Thomas, 2010). Similarly, CCANZ (2010) claims that the use of insulation helps to slow the transfer of heat in and out of a house as well as reduce both heating and cooling needs.

The estimated heat losses for a typical New Zealand home without insulation, as pointed out by Beacon Pathways\(^1\) (2013) is 30-35 percent through the roof, 21-31 percent through the windows, 18-25 percent through the walls, 12-14 percent through the floor and 6-9 percent through air leakage. However, as highlighted by Donn and Thomas (2010), glass is not only the greatest source of heat gain but also the greatest contributor of heat loss in a house, as a sheet of glass can conduct over ten times more heat than the same area of insulated wall. This is explained in the next section.

It is important to measure the effectiveness of insulation in reducing heat transfer and the two common methods used are U-value and R-value. U-value is a measurement for insulating qualities by using the inputs of all the thermal resistances encountered in the heat path (Skates, 2011). Similarly, Johnston and Gibson (2010) explain that U-value is a measure of how much energy is lost through a window unit. Lower U-values indicate better insulating qualities of walls or windows (Skates, 2011). R-value is the measurement of the efficiency in which the material slows down the transfer of heat that is inversely proportional to the material’s ability to conduct heat and thermal resistance (Skates, 2011). Johnston and Gibson (2010) explain that R-values measure the heat movement through a solid material and higher R-values mean greater resistance to heat flow.

\(^1\) Beacon Pathways is a research consortium formed by New Zealand Steel, EECA, Certified Builders, Insulpro Manufacturing and Centre for Research Evaluation and Social Assessment (CRESA) Ltd.
According to Smarter Homes (2013a), the R-value reading based on thermally broken aluminium frames\(^2\) is:

- R0.17 for single glazing
- R0.31 for standard double glazing
- R0.39 for double glazing with low-E glass
- R0.41 for double glazing with low-E glass plus argon gas

(See Appendix R for performance values for other frame options). It is important to note that the R-value reading for standard double glazing with normal aluminium frame is R0.25 (see Appendix R) and this does not meet the Building Code requirement reading of R0.26 for energy efficient windows which is described in section 2.6 on regulation.

Skates (2011) explains that when a material is better at conducting heat, R-value will be lower and it is poorer at insulating, and vice versa. Therefore, from the above R-value reading, it can be interpreted that double glazing is more effective in reducing heat transfer through windows.

In summary, heat moves from indoors to outdoors in winter and from outdoors to indoors in summer, through conduction, convection and radiation. Therefore it is important to consider the role of conduction, convection and radiation in building energy efficient homes. The three instruments that are involved with utilizing heat energy from the sun are glass to collect heat, thermal mass to store the heat and insulation to retain the heat by reducing heat loss. The majority of the heat without insulation is lost through the roof, windows, walls, floor and air leakage with glass. Furthermore, glass is not only the greatest source of heat gain but also the highest cause of heat loss in a home. U-value is used to measure the amount of energy lost through the windows while R-value measures the efficiency of the material such as walls or windows in slowing down the heat. The R-value for thermally broken aluminium frames is 0.17 for SGW and DGW is 0.31 with the higher value denoting higher

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\(^2\) Thermally broken aluminium frames refers to placing insulation between the interior and exterior part of the frame or combine aluminium with other materials as aluminium is a poor insulator since it conducts heat (Smarter Homes, 2013b).
performance. The minimum R-value requirement for energy efficient windows is 0.27, as explained in section 2.7 – regulation.

2.3 Existing Double Glazing Technology and Future Trends

To contextualise the review on retrofitting DGW for older homes in New Zealand, this section will look firstly at the design of double glazing windows by using different types of glass to meet the required technical specification for homes. Secondly, the conventional method of producing double glazing windows will be studied. Finally, this section will study the future trends of double glazing technology in New Zealand.

As there are complex requirements for different homes, various combinations of glass panels as well as filling the gaps between glass panels with air, argon or krypton are used in the design of double glazing windows to meet the customers’ performance level. Some of the typical glass panels in DGW design are monolithic\(^3\) glass, laminated glass, low-E glass monolithic glass, low-E laminated glass or different thickness monolithic glass. The performance of DGW depends on the design, and higher performance usually comes with a higher price.

One of the advantages of using low-E glass in DGW is that it can help to keep the room warmer. As explained by Pilkington (Nippon Sheet Glass, 2015), low-E glass has an invisible coating that reduces heat transfer by reflecting interior heat back to the room. Pilkington adds that double glazed low-E windows can make a home twice as energy-efficient when compared to older double glazed windows without low-E coating (Nippon Sheet Glass, 2015). RETRO Double Glazing\(^4\) (2016) also reported that modern houses with insulation that meets the 2009 building code can still lose up to 45 percent of their internal heat

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\(^3\) Monolithic glass is a single sheet of glass formed using the float glass manufacturing process which is often modified for increased strength, improved insulating capability, and safety glazing requirements (Guardian Industries Corp, 2016b). Guardian Glass operates in more than 25 countries, serves customers in over 100 countries and employs over 17,000 people (Guardian Industries Corp, 2016a).

\(^4\) RETRO Double Glazing is a retrofitting double glazing subsidiary company of Metro Performance Glass.
through single glazed windows; classic double-glazing windows can reduce the heat loss by up to 33 percent and low-E double glazed units can reduce heat loss to 28 percent. It is interesting to note that while Retro Double Glazing claims that DGW is around one and a half times more efficient\(^5\), Pilkington claims that it is twice as efficient when comparing low-E double glazing to classic double glazing. This difference could be due to Pilkington using the most efficient low-E glass with triple soft coating and RETRO Double Glazing using normal single coated low-E glass for their calculations.

Several positive features of laminated glass make it an attractive choice to use in designing DGW. One of the key benefits as highlighted by Solutia\(^6\) (Eastman Chemical Company, 2016b), is that Saflex interlayer used in the laminated glass acts like a sun block. It screens 99 percent of the most harmful and damaging UV rays, an equivalent of Sun Protection Factor (SPF) of 50+, preventing damage to interior furnishings, fabrics, drapes, wall coverings, photographs and artwork (Eastman Chemical Company, 2016b). The other benefits that can be achieved with the use of laminated glass in DGW are significant noise reduction, safety and security (Pilkington, 2015). Laminated glass is produced by sandwiching a polyvinyl interlayer between two pieces of glass in a controlled environment room in terms of humidity and air cleanliness and passed through pressurised rollers and heating ovens (G. James Glass & Aluminium, n.d). The assembled glass is then placed into a pressure vessel under 8 to 12 bar pressure to bond the glass and interlayer (G. James Glass & Aluminium, n.d).

The conventional method of producing DGW involves washing and drying cut-to-size glass, placing spacer filled with molecular sieve or desiccant\(^7\) to prevent condensation in the air gap between two panes of monolithic glass, pressed together and sealed with silicone around the perimeter of the glass which is

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\(^5\) One and a half times more energy efficient (17% divided by 11%) as heat loss is 17% for low-E double glazing (45% - 28%) and compared to 11% for classic double glazing (45% - 33%).

\(^6\) Solutia is a subsidiary of Eastman Chemical Company, the world leader in PVB (Polyvinyl butyral) interlayer production. PVB is the interlayer that bonds two sheets of glass together.

\(^7\) Desiccants are effective at removing water from liquids and gases for a long period of time. Molecular sieve is a common type of desiccant.
also known as an Insulated Glass Unit (G. James Glass & Aluminium, n.d)\(^8\) as shown in figure below.

Two pieces of glass are separated by a metal spacer and sealed to provide a hermetically sealed unit. It has a primary water vapour proof seal and the secondary polysulphide seal. The airspace is provided with a desiccant inside the metal spacer to prevent condensation forming within the unit (Viridian Glass, 2016, para. 2).

Figure 2.1: Insulated Glass Units (Viridian Glass, 2016)

KIWIDG\(^9\) (2016b) explains that standard DGW can reduce heat loss by 56 percent. This heat loss could reduce up to 74 percent for those seeking higher performance for their windows by using DGW built with low-emissivity (low-E) glass (KIWIDG, 2016a). Harley (2012) elaborates that argon or krypton gas are nontoxic inert gases and safe to use for homes in DGW. In a report prepared for Beacon Pathway Ltd, Burgess and Bennet (2006) explain that the use of argon or krypton gas gives the best thermal performance, with argon requiring 10-12 mm air gap while krypton requires only 6mm air gap.

The future trend in double glazing technology is different from the conventional method of filling the air gap with air, argon or krypton. Known as Pilkington Spacia, it uses on-line coated low-E vacuum glazed extra thin glass (Pilkington, 2015). This is the world’s first commercially available vacuum glazing offering similar thermal and acoustic performance of conventional double glazing with low overall thickness of 6mm. Pilkington (2015) explains that the technology for Pilkington Spacia (as shown in figure 2.2) is to extract the air between the two panels of glass, creating a vacuum and sealing the assembled unit. A gap of 0.2mm thick is more effective at minimising conduction and convection heat

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\(^8\) G.James Glass & Aluminium, established in 1917, is one of Australia’s leading manufacturers of aluminium windows and aluminium doors, supplying to the residential, commercial, high-rise and monumental building and construction markets.

\(^9\) KIWIDG represents KIWI Double Glazing, a Retro Double Glazing Specialists in Auckland
losses than the conventional double glazing. This technology has been successfully used in Japan for more than ten years (Pilkington, 2015). Hence, using this new form of double glazing without changing the joinery in New Zealand older homes is likely to be popular choice if the original frames are in good condition and technology and supply is easily available.

A vacuum, even a small one, is much more effective at minimising conduction and convection heat losses, so the gap between the two panes can be reduced to just 0.2 mm, giving an overall thickness of just over 6 mm. Heat flow through radiation is limited through one of the glass panes having a low-emissivity coating, similar to that used in modern conventional double glazing (Nippon Sheet Glass, 2016, p. 19).

In summary, the lowest cost currently for retrofitting is using double glazed windows with air in the space between the two panels of float glass. Performance could be improved with argon or krypton gas, low-E and laminated glass with additional cost. The future trend in New Zealand could be using vacuum glazing for retrofitting SGW as it can fit into existing frames designed for SGW with approximately the same thickness and weight as well as enjoying the same benefits as double glazing. However, it is unclear when or if this technology will be adopted although it has been used in other countries for the past 10 years; government intervention could be one of the solutions. This knowledge of DGW current technology and its future trends will help to increase the understanding of homeowners about the benefits of using DGW as asked in sub-question 3.

2.4 Comfort, Health and Safety

One of the key benefits of DGW is that they help to provide a comfortable, healthy and safe environment in a home. DGW create comfort in a home by reducing noise as well as maintaining a stable temperature that keeps the
surroundings cool in summer and warm in winter. Furthermore, having a stable temperature reduce condensation and controls the growth of mould and fungi that can cause health problems thereby providing a healthier environment. DGW using laminated glass can also contribute to a safe environment because it can reduce injury from falling glass.

One of the most important benefits of DGW in increasing comfort of a home is that DGW can reduce noise levels (Window Association of New Zealand, 2010). Noise is defined as sound which is usually loud and disagreeable or which is undesired by the recipient (Nolan, 2011). As Mckinney, Schoch and Yonavjak (2013) explain, noise is classified as air pollution because it is usually transmitted through air. The authors further elaborate that noise is unwanted because it is too loud for comfort or an annoying mixture of sounds that distract people such as distant conversations (McKinney et al., 2013).

However, before moving onto the topic of how DGW can reduce noise from entering a home, it is important to note that noise has a subjective element. Noise reduction from using DGW is also a complex issue and often misunderstood by many people. McKinney et al., (2013) point out that an individual’s experience of noise depends on their state of mind and hearing sensitivity which is one of the reasons why some people are not concerned about certain noises while others find noise levels to be difficult to deal with. This suggests that more research on this subject would be helpful.

Nolan (2011) explains that sound is measured by the decibel scale and the unit of measurement is the decibel\(^ {10} \) (dB) with the threshold of hearing at 0 dB and the threshold of pain at 140dB. (Nolan, 2011). A sound level expressed in decibels is an efficient method of handling the sensitivity of the ear to the wide range of sound pressures (Everest & Pohlmann, 2015). Some of the typical source of sound and its measurement are:

- Aircraft carrier deck jet operation sound level is measured around 140dB which is painfully loud.

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\(^ {10} \) Deci refers to the units of 10 used and bel refers to Alexander Graham Bell, a teacher of the deaf and inventor of telephone (McKinney et al., 2013).
- A heavy truck sound level is measured at around 90dB which could cause hearing damage over an 8 hour period.
- Motorway traffic sound level is measured at around 70dB which makes the using of telephones difficult.
- A typical quiet living room sound level is measured at around 50 dB.
- Rustle of a leaf reading sound level is measured at around 10dB which is just audible.

A serious health hazard identified by Sankar (2015) is that of noise pollution contributing to noise-induced hearing loss. Mckinney et al. (2013) explain that an individual can suffer hearing loss from loud noises which can occur rapidly from very loud noises or slowly from long-term exposure to moderately loud noises. Hearing damage begins at around 70 dB for long exposure to sound and irreversible hearing loss can occur almost instantaneously from around 130 dB. (McKinney et al., 2013).

A number of authors, such as Chambers (2009), El Nemr (2010), Sankar (2015) and Mckinney et al. (2013), point out that noise pollution, especially long term, can cause emotional trauma and lead to sleep disturbances, annoyance and aggression as well as physical illnesses such as depression, high blood pressure, those affecting the cardio-vascular system\(^\text{11}\) and stress. Chambers also highlights noise pollution contributes to poor concentration and low reading levels in children. El Nemr also suggests that health experts believe that excessive noise can lead to neurosis and nervous breakdown. Noise pollution clearly establishes the need for effective noise reduction strategies with DGW playing an important role.

Nolan (2011), Pilkington (2015) and El Nemr (2010) highlight that noise has grown worse with industrialisation, urbanisation and advances in technology as well as increased population, with future trends suggesting that traffic and other noise are going to increase as living space declines. The increasing noise levels in society (Pilkington, 2015) has led to a growing interest in protecting

\(^{11}\) Noise pollution can constrict the arteries, increases flow of adrenaline and force the heart to work faster (El Nemr, 2010); the heart and circulatory system make up one’s cardiovascular system.
people from noise. The Resource Management Act 1911 (RMA) currently provides enforcement measures for unreasonable and excessive noise in New Zealand (Nolan, 2011). As a general guideline set in the latest Standards New Zealand Act, noise limits for reasonable protection of health and amenity associated with the use of land for residential purposes should not exceed 55 dB in the daytime and 50 dB in the evening (Standards New Zealand, 2008).

As highlighted by Dupont, sound finds its easiest way into a building through windows unlike concrete wall that blocks sound (DuPont de Nemours, 2003). Everest and Polhmann (2015) add that a typical 3mm single pane glass window provides relatively poor sound insulation with a sound transmission class (STC) rating of 25. It requires an STC rating of 50 to provide a sufficient sound barrier similar to a concrete-block wall (Everest & Pohlmann, 2015). Commercially available pre-fabricated DGW can provide an STC rating of 50 or more for sound insulation (Everest & Pohlmann, 2015), which is adequate in terms of noise level reduction in a home.

However, Saint-Gobain Glass (2016) highlights that standard double-glazing can only reduce the amount of noise that both enters and leaves your home by approximately 3-4 dB which may not be sufficient if homes are located near a busy motorway. One of the options of reducing noise level is to use two glass panes of different thicknesses (Everest & Pohlmann, 2015). G. James Glass (n.d) reveals higher noise reduction can be achieved using glasses of different thickness with at least 30 percent difference. DuPont (DuPont de Nemours, 2003) adds that a PVB interlayer in laminated glass will reduce noise by absorbing sound rather than transmitting it. Hence, at a significantly higher cost, using different combinations of the above options in DGW can further reduce the level of noise entering through the windows.

One of the advantages of retrofitting DGW is that DGW can help to create a stable temperature in homes. As explained by Harley (2012), the biggest role

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12 Saint-Gobain, with 170,000 employees, is one of the world’s leaders in the design, production and distribution of construction materials delivering innovative products and services with tomorrow in mind.

13 DuPont is a science company dedicated to solving challenging global problems with a portfolio of products, materials and services to meet the ever-changing market needs of diverse industries in more than 90 countries.
radiation plays in a home’s comfort and health is the surface temperature of glass, with temperature coldest in winter and warmest in summer. Hence as explained in section 2.2 - home insulation and double glazed windows - DGW can reduce the impact of radiation on the surface of the glass to the interior of a home, as the air space between the two panes of glass in DGW acts as an insulating barrier, slowing the transfer of heat in and out of a house, resulting in a stable temperature.

By creating a stable temperature, well insulated walls and DGW can reduce the risk of condensation in homes as surface temperatures are more stable and less likely to fall below the level at which condensation occurs (CCANZ, 2010). Similarly, EECA (2015) reports that DGW help to reduce condensation build up in cold weather, with the air (dry or inert gas) acting as an insulation or barrier in between two pieces of glass, separating the warm inner pane and cold outer pane. In addition, CCANZ (2010) highlights that the consequence of condensation in homes is that it can lead to the growth of mould and fungi.

The benefits of regulating the temperature in a home, hot or cold, are increased level of comfort and health. As Smarter Homes (2013a) points out, DGW can make a big difference to comfort levels in homes as it help to keep temperatures stable. Similarly, EECA (2015) supports the benefits of DGW by highlighting that DGW will improve the thermal comfort of a home. Furthermore, an even, comfortable temperature within a house can contribute to a healthier living environment as cold temperatures for older people and very young people could aggravate asthma and other allergic attacks (CCANZ, 2010).

Another health benefit from regulating the temperature in a home is preventing illnesses by reducing the growth of mould and fungi. Moulds are living organisms that can trigger asthma attacks and pose serious health threats to individuals who have compromised immune systems (Larsen, 2010). Therefore, DGW can contribute to better health and lower hospital bills as it will reduce mouldy homes (Smarter Homes, 2013a). CCANZ (2010) adds that the growth of mould and fungi can exacerbate respiratory conditions for people with these illnesses.
Providing a safe environment in a home is another benefit that can be achieved by retrofitting DGW in homes, using laminated glass in the DGW design. G. James Glass (n.d) explains that when an accidental human impact occurs, the bond between the glass and interlayer in the laminated glass combine to absorb the force of the impact with fragments typically remaining intact. G. James Glass adds that this feature in the laminated glass reduces the likelihood of serious injury (G. James Glass & Aluminium, n.d). Solutia (Eastman Chemical Company, 2016a) points out that the PVB interlayer in laminated glass provides protection from windborne debris in areas prone to hurricane and other natural disasters. Solutia adds that the wide range of PVB interlayer products can meet the requirements of the most stringent hurricane codes or racking motions of an earthquake, helping to prevent injury and damage from the glass fallout. Therefore, using laminated glass on one or both panels in the DGW can increase the safety of a home.

In summary, by reducing noise, DGW can provide comfort to a home with a quiet environment and create a healthier environment with less noise related sicknesses. With the future predictions of increasing noise levels, noise control and reduction is becoming more central. However, standard DGW can only achieve modest noise reduction which may not be sufficient for environments with high noise levels such as near busy motorways. Hence, in environments with high noise level, DGW can be designed to achieve a significantly higher noise reduction with a higher capital investment. Furthermore, by maintaining a stable temperature in a home, DGW provides comfort by keeping summer cool and winter warm. The stable temperature can also foster a healthier living environment by reducing mouldy conditions as well preventing a cold environment which both can cause illnesses. The other benefit revealed in this section is that DGW with laminated glass can provide a safe environment in a home as it will reduce injury. Thus, this section is aligned to sub-research question 3 - providing an understanding of the benefits of DGW which help to provide comfort, health and safety in homes.
2.5 Environmental Issues

The environmental impact of human activities can be classified into two broad categories: resource depletion and pollution (Rieuwerts, 2015). Global population growth and mass consumerism continue unabated with agricultural, industrial and urban expansion in many parts of the world to satisfy the people’s requirements for food, housing, energy and material goods leading to resource depletion (Rieuwerts, 2015). Rieuwerts (2015) further suggests that human activity is disturbing natural environmental cycles through generating pollution which is altering the atmosphere and contaminating the world’s soils and waters.

This section discusses global warming from air pollution which is causing extreme weather to become more frequent. Firstly, it examines the role of greenhouse gases, such as CO₂, as well as air particles, such as aerosols in the atmosphere that help to regulate the Earth’s temperature. Secondly, this section describes the increasing level of CO₂ in the atmosphere. Thirdly, it discusses the human activities, such as burning of fossil fuels and cutting down of tropical rainforests, that increase CO₂ in the atmosphere which lead to global warming. The sources of energy used to heat up homes in cold weather that can increase the emission of carbon dioxide (CO₂) to the atmosphere are also identified. The consequences of climate change from global warming include rises in sea level, increasing frequency of extreme weather events, major economic damage, loss of life and serious health issues.

The atmosphere absorbs some of the solar radiation from the Sun and re-emits it back to Earth which helps to regulate Earth’s surface temperature. According to Cook (2012), the majority of the solar radiation from the sun passes through the atmosphere, heating up the planet and then is reflected back into the atmosphere. Some of this solar radiation is absorbed by the greenhouse gases and re-emitted back to Earth, warming the atmosphere and making the Earth habitable (Cook, 2012). CO₂ is one of the major components of greenhouse gases that absorbs some of the solar radiation (Cook, 2012). Furthermore,
Cook (2012) claims that the increase in CO₂ in the atmosphere makes the earth warmer by soaking up more heat and re-emitting it back to Earth.

On the other hand, there are also some components of the atmosphere, such as aerosols, that help to regulate the Earth’s surface temperature by reflecting back (not entering the Earth atmosphere) some of the Sun’s solar radiation (Cook, 2012). This act of reflecting back the sun’s solar radiation results in less heat entering the Earth so making it cooler (Cook, 2012). Aerosols or the fine particles emitted to the atmosphere are produced by biological process, combustion of coal, or volcanic eruptions (Cook, 2012). A study by Scripps Institution of Oceanography shows that the aerosols ejected from two major volcanic eruptions, the 1982 eruption of El Chichón in Mexico and the 1991 eruption of Mt. Pinatubo in the Philippines, had a net cooling effect on the Earth for several years (cited in Monroe, 2016). However, the scientists expect cloud trends to continue into the future resulting in the planet getting warmer due to increasing greenhouse gas concentrations (cited in Monroe, 2016). Cook (2012) also suggests that the impact of CO₂ far outweighs the impact of components such as aerosols or the fine particles on the Earth’s surface temperature.

There had been a significant rise in CO₂ over the last part of the 20th century and into the 21st century. The atmospheric CO₂ at Mauna Loa observatory recorded a sharp increase over the last 40 years (Chivers, 2010). Similarly, Cook (2012) reports that CO₂ has increased by almost a third compared to its typical level over the past 200 years. This increase in CO₂ is supported by a study from Scripps Institution of Oceanography which found that cloudy storm tracks are moving towards the Poles and cloud tops are moving higher in the atmosphere which is consistent with human-caused increases in greenhouse gas concentrations (cited in Monroe, 2016). It is also important to note that although methane and nitrous oxide are part of the greenhouse gases that have increased significantly, their overall concentration in the atmosphere is still

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14 Aerosols are minute particles suspended in the atmosphere. Three types of aerosols that significantly affect the Earth’s climate are the volcanic aerosol from major volcanic eruptions, desert dust and pollution aerosols.

15 Scripps Institution of Oceanography at UC San Diego is one of the oldest, largest and one of the most important centres for global science, research and education in the world.
low which means they have a less serious impact on warming up the Earth as compared to CO₂ (Cook, 2012).

According to Gilbert (2016), global warming is confirmed by meta studies\(^\text{16}\) which show that 97 percent of published climate scientists agree that global warming is occurring and that it is caused by human activities. One of the main causes for the increase of atmospheric CO₂ is due to the burning of fossil fuels (Cook, 2012). In addition, Chivers (2010) suggests that the increase of atmospheric carbon dioxide could be due to oil, gas and coal that are mined and burned, releasing CO₂ into the atmosphere. The increase in CO₂ is exacerbated by the chopping down and burning of tropical rainforests which reduce the planet’s ability to absorb CO₂ (Chivers, 2010).

The EECA (cited in Edmunds, 2015) and Level (2015) point out that most energy sources used for space heating with the exception of solar heating contribute to global warming. Skates (2011) points out that the majority of the heating in cold weather comes from the burning of fossil fuels releasing gases such as carbon dioxide (CO₂) and Nitrous Oxide (N₂O) into the atmosphere. These harmful gases could result in climate change (Skates, 2011). Porter (2015) suggests that the most cost-effective way to cut down carbon dioxide production is to reduce heat loss from houses. Adopting insulation enhanced with DGW can reduce energy use as less heating is required (RETRO Double Glazing, 2016) and therefore cut CO₂ production and help to address global warming. Global warming is now a generally recognized phenomenon and carbon-dioxide has been identified as one of the main culprits (Skates, 2011).

The consequences of global warming include significant climate change. This climate change is associated with rises in sea level, extreme weather events, possible biological/ ecological changes and the spread of tropical diseases (Cook, 2012). Castro, Taylor and Brokensha (2012) highlight that the increased concentration of carbon dioxides, methane and other heat trapping gases are warming the planet as measured by an increase in average air and ocean

\(^{16}\) A meta-analysis uses a statistical approach to combine the results from multiple studies to produce an estimate from the multiple results (Jesson et al., 2011).
temperatures, large-scale snow and ice melting, and rising global sea levels. Quaschning (2010) highlights that global temperature rises are causing storms to be more violent, rainfall to be heavier and high tides and flooding to be more frequent than before with huge economic damage to the world economy as well as loss of life.

Examples of extreme weather being reported across the world are:

*In Taiwan*
- the category 4 storm, super typhoon Nepartak on 8 July 2016 (Calvo, 2016)
- the strongest category 5 storm, typhoon Meranti on 14 September 2016 (ABC NEWS, 2016)

*In Haiti*

Both Taiwan and Haiti were devastated with huge loss of lives, properties, livelihood as well as serious health issues.

In summary, atmosphere helps to regulate the Earth’s surface temperature by absorbing and reflecting the Sun’s solar radiation. The greenhouse gases in the atmosphere where CO\textsubscript{2} is a major component, absorb the energy from the Sun and help to keep the Earth warm. Aerosols or fine particles that are released into the atmosphere during volcanic eruptions, biological process and combustion of coals, help to reflect back some of the Sun’s radiation, keeping the Earth cool. The sharp increase of CO\textsubscript{2} over the last 40 years with cloudy storm tracks moving towards the Poles and cloud tops moving higher in the atmosphere showed that the greenhouse gas concentrations are increasing.

97 percent of published climate scientists agree that global warming is occurring and that it is caused by human activities. The main causes for the increase of atmospheric CO\textsubscript{2} are identified as the burning of fossil fuels that release CO\textsubscript{2} into the atmosphere as well as the chopping down of tropical
rainforests which reduces the planet's ability to absorb CO₂. The burning of fossil fuels is identified as the main source of energy used; therefore, using insulation enhanced with DGW in homes requires less heating so it can reduce energy use leading to less CO₂ emission into the atmosphere. The consequences of global warming include significant climate change that is linked to rising sea levels, increasing incidents of extreme weather events, huge economic damage, loss of life as well as health issues. Therefore, this section provides information related to sub-question 4 - participants’ interest in reducing environmental issues as insulation and DGW can help to reduce global warming.

2.6 Regulation

Regulation can play a positive impact on the retrofitting of DGW in older homes in New Zealand. Councils possess good legislative foundation such as through the Local Government Act 2002 and the Resource Management Act 1991 as well as tools, such as regulation, fiscal tools, community education and councils’ own administrative practices, to promote more sustainable buildings choice (Howell, 2010). This section, firstly, covers some of the main regulatory requirements for windows for new buildings and alterations or additions to existing buildings. Secondly, it will briefly look at the increasing number of new houses built using DGW due to the new legislation. Thirdly, it will look at the possibility of using SGW in the new legislation but this option is not supported by sustainable buildings experts as they claim it will compromise the objective of healthy and comfortable living. Fourthly, this section will highlight the rules and regulations governing the retrofitting of DGW in existing homes, the exemption criteria for consents requirement as well as show the possible consequences of not getting the required consents before starting work. Finally, it will explore the process of getting consents from Auckland Council.

Burgess (2014) explains that the legislation to meet increased energy efficiency requirements was introduced in 2007/2008 for new houses in New Zealand. Andric (2011) adds that policy change for windows under Building Code, section 400 of the Building Act 2004, which was implemented on 30 September
2008, was more concerned with the health, comfort and environmental impact from the lack of home insulation in New Zealand than on its economic cost. Similarly, a survey by BRANZ (Burgess, 1998), points out that it is difficult to offset the difference in purchase cost between single glazing and DGW purely against the cost of heating a home in New Zealand. The cost should be measured against the advantages of DGW, such as increased thermal comfort, noise reduction, reduction of internal window condensation and the ability to leave view windows without curtains at night (Burgess, 1998). The New Zealand standard applicable for the thermal performance of windows in housing is NZS4218:2004 for energy efficient windows and the latest version is NZS4218:2009 (Burgess, 2014). Tasman District Council (2016) points out that the energy efficiency requirements make DGW necessary in most new houses in order to meet the new glazing R-value of 0.26. It should be noted that for any additions or alterations to an existing home which can include retrofitting DGW, the windows must also meet the Building Code R-Value of 0.26 energy efficiency for homes in Auckland (MBIE, 2016a).

EECA (2015) reports that most new houses currently built in New Zealand are fitted with DGW. This could be due to the fact that clear insulating glazing units (previously known as double glazing units) in standard aluminium frames can meet the required energy efficiency R-Value of 0.26 (Burgess, 2014). Furthermore, McChesney et al (2008) claim that one of the main factors leading to the increasing number of homes being built in New Zealand fitted with DGW is the legislation requirements of a minimum standard for insulation in the building code to take effect from October 2008. The other factor that most likely influenced a significant national market penetration in the use of DGW which rose from 30 percent in 2007 to 90 percent in 2011 is the introduction and enforcement of the legislative driver of energy efficiency requirement (Burgess, 2014).

Homeowners still have the option of using single glazing windows in the new legislation by using insulation in one part of a house to be traded against the insulation in another part of the house with the heat loss calculation method – NZS4218:2004 (Tasman District Council, 2016). However, CCANZ (2010)
argues that since insulation is the most important factor influencing energy efficiency and comfort, people should be encouraged to use higher levels rather than just the Building Code minimum. CCANZ adds that using better insulation materials usually cost a little more as the installation cost remains the same (CCANZ, 2010). This statement is supported by the New Zealand Business Council for Sustainable Development (2008) report containing a research finding by ShapeNZ showing that most respondents felt home with improved performance would cost 20 percent more to build than a typical home but the actual cost is closer to around 5 to 10 percent higher.

Building consents and resource consents are the rules and regulations governing the retrofitting of DGW in existing homes. Auckland Council (2016a) is required by legislation and regulations to manage both building consents and resource consents from application to the approval stage. It is responsible for ensuring that all significant building work is safe, durable, sustainable, and poses no danger to the health and wellbeing of property owners and users (Auckland Council, 2016a). Building consents are required to ensure that construction activities are safe, healthy and built right while resource consents are mandatory to safeguard the environments from damage by the construction activities (Auckland Council, 2016a). Auckland Council (2016a) adds that for most of the renovation works, including retrofitting DGW, any additions or alterations to the structural building construction activity require an approved consent before commencing work to ensure that the planned building work complies with the Building Act 2004 and the Building Code (Auckland Council, 2016a).

It is interesting to note that according to Auckland Council (2016b), consents can be exempted for replacing windows or doorways if the following criteria are met:

- Building is not more than two storeys high.

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17 Sustainable (environmental) is defined as conserving the natural resource, human surroundings and overall ecosystem without compromising human development goals (Shastri, Banerjee, & Preeta, 2010)
Work does not affect any specified system\textsuperscript{18}

Windows have not failed to satisfy the provisions of the building code for durability.

However, the Ministry of Business, Innovation and Employment (MBIE) highlights that it is the building owner’s responsibility to decide whether building work is exempt from building consent (MBIE, 2016b). The MBIE adds that building owners opting for exemption must ensure that altered buildings under exempted building work must comply at least to the same extent with the Building Code before the building work was undertaken (MBIE, 2016b). It further adds that building owners can still opt to apply for a building consent even if building work is exempted (MBIE, 2016b), but this option would incur additional cost and time.

The consequences of building without a building consent may result in a fine, trouble selling the property or insuring the building (Auckland Council, 2016c). The MBIE (2016b) states that a fine is up to $200,000 and if work continues, a further fine of up to $10,000 per day, for building work without a building consent when it is not exempted.

The next step after owners have considered retrofitting DGW in their homes is to look at the process of applying for consents. As the application process can be quite complex, involving a number of legal and regulatory rules, Auckland Council (2016a) strongly recommends that homeowners engage a professional such as a master builder, engineer, planner, surveyor or architect to handle the consenting process.

The building consents process as shown in Appendix L follows the regulations laid out in the NZ Building Code, NZ Building Act 2004, the legacy District and Regional Plans which are still in effect, and the Proposed Auckland Unitary Plan (Auckland Council, 2016a). Basically, the process of applying for building consent involves

\textsuperscript{18} Systems in buildings that are vital to the safe use of the building, eg, fire safety systems, lifts and ventilation systems (Auckland Council, 2016d).
• A pre-lodgement meeting, lodging an application and the application accepted by Council - additional information may be required
• Building consent is issued
• Inspection during construction and final inspection after construction
• Application for a code compliance certificate with all necessary documentation
• Code compliance certificate is issued

Construction activities while retrofitting DGW in a home may affect people and communities with issues such as noise, increased traffic or parking or reductions in privacy, and could mean it is necessary to get a resource consent approval before commencing work (Auckland Council, 2016a). Furthermore, Auckland Council (2016a) points out that the most important step before submitting the resource consent application is getting affected persons’ approval if the proposed activity will affect people and communities. The resource consents process as shown in Appendix K must comply with the Resource Management Act which is designed to ensure environmental considerations are included in the development. The process of applying for resource consents are

• Contact Council
• Prepare and lodge application
• Council decides whether it is notified consent or non-notified consent.

In summary, the new legislation of NZS4218:2009 for energy efficient windows must meet the thermal performance of the new glazing R-value of 0.26; and a clear DGW is able to meet this value. With the legislation, the national market penetration for DGW in new houses has increased significantly. The SGW can still be used by using insulation from another part of the house to meet the heat loss calculation but it is not recommended as CCANZ argued that people should be encouraged to use higher levels of Building code for efficiency and comfort. The new legislation most likely applies to the retrofitting DGW as it often involves structural changes to a building when it is installed due to the increased weight and thickness of the DGW. The consequences of not getting
consents before starting work could be a fine of up to $200,000 and further $10,000 fine per day if work continues. The process of getting consents is complex for homeowners. It involves lodging an application, inspections and documentary support and Council strongly recommends engaging a professional such as a master builder, engineer or architect for the application. The consent process also involves a considerable amount of time and cost. This will be discussed in the next section.

2.7 Resources and Time Frame

The main resource challenges for retrofitting DGW are cost, shortage of skilled labour and time frames. There are two main cost involved: the cost associated with retrofitting DGW; and the cost of getting building consent and resource consent from Council, if consents are required. The costs associated with retrofitting DGW entail the removal of SGW, purchase and installation of DGW, and the possibility of building new walls and joinery. If building consent and resource consent are required, fees associated with the application as well as engaging a professional to help most homeowners with the complex process can add significant cost. The other resource challenge is the shortage of skilled workers in the building industry and this could make it difficult for homeowners to find reputable companies to retrofit DGW in their homes. The time frame required for retrofitting DGW as well as application for council consents is the last resource challenge discussed in this section.

Burgess and Bennet (2006) suggest that retrofitting SGW with DGW is more expensive than fitting DGW in a new building as existing window frames need to be replaced and, in some cases, the walls may need to be rebuilt to fit the DGW. According to Pocock19, the cost of retrofitting double glazing to a typical three-bedroom home is around $7000 to $10,000 (Clement, 2015, May 5). Similarly, Refresh Renovations20 estimate the cost of retrofitting DGW for a typical house in New Zealand to be approximately $10,000 and this can double if replacing joinery is required (Matheson, 2016). Therefore, using Refresh

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19 Ronnie Pocock is the marketing manager at Fletcher Aluminium.
20 Refresh Renovations is a renovation specialists company with a team of designers, builders and tradespeople who design and build for renovation projects (Refresh Renovations, 2016).
Renovations estimated cost, and assuming 50 percent of the house joinery needs to be replaced, the average cost of retrofitting a home would be around $15,000\textsuperscript{21}.

There would be approximately 1.04 million homes that are still using SGW based on the houses that were built before the legislation for increased energy efficiency through the New Zealand Building Code in 2008. This is based on the assumption that these houses were not renovated as the ruling is only applicable to houses built after the energy efficiency requirement was implemented. The New Zealand Business Council for Sustainable Development (NZBCSD) reported in 2008 that 1.04 million homes were built before insulation was required in New Zealand (NZBCSD, 2008). NZBCSD (2008) adds that although many of these homes have been upgraded, they still lack sufficient insulation. Furthermore, many homes built after insulation was required do not meet the insulation requirements (NZBCSD, 2008). Edmunds (2015) reports that two-third of New Zealand homes are currently without insulation. Therefore, with 1,570,000 estimated occupied dwellings in New Zealand in 2013 (Statistics New Zealand, 2014b), the number of homes without insulation works out to be around 1.047 million\textsuperscript{22} homes. It is interesting to note that the figure does not seem to have changed much from 2008 to 2013.

Furthermore, assuming all existing homes without insulation were retrofitted with DGW, the total cost would be around NZ$16 billion\textsuperscript{23}, using Refresh Renovations estimated cost of $15,000 per home. This cost is major considering that New Zealand is only a small economy with Real\textsuperscript{24} GDP\textsuperscript{25} of NZ$154.2 billion; its top export commodities, milk powder and other dairy products, are valued at around NZ$11.8 billion for year

\textsuperscript{21}The cost for retrofitting DGW is $10,000. The cost of replacing joinery is $10,000 and assuming 50 percent of homes need replacement, the additional average cost is $5,000. Therefore, the total average cost is $10,000 plus $5,000, totalling $15,000.
\textsuperscript{22}1.570 million multiplied by two-thirds is 1.047 million.
\textsuperscript{23}The estimated cost of retrofitting is 1,047,000 houses multiplied by $15,000 equalling approximately $15.7 billion.
\textsuperscript{24}Real GDP is adjusting the figures for inflation (The Economist, 2011).
\textsuperscript{25}GDP is one of the primary indicators used to gauge the health of a country’s economy. It represents the total dollar value of all goods and services produced over a 12 months period (New Zealand Trade & Enterprise, 2016).
ending September 2015 (New Zealand Trade & Enterprise, 2016). It is also interesting to recognise that retrofitting DGW is part of the construction industry and the cost of retrofitting would represent slightly more than half of the total construction sector revenues which amount to slightly more $30 billion 26 annually (MBIE, 2013).

For homeowners, there is a significant cost associated with getting consents from Council, which usually involves engaging a professional for the application process as well as paying the fees to the Council for processing the application. The Council recommends that homeowners engage a professional, such as an architect, surveyor or engineer, to help with the complex process of applying for the building consents and resource consents approval (Auckland Council, 2016a); the professional service charge is usually quite high. Some of the fees associated with building consents include a pre-application meeting ($287), fire engineering brief meeting cost (based on hourly rates), a building application cost (total deposit of $1,901 for project value $5,000 to $19,999), a building inspections cost (deposit of $144 per inspection), a temporary structure cost ($447), a filing fee cost for third party reports ($190) and other charges (Auckland Council, 2016e). Similarly, fees that could be applicable for resource consents are a pre-application meeting cost ($287), a land-use cost ($500), fully notified or limited notified charges consent and other charges (Auckland Council, 2016e). See Appendix N for building consent, Appendix O for resource consent and Appendix P for hourly rates.

Another resource challenge is the skilled labour shortage associated with the massive growth in the building industry (CSLG, 2013). The Construction Sector Leaders Group 27 (CSDLG, 2013) points out that the construction companies are bringing in skilled labour from the United Kingdom, Ireland and Asia to cope

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26 The construction total annual revenue for 2010 is $31.923 billion, for 2011 it is $32.470 billion and for 2012 it is $32.875 billion (MBIE, 2013).
27 The construction sector workplace plan is a collaborative effort of the building and construction industry with the Canterbury Earthquake Recovery Authority and the MBIE. Other firms that are part of the panels to oversees its delivery are supports and for its delivery are Leigh Construction, Hawkins, Scirt Rebuilding infrastructure, Fletcher, City Care, Fulton Hogan, Specialist Trade Contractors Federation, Master Builders, New Zealand Contractors’ Federation, New Zealand Building Industry Federation and New Zealand most qualified Builders (CSDLG, 2013).
with the shortage of specialist trades people. Similarly, a Statistics New Zealand survey (MBIE, 2013) also showed that there is difficulty in hiring and retaining skilled staff in the construction sector with 48 percent of respondents reporting ‘severe’ or ‘moderate difficulty’ recruiting tradespersons and related workers (see Appendix I). Some of the main problems associated with this issue are the quality of the workforce, competition for the limited skilled and experienced staff as well as the escalation of building costs (CSLG, 2013). Hence, with most construction companies currently working at full capacity, homeowners seeking to retrofit their homes with DGW may find it difficult to source a reputable construction company that can do a good job as well as paying a high cost to get the job done.

According to CSLG (2013), the reason for the skilled labour shortage is that the construction sector in the whole of New Zealand is currently facing a massive growth in the building industry. Some of the growth in the building market is associated with the strengthening of buildings to meet earthquake standards in Wellington, repairs for leaky buildings and new building projects under the Auckland Plan (CSLG, 2013). In addition, growth in Auckland has moved into a new phase with house building projected to increase over a sustained period (CSLG, 2013). This increase has resulted in annual consents for 29,627 new homes reaching $10 billion for the first time, an increase of 14 percent in numbers, for the 12 months period ending August 2016 (Statistics New Zealand, 2016). Hence, Auckland as well as New Zealand as a whole are currently experiencing growth in the housing market.

The last resource challenge to be discussed in this section is time frame. As Burgess and Bennet (2006) point out, it is time consuming to remove both SGW and existing window frames and replace them with new DGW and window frames. Furthermore, additional time may be required for rebuilding the walls to fit the DGW size and weight (Burgess & Bennett, 2006). In addition, it also takes time to get building and resource consent from the Council. With reference to Appendix L, it normally takes 20 working days from the time an application is accepted to issuing a building consent (Auckland Council, 2016a). It also takes another 20 working days after final inspection to issue the code
compliance certificate (Auckland Council, 2016a). The time frame for processing resource consent is around one month for non-notified\(^{28}\) application or three months for notified\(^{29}\) application (Auckland Council, 2016a).

However, gaining a building consent approval is often not a smooth process. For example, business applicants face overly complicated systems that take three times longer than the Council indicated time frames resulting in costly delays waiting for approval (Ryan, 2016, July 25). Auckland Councillor Cameron Brewer recently commented on the issue: “we have seen some improvements in the amount of consents completed within the 20-day statutory time-frame but it seems for many the clock keeps stopping, the questions keep coming, and the requests and rules keep changing. Hearing these examples shows Council’s still got a long way to go” (Ryan, 2016, July 25, para. last). Similarly, architects, builders and renovators that are proposing better solutions to improve home performance are frustrated with councils causing delays to building approvals due to their risk adverse approach after their [councils’] experience with leaky buildings (NZBCSD, 2008).

In summary, the first resource challenge is high capital investment related to the retrofitting process that includes removing SGW and the cost of the new DGW and installation. Depending on the condition and type of window frames and walls, additional costs may be required to rebuild walls and install new window frames to accommodate the wider and heavier DGW. The other resource challenge relates to the cost of getting consents from council as retrofitting DGW may involve structural change due to the increased weight of windows on the walls. The final resource challenge identified is the shortage of a skilled labour force which could affect the quality of the workforce and result in escalating costs and the difficulty in finding a reputable company to undertake the retrofitting of DGW in a home. The first time frame challenge is the time required for the retrofitting process to remove the SGW, produce DGW in the factory and install the DGW. Additional time is required for changing the

\(^{28}\) Non-notified consent means the consent process and decision is not publicly advertised (Auckland Council, 2016a).

\(^{29}\) Notified consent means details about the application are publicly advertised to give the public the opportunity to have a say on the activity proposed in the resource consent application (Auckland Council, 2016a).
window frames and building new walls. The other time frame challenge is the period of time to get the building and resource consents which may be required for retrofitting DGW in homes; this often significantly exceeds 40 days.

2.8 Conclusion

As Nick Main, Chair of the New Zealand Business Council for Sustainable Development (NZBCSD, 2008) suggests, housing is the major component of quality of life and the majority of New Zealand homes are cold, damp and difficult to heat. He believes that “the biggest challenge is how best to address the large number of existing homes which can, with retrofitting and renovation, perform better” and “our existing homes can be more comfortable, warmer in winter, cooler in summer and healthier while using less energy and water” (NZBCSD, 2008, p. 2). The policy change in 2008 has resulted in most of the new houses built using DGW but most of the existing homes have still not been upgraded to DGW. This issue underpins the main research question of this thesis, that is what are the challenges facing homeowners and other stakeholders in retrofitting DGW in older homes.

2.9 Chapter Summary

This literature review has examined the benefits, environmental issues, regulations, resource challenges and time frames which influence the interest level of homeowners as well as an understanding of the challenges in retrofitting DGW in their older homes in New Zealand. The first three sections reviewed the benefits of retrofitting homes with DGW through an analysis of the literature. Section one highlighted the positive impact of home insulation enhanced with DGW to create an energy efficient home. The second section discussed the level of benefits that can be achieved with different options using the current technology as well as the possible future trends that could be followed in New Zealand. The third section reviewed the comfort, health and safety that can be attained by reducing noise level, regulating temperature and use of laminated glass.
Section four examined the effects, consequences, and human impact on environmental issues and how the use of DGW can help to reduce the environmental problems. The last two sections reviewed the challenges associated with retrofitting DGW. Section five assessed the challenges linked to some of the main regulatory requirements in retrofitting DGW for older homes. The final section of this chapter discussed the costs, shortage of skilled workers and time frames associated with retrofitting DGW for homeowners.

Chapter 3 discusses the research methodology and use of a qualitative approach, data collection, questionnaires, data analysis and ethical issues relevant to this study.
Chapter 3 - Methodologies

3.1 Introduction

This chapter discusses the research methodology, data collection, questionnaire, data analysis and ethics issues. In the research methodology, it evaluates the three different methodologies, quantitative, qualitative and mixed-method, which are used for research. It then selects and explains the most appropriate research approach for this research. Next, the chapter describes the process of data collection that included sourcing of participants, interviewing as well as transcription of interviews. The questionnaire section focuses on structure, use of right wording, the method of eliciting appropriate response through thematic questions as well as dynamic questions and the interview questions developed for this research. For explaining the data analysis, the chapter describes selection, process, as well as issues of thematic analysis. It ends by discussing the ethical guidelines that are adopted for this research.

3.2 Research Methodology

Research methodology refers to the selecting of an approach to research that will direct the design of the study through which data will be gathered and analysed (Given, 2016). This section starts by explaining the differences between quantitative and qualitative approaches. Next, it examines the weaknesses of quantitative and qualitative methodologies. This is followed by the discussion about the selection and process of the qualitative approach used for this research.

Two methodologies, quantitative and qualitative, are commonly used by researchers in their studies and it is important to match the right approach to the right research context (Zikmund, Babin, Carr, & Griffin, 2013). In a quantitative study, the data is in numerical form and this information is analysed using quantitative data techniques (Azorín & Cameron, 2010). On the other hand, information in a qualitative study is mostly a record of what people have
said, and this data can provide an understanding of their motivations and actions within the context of their working and personal lives (Myers, 2013). As defined by Braun and Clarke (2013), qualitative research uses words as data whereas quantitative research uses numbers as data.

The qualitative approach is often criticised, as pointed out by Cronholm and Hjalmarsson (2011), for producing weak results because they are hard or impossible to generalise; they are not objective, are hard to replicate and there is a lack of transparency. Furthermore, Hirose, Itao and Umeda (2012) also argue that interpretation of data depends on the interviewers’ background - their experiences, knowledge or education - which can result in interpretation of data from multiple perspectives. Similarly, quantitative approaches are often criticised for producing weak results since they use irrelevant hypotheses and their descriptions are too superficial.

From the two methodological approaches, qualitative methodology was chosen as the most suitable approach as it can achieve depth and breadth, capture complexity and explore other phenomenon central to this study (Carcary, 2011). Fortune, Reid and Miller (2013) also point out that qualitative research is open to multiple ways of evaluation and is often situation dependent. Braun and Clarke (2013) suggest that qualitative research is rich, exciting, and challenging in a lot of ways that capture the complexity, mess and contradiction that characterises the real world. Furthermore, qualitative research does not take the data at face value but uses its expressed meaning or experiences to explore some other phenomenon (Braun & Clarke, 2013). In addition, Given (2016) stresses that by engaging with people and by demonstrating that the project is advancing societal values, researchers are able to gather rich, valuable data that cannot be gathered by other methods.

As explained by Braun and Clarke (2013), the process of qualitative research values subjectivity and reflexivity. The authors add that qualitative research is a subjective process as it involves a researcher’s histories, values, assumptions, perspectives, politics, and mannerisms (Braun & Clarke, 2013). Some of the many factors that shape the researcher’s subjectivity in this study include more...
than 20 years of working experiences and knowledge in the architectural glass industries. It is important to note that subjectivity influences the way the research topic is introduced in the interviews, how the questions are asked to maximise value to the research as well as the passion of the researcher in looking forward to the results of the data (Braun & Clarke, 2013). Braun and Clarke add that to do qualitative research well, one needs to become reflexive, where reflexivity refers to the process of critically reflecting on the knowledge that is produced in the research and the researcher’s role in producing that knowledge (Braun & Clarke, 2013).

In summary, both qualitative and quantitative methodology exhibited weaknesses. However, they still could be used to validate and strengthen the research objectives. Nevertheless, the qualitative method was chosen as the most appropriate for this study as it can provide an understanding of the complex issues involved as well as help the researcher to achieve depth and breadth during the interviews with the participants. It was recognised that qualitative research involves subjectivity that draws on researcher’s histories, values, assumptions, perspectives, politics, and mannerisms.

### 3.3 Data Collection

This research uses the unstructured interview method for data collection as the main purpose is to obtain unique information from, or interpretations of the person (Stake, 2010). According to Brinkmann (2013), unstructured interviews have very little pre-set structure; this allows the interviewer to gather from the respondent the most important influences, experiences, circumstances, issues, themes, and lessons which can only be known in the course of spending time with the interviewees.

Packer (2011) points out that we live in a society where interviews can be watched, heard or read daily on television, radio, newspaper and magazines. The author adds that most often, a qualitative interview that takes place between two strangers is a scheduled and not a spontaneous interview (Packer, 2011). The nature of interviews is open-ended and an interviewee may not
necessarily co-operate by following the researcher’s line of questioning resulting in the researcher’s behaviour likely to be constrained (Yin, 2014).

This section discusses the identification of stakeholders as well as methods employed in sourcing for potential participants. From there, it describes the difficulty of recruiting participants. Next, it explains the purpose of interviewing. Moving forward, it discusses the online interviews as well as face to face interview. Some of the good practices are also examined, such as recording and note taking, listing topics for discussion, time frame and adopting the right protocol for the interviewing process. The last part of this section will describe the transcription process and evaluate the practice of sending a summary of interviews to participants.

As highlighted by Braun and Clarke (2013), it is always good to ask questions about who might have a stake in the outcomes and in what ways, good or bad, research might be interpreted. Hence, the stakeholders with an interest in this research are manufacturers of DGW, builders of new homes, eco-advisor\(^{30}\), renovators for older homes, Auckland Council, the Window Association and owners of old homes. In using a wide range of stakeholders with links to this research field, rich data with different perspectives based on their experiences, knowledge and background can be collected.

This research was limited to the Auckland area and the participants were sourced through:

- internet search engines such as Google and Yahoo
- yellow pages
- driving through industrial estates and housing estates
- getting contact details from offices and display board on renovation sites
- researcher’s personal contacts.

Another technique employed by the researcher in this study to find participants was ‘snowballing’. Tolich and Davidson (2011) explain that snowballing involves asking participants that have been interviewed in the research to

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\(^{30}\) Eco Advisors are consultants for creating healthier buildings, improving energy, water and material use, minimising waste, reducing environmental damage and environmental compliance risk with local regulations.
recommend other people relevant to the research, that is, within their network. The tools used by the researcher to invite potential participants to become involved in the study were telephone, email and circulating flyers (see Appendix A) in churches, cafes, and schools. In addition, to attract interest in the research, information on the research topic and a brief introduction of the researcher (see Appendix B) were sent to the potential participants.

According to Braun and Clarke (2013), recruiting participants can vary from very easy to extremely difficult, depending on the research topic. It is often difficult to recruit individuals in industries, where they may fear a threat to their job, or be sensitive to the possibility of criticism of their way of doing their work (Orna & Stevens, 2009). The challenge is for the researcher to convince potential interviewees that they should take the time and effort necessary to participate in the study (Maggi & Claire, 2013). In this regard, the researcher faced extreme difficulty in recruiting participants, especially potential participants from the industries. The success rate of getting participants was 12 out of 63 potential participants that were contacted by emails and phone calls and agreed to participate in the research. This figure does not include potential participants from flyers that were distributed in cafes and churches. Furthermore, most of the participants only agreed after close follow-up with multiple phone calls and emails to convince them that their input was vital for this research as well as the society.

Two types of interviews were conducted for this research, face to face interviews and online interviews. The interviews conducted for this research were mostly face to face with online interviews only for participants travelling overseas, located away from Auckland or who could not participate in person. Braun and Clarke (2013) define the interview as a goal of getting participants to talk about their experiences and perspectives as well as capturing their language and concepts, in relation to a topic that the researcher has determined. Interviews are conducted to find out meaningful perspectives conveyed by the participants and it is the participant's responsibility to share something from his or her perspective or experience (Maggi & Claire, 2013). Packer (2011) adds that good interviews produce rich data filled with words that
reveal the respondents' perspectives. Although researchers strive to uncover facts in the interviews, they should not focus on getting specific answers to questions but rather try to develop an understanding and interpretation of people and the situation (Maggi & Claire, 2013).

Salmons (2015) explains that researchers may choose online interviews when in-person interviews are impractical due to the presence of an outsider who may be disruptive, geographical location or hard-to-reach populations. The author adds that those who spend much of their time online may not be willing to make time for, or to travel to another location for a face-to-face interview but may agree to an online interview (Salmons, 2015). Furthermore, participants may find online communications less stressful and more convenient as they can be interviewed at home or at work, in a familiar and non-threatening physical environment (Salmons, 2015). Packer (2011) claims that participants are often at ease and able to talk freely about their points of view online. In addition, participants also have the time and space to elaborate on their own thinking in email interviewing, unhindered by the presence of the researcher, allowing for a thoughtful and personal form of conversation (James & Busher, 2009). It is also more suitable for participants who are reticent or “shy” in a face-to-face interview; they may have more confidence to “speak” freely in an email interview (James & Busher, 2009).

According to James and Busher (2009), the internet has consolidated itself as a powerful platform for individuals to communicate and as a source of information, at home, at school and at work. Furthermore, it is important to consider what participants say and the way they say it as this may contribute information when using online interviewing for qualitative research. In addition, the absence of face-to-face contact can affect participants’ knowledge construction as well as the authenticity and identity of online contributions (James & Busher, 2009).

Zikmund et al. (2013) point out that the face-to-face interview is chosen for direct feedback and clarification, probing for complex answers as well as completeness of questionnaires. The influence on the researcher’s own background and existing viewpoints on the topic could also pose a challenge to
the researcher connecting with the personal view of the participant (Davies & Hughes, 2014). Furthermore, Braun and Clarke (2013) highlight that conducting interviews can be emotionally draining and requires intense focus. Hence, the researcher should acknowledge this hindrance and apply professional skills to gain access to the perspective of the participant during the interview and not allow their own viewpoint to challenge the validity of the participant’s responses (Davies & Hughes, 2014).

This research is complex with lot of different data to collect, hence recording and note taking were used in all the face to face interviews. According to Dawson (2009), an appropriate recording instrument should be used in conducting a face to face interview. Maggi and Claire (2013) explain that recording the interview will allow production of a full transcript, which the researcher could review and add in details from the notes taken. Using digital recording provides a documented account that can be reviewed, listened to or read again and again, particularly when there is confusion about the meaning of a participant’s comment (Maggi & Claire, 2013). On the practice of note taking, Olson (2011) claims that taking notes is often distracting to participants and advises taking mental notes. However, Braun and Clarke argue that it is important to take notes during interview as it can supplement the interview transcripts (2013). It is helpful to prepare a list of topics for interviews (see Appendix F for list of topics) as it can act as a guide, and at the same time, avoid repetition by ticking off the topics once it has been discussed (Dawson, 2009). Another good practice is to plan and set the time schedule (see Appendix B for total time frame set at 40 minutes) for each topic discussion to ensure the interview session is completed within the agreed time frame (Dawson, 2009).

During the interview, it is important that the researcher uses the right protocol to communicate with participants in accordance with some of the following guidelines. First, the researcher should listen, observe and avoid being judgemental about participant responses, as participants may not talk freely if they believe that you do not agree with them (Maggi & Claire, 2013). Next, Maggi and Claire (2013) suggest that the researcher should also avoid talking
too much, encourage the participant to speak and strive to remember comments and use them to introduce the next question. The authors also add that it is only possible to ask good follow-up questions if the participants’ comments have been heard and understood (Maggi & Claire, 2013). Therefore, while probing for clarification, explanation or understanding, researchers should not influence participant’s response and should use appropriate phrases to seek details or clarifications (Dawson, 2009).

Observation is also an important guideline to use during the process of interviewing. Interviewees tend to send many messages through body language and gestures, such as facial expressions, that provide information about how the participants feel about what they are saying or if the participant does not maintain direct eye contact, it could indicate that he or she is not being completely honest, is embarrassed or does not want to think about it (Maggi & Claire, 2013). It is also important to establish rapport by treating the participants with respect, attending to the researcher’s appearance (such as dressing well for the occasion), good use of body language, strong eye contact and respect the participant’s personal space during the interview (Dawson, 2009). Closing statements generally contain a few final comments about the research, to thank the participant and provide contact information; these will give a favourable impression (Maggi & Claire, 2013). Such good practices were adopted in this research to ensure interviews were smooth and ensured rich and adequate data were collected.

According to Packer (2011), the step after conducting an interview is to transcribe it. Transcription means translating the spoken word from audio/video recordings to written words (Brinkmann, 2013). It could be a verbatim transcription that includes pauses, hesitations, laughter and body language or it could be a paraphrased transcription that captures the gist of what the speaker was saying (Guest, Namey, & Mitchell, 2013). Paraphrased transcription is more appropriate to capture the main ideas of the discussion and was used for this research in the face to face interviews. Since the transcription was assisted by another person, a confidential agreement for the transcriber was signed to
maintain confidentiality for the source of data (see appendix H for sample of agreement).

Furthermore, researchers are advised to transcribe the interview as soon as possible when it is still in their mind (Braun & Clarke, 2013). Thus, to allow time for transcription, the best option is to schedule interviews a few days apart (Braun & Clarke, 2013). Such a process was employed in this research where interviews were scheduled a few days apart and transcribed immediately after the interview.

After the transcriptions are completed, they should be sent to the participants for verification and, if necessary, changes. However, Olson (2011) points out that transcripts should not be sent to participants for review and confirmation. The author argues that this is not helpful as participants tend to spend time on correcting sentence structure and grammar and providing analytical comments about their statements rather than helping to check accuracy of the transcripts (Olson, 2011). However, Maggi and Claire (2013) claim that it is always challenging to stay true to a participant’s actual intent as the transcriptions of the interviews from discussion using notes taken as well as the recording of the conversation could take on a different meaning out of context. Therefore, to maintain the accuracy of the data in the transcripts for this research, a summarized copy of the discussions was sent to all participants for verification and changes for both online as well as face-to-face interviews.

In conclusion, stakeholders identified for this research were manufacturers of DGW, builders of new homes, eco advisor\textsuperscript{31}, renovators for older homes, Auckland Council, the Window Association and owners of old homes. This research was limited to the Auckland area and some of the methods employed to source for participants were social media, yellow pages, driving through industrial estates and housing estates, the researcher's personal contacts, as well as using the ‘snowballing’ technique. The task of recruiting participants can vary from very easy to extremely difficult with industries being more difficult.

\textsuperscript{31}Eco Advisors are consultants for creating healthier buildings, improving energy, water and material use, minimising waste, reducing environmental damage and environmental compliance risk with local regulations.
The interviews conducted for this research were mostly face to face interviews with online interviews only for participants who could not participate personally. One of the advantages identified for the online interview is that participants who are reticent or ‘shy’ in face-to-face interview may have more confidence to ‘speak’ freely in an email interview. For face-to-face interviews, researchers should ensure that appropriate recording devices, note taking, listing of topics for discussion and the setting of time frames are prepared before the interview. During the interview, the researcher should establish a rapport by adopting the right protocol such as being an active listener and observer, and avoid being judgmental and respecting the participant. The final part of this section discussed transcription of the recordings and sending summaries of the interviews to participants for verification and changes.

### 3.4 Questionnaire

According to Creswell (2014), a qualitative study research question assumes two forms: a central question; and associated sub-questions. The author adds that the central question is a broad question with several sub-questions in which sub-questions become the specific questions used for interviews (Creswell, 2014). This section firstly looks at the purpose, structure and types of information generated with regards to questionnaires. Secondly, it discusses the design of questions for unstructured interviews. Thirdly, it examines the issue of using the right wordings and types of questions that should be avoided. Fourthly, the section examines the method of eliciting appropriate responses from the interviewees with thematic questions and dynamic questions. Finally, it sets out the questions designed for this research.

The purpose of a questionnaire is to collect information that can be used as data for analysis (Martyn, 2010). The questionnaire is structured to gather information by asking people directly about the points concerned with the research (Martyn, 2010). It is likely for the information gathered from questionnaires to fall into two categories - facts and opinions (Martyn, 2010). Facts require participants to reveal straightforward information; an example
might be marital status (Martyn, 2010). On the other hand, opinions require participants to reveal information about their feelings, to express values and to weigh up alternatives that involve judgement about things (Martyn, 2010). Therefore, the information gathered in this qualitative research questionnaire most likely falls into the category of opinion as it seeks to find out the challenges from the participants’ perspectives or opinions based on their knowledge and experience.

The questionnaire for this research is designed in line with unstructured interviews for gathering data (the choice of using unstructured interviews was explained in the data collection section). In designing questions, Brinkmann (2013) explains that interviewers cannot devise a lot of specific questions. Rather, they ought to facilitate the interview process with their main role being a good listener. This could take the form of a single question with a brief set of prompts to deal with a range of topics and the interviewee is allowed to respond freely with the interviewer responding to points worthy of being followed up (Bryman & Bell, 2011). Braun and Clarke (2013) add that the researcher has, at most, a list of themes or topics for discussion as the interview is strongly participant-led. As unstructured interviews have very little pre-set structure, it is important to adjust the questionnaire during the interview as the researcher learns more about the participant’s knowledge, experience and understanding (Brinkmann, 2013).

Maggi and Claire (2013) point to questions that should be strictly avoided: questions leading interviewees to relate something that they would otherwise not; manipulative questions; leading questions; and “why” questions that tend to encourage intellectualization and can be threatening. The wording used in the questions should also be completely unambiguous. They should not be vague. They should contain a minimum amount of technical jargon and must suit the specific group of participants targeted for the research (Martyn, 2010).

Kyle (2007) describes how in interviews, thematic questions use the word ‘what’ to gather information. In addition, questions that tend to elicit information are behaviours, opinions, feelings, knowledge and senses (seen, touched, heard,
tasted or smelled), as pointed out by Maggi and Claire (2013). Kyle (2007) and Salmons (2015) claim that using dynamic questions in interviews with the word ‘how’ to probe and build rapport can keep conversation flowing. Maggi and Claire (2013) advise that after the initial questions, researchers should probe for perspectives and experiences that are the core information required for the research. Similarly, Braun and Clarke (2013) concur that prompts and probes will encourage participants to open up, expand on their answers, and provide more details.

With the above guidelines on questionnaires, this researcher designed four main questions or themes to function as discussion topics for interviews in this research:

1. What do you think are the main challenges faced by homeowners or other stakeholders in retrofitting single glazed windows with double glazed windows in home?
2. What are your/the public interests in retrofitting single glazed windows with double glazed windows?
3. What is your/the public understanding of the benefits of using double glazed windows for homes?
4. What is your interest in reducing the impact of environmental issues which is one of the benefits of using double glazed windows?

In each of the main questions, some sub questions were prepared but not shown to the participants to help the researcher in prompting interviewees for in-depth discussion of the topic (see Appendix F). The questionnaire based on the four themes - challenges, benefits, interest level, and environmental issues - were adjusted during the interview in response to the participants’ knowledge and experience.

To sum up, a questionnaire is structured to gather information which falls mainly into two categories, facts and opinions. Facts are straightforward information such as marital status and gender, whereas opinion requires participants to use their judgement in giving information. In designing questions, interviewers cannot devise a lot of specifics questions, but facilitate the interview process with their main role entailing being a good listener. Therefore,
a single question with a brief set of prompts is normally designed to deal with the wide range of topics and the interviewee is often allowed to respond freely. Some of the questions that should be strictly avoided are questions that lead the interviewee to relate something that they would otherwise not, manipulative questions and the ‘why’ questions. Furthermore, words used in the questionnaires should be unambiguous, use minimal technical jargon and suit the targeted group of participants. Two common types of questions were used in the questionnaire for this research: thematic questions that used the word ‘what’ to gather information; and dynamic questions that used the word ‘how’ to probe and to establish rapport with the interviewee. The researcher designed four main questions with sub-questions to help with the interview for this research.

3.5 Data Analysis

Data analysis is the application of reasoning to understand how the raw data that have been gathered are transformed into meaningful results to meet the objectives of the research (Zikmund et al., 2013). Thomas and Hodges (2010) point out that the researcher spends considerable time reading through transcripts of interviews conducted with participants, identifying recurring themes or ideas in the material, and selecting illustrative quotations. Furthermore, as text and data image are so dense and rich, it is important to focus on some of the data that are related to the objectives of the research and disregard other parts (Creswell, 2014). This section looks at the selection and process of thematic analysis for data analysis. Then it discusses each of the steps involved in a thematic analysis, i.e., familiarization with the data, generating the initial code, searching for themes, reviewing, and refining. The section ends by highlighting some of the issues associated with thematic analysis that researchers need to be aware of in order to take precautions.

Braun and Clarke (2013) explain that thematic analysis is one of the methods used for analysing data. Furthermore, the thematic analysis approach focuses on what is common to several interviews (Packer, 2011) and this makes it suitable for this research as the researcher can draw on the strength of
significant themes to support the objectives of this study. Given (2016) adds that the process of coding is influenced by the researcher's background, experiences, perspectives as well as the end goal of the analysis and writing. The process of thematic analysis involves searching for connecting threads and patterns among the excerpts within those categories and for connections between the various categories (Packer, 2011). Furthermore, the analysis and interpretation of the data will lead to the development of thematic codes or labels that represent the ideas (Given, 2016).

Silverman (2011) outlines the steps involved in thematic analysis; they are basically familiarizing one’s self with the data, generating initial codes, searching for themes, reviewing themes and refining themes according to the instructions below:

1. Become familiar with the dataset (take note of the initial comments and ideas) (p. 274).
2. Generate initial codes (systematically code whole dataset)
   - Label key, essential, striking, odd, interesting things.
   - Label similar items with same label.
   - These labels can be drawn from ideas emerging from close, detailed reading from your reading archive, as well as from your prior reading of empirical and theoretical works.
   - With each new application of a label, review prior labelling practices and see if the label fits what has gone before. If yes, use that label. If no, create a new one. If it fits somewhat, modify the understanding to include this label (pp. 274, 277).
3. Search for themes (collate similar codes into potential themes, gather all data for potential theme)
   - Come up with a document that lists the labels. It might be useful to give some key examples, to write a sentence or two that explains the gist of the labels and what sort of things should go together under specific labels (p. 274, 277).
4. Review themes (check if themes work in relation to dataset, check for examples that do not fit, generate a thematic map/diagram)
• For each label, collect together all the data under that label. Check whether the data and ideas collected under this label are coherent, and what are the key properties and dimensions of all the data collected under that label (p. 274, 277).

5. Refine themes (refine specifics of each theme and linkages between them, generate propositions, look for complexity, associations)

• Try to combine labels, look for links between them, look for repetitions, exceptions and try to reduce them to key ones. This will often mean shifting from more verbatim, descriptive, labels to more conceptual, abstract and analytic labels.
• Keep evaluating, adjusting, altering and modifying labels and labelling practices.
• Go back over what is already done and relabel it with new representation or ideas.
• Focus on key labels and their relationship by looking for links, patterns, associations, arrangements, relationships and sequences (p. 274, 277).

Packer (2011) explains that the final step in coding qualitative material is to replace the interviewee’s original words with a formal description.

There are some issues in thematic analysis that the researcher needs to be aware of in order to take precaution. According to Silverman (2011), changing participant’s words, for example taking out an utterance, could lead to losing a good point of analysis and can cause confusion. Another issue is that when faced with a large amount of data, bored with seeing the same issues again and again, the researcher may casually glance at it instead of looking at it thoroughly, resulting in missing out on new themes or points (Silverman, 2011). Zina (2010) also pointed out that it is important to recognise biases in thematic analysis as interpretations are always entangled with a researcher’s biases, prejudices, worldviews and paradigm. Hence, one way of managing biases is for the researcher in thematic analysis to consciously be aware of the biases by listing and remembering as many assumptions and pre-conceived notions as possible (Zina, 2010).
In summary, thematic analysis was chosen for this research because it focuses on what is common to several interviews and this allows research to draw on the strength of the relevant themes to support the study. Thematic analysis involves searching for connecting threads and patterns among the excerpts within categories and for connections between various categories. It is pointed out that the process of coding is influenced by the researcher’s background, experience and perspective as well as end goal of analysis and writing. The steps in the thematic analysis are familiarization with the data, generating initial codes, searching for themes, and reviewing and refining themes. The issues that researchers need to be aware of are: changing a participant’s words; merely glancing through a large amount of data; and their own biases.

**3.6 Ethical Considerations**

The basic principle is that researchers must recognise their moral responsibility to research participants and the needs of the research participants must take precedence over the goals of the research (Olson, 2011). Thomas and Hodges (2010) explain that research ethics are the standards of professional conducts that researchers are expected to maintain in their dealings with colleagues, sponsors and founders, research participants and the wider community. Due to much attention and controversy focused on the ethics of research, organisations have issued formal ethical guidelines defining principles and practices for conducting a research (Donn & Thomas, 2010). Based on ethical consideration, this first section looks at the reasons for the creation of ethical guidelines for research. Then, it examines some of the critical guidelines for ethics to be used in this research. The last part of this section discusses some of the ethical practices that should be avoided.

As pointed out by Zikmund et al. (2013), ethical issues do exist in research for all human interactions. Given (2016) explains that researchers and participants may benefit or are harmed by being involved in the study, hence, privacy, confidentiality, data ownership, consent, safety, representation of findings, and many other issues pertaining to the study must be explored and dealt with.
Furthermore, Guest et al. (2013) highlight that before embarking on data collection involving participants, it is critical to understand, design and conduct qualitative research within the boundaries of internationally recognized ethical guidelines that emphasise respect, beneficence and justice. It is important, too, to consider the researcher’s safety, physical, psychological and emotional and where, when and how research takes place (Braun & Clarke, 2013).

This research was approved by the Unitec Research Ethics Committee (UREC) with ethic approval: 2015-1080 as shown in Appendix I. It follows the guidelines (UREC, 2014) of the Unitec Research Ethics Committee (UREC) with the ethics approval: 2015-1080 shown in Appendix I. Some of the important criteria before carrying out an ethical interview using UREC (2014) and Creswell (2014) guidelines are highlighted below:
- Identify a beneficial research problem, i.e. it is important to identify a problem that will be meaningful to the individuals or companies being studied (see Appendix B).
- Disclose the purpose of the study, deception occurs when participants understand one purpose but the researcher has a different purpose in mind (see Appendix C).
- Do not pressure participants into signing a consent form; the researcher should explain in the instructions for consent form that participants can decide not to participate in this research (see Appendix D).

There are a few important ethical guidelines that are not mentioned above but are worth discussing. Firstly, it is important to respect the norms and charters of indigenous cultures; the researcher needs to anticipate any cultural, religious, gender, or other differences of the participants and any sites that need to be respected (this is not applicable as no Maori was involved in this research) (UREC, 2014). Secondly, Salkind (2012) points out that all participants must sign and understand an informed consent form (see Appendix D) that includes the role of participants, potential risks and benefits and participant’s rights. In addition, the company management representative must sign the organisational consent form (see Appendix E) to allow the researcher permission to interview
their employees in their organisation. Olson (2011) also points out that it is important to maintain anonymity of participants: strategies such as the removal of names of locations and individuals in the transcript helps to protect identity of participants. Even when participants expressly state that they would like to be identified, the researcher must have explicit written consent signed by the participant giving permission to do so (Olson, 2011).

There are some practices that are not ethically sound and researchers should strictly avoid them. For example, the British Psychological Society advises that it is ethically unhealthy to offer compensation or inducements (financial or otherwise) to attract participant (Braun & Clarke, 2013). Hence, this researcher chose not to offer compensation to recruit participants with all participants being chosen based on their willingness and ability to contribute to this research. Another example highlighted by Kumar (2011) is when there are many stakeholders in the research and each category of stakeholders may have different interests, perspectives, purposes, aims and motivations, which could affect the way the research activity is carried out and the way the results are communicated and used. Therefore, it is important to ensure that the research is not affected by the self-interest of any party and is not carried out in a way that harms any party (Kumar, 2011). The concern is relevant for this research with the participation of diverse stakeholders so care was taken to avoid promoting the self-interest of any group in this research.

In summary, ethical guidelines are developed because researchers and participants may benefit or be harmed in a study. Some of the critical guidelines adopted for this study are identifying a beneficial research problem, disclosure of the purpose of the study, using a consent form for participants to sign which includes privacy and confidentiality, as well as respecting norms and charters of indigenous cultures. Ethical practices that should be strictly avoided in the research include offering monetary rewards for participating in the research as well as avoiding the promotion of the self-interest of any group in this research.
3.7 Conclusion

As described by Braun and Clarke (2013), method refers to a tool or technique for collecting or analysing data; the interview is a method of collecting data while thematic analysis is the method of analysing data. By adding in ethics issues, this chapter is concluded.

3.8 Chapter Summary

This chapter discussed the qualitative and quantitative methodologies and the selection of the qualitative method as the most suitable approach for this research. It also identified relevant stakeholders linked to this research. Next, it explored the sourcing of participants through various means, such as social media, personal contacts as well as ‘snowballing’ technique. Online as well as face-to-face interviews, the recording and transcription of interviews that were used in this research were also explained. In the discussion of questionnaires, it was demonstrated that a single question with brief sets of prompts designed to deal with a wide range of topics and where participants are allowed to respond freely seemed to be the best approach for this research. Vague, ambiguous words, too much technical jargons, and leading or manipulative questions should be avoided. Thematic analysis was chosen for this research as it focuses on what is common to several interviews, allowing the researcher to draw on the strength of appropriate themes to support the research. Some of the critical guidelines on ethics were discussed and this study was shown to follow UREC ethical guidelines.

The next chapter outlines the findings with the use of thematic analysis, with emphasis on the main themes and sub-themes from the data collected.
Chapter 4 - Findings

4.1 Introduction

The results of this thematic analysis of qualitative data presented were provided by 12 stakeholders (represented by seven homeowners, one house builder, one eco advisor, one manufacturer/renovator, one member of Auckland Council, and one member of Window Association of New Zealand). The responses of the 12 stakeholders to the four questions listed in Table 4.1 were copied directly from the interview or email transcripts originally documented in MS Word and pasted into MS Excel.

Table 4.1 Questions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>What do you think are the main challenges faced by homeowners or other stakeholders in retrofitting single glazed windows with double glazed windows in your home?</td>
</tr>
<tr>
<td>2.</td>
<td>What are your public interests in retrofitting single glazed windows with double glazed windows?</td>
</tr>
<tr>
<td>3.</td>
<td>What is your public understanding of the benefits of using double glazed windows for homes?</td>
</tr>
<tr>
<td>4.</td>
<td>What is your interest in reducing the impact of environmental issues which is one of the benefits of using double glazed windows?</td>
</tr>
</tbody>
</table>

4.2 Overview of Thematic Analysis

A total of 131 significant statements (phrases, sentences, or paragraphs) were extracted from the stakeholders’ answers, with one coded statement on each row of the Excel worksheet (see Appendix A). Each statement was identified as significant for the purpose of summarising the stakeholders’ knowledge and attitudes regarding the challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in older homes in New Zealand. Background information and other non-significant statements provided by the stakeholders that were not directly aligned to the research objectives were
deleted. Table 4.2 presents the frequency distribution with a total of 131 significant statements by 12 participants.

Table 4.2 Frequency of significant statements expressed by stakeholders

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Representatives</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeowners</td>
<td>7</td>
<td>66</td>
<td>50.4%</td>
</tr>
<tr>
<td>House builder</td>
<td>1</td>
<td>23</td>
<td>17.6%</td>
</tr>
<tr>
<td>Eco advisor</td>
<td>1</td>
<td>17</td>
<td>13.0%</td>
</tr>
<tr>
<td>Auckland Council</td>
<td>1</td>
<td>11</td>
<td>8.4%</td>
</tr>
<tr>
<td>Manufacturer/Renovator</td>
<td>1</td>
<td>7</td>
<td>5.3%</td>
</tr>
<tr>
<td>Window Association of New Zealand</td>
<td>1</td>
<td>7</td>
<td>5.3%</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>131</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The seven homeowners provided slightly over half of the significant statements, and therefore the results of this study were dominated by the knowledge and attitudes of the largest group of stakeholders. After organising the transcription of the answers, assuming that all of the significant statements had equal value, a thematic analysis was conducted to reveal the multi-dimensional structure of the data. This process resulted in the emergence of four primary themes, each of which consisted of a number of significant statements, aligned to one of the four research questions, as summarised in Table 4.3.

Table 4.3 Four primary themes aligned to research questions

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Primary Theme</th>
<th>Number of significant statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are the main challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in home?</td>
<td>Challenges</td>
<td>60</td>
</tr>
<tr>
<td>2. What are homeowners and other stakeholders’ interests in retrofitting double glazed windows?</td>
<td>Interests</td>
<td>22</td>
</tr>
<tr>
<td>3. What are homeowners and other stakeholders’ understanding of the benefits of using double glazed windows for homes?</td>
<td>Benefits</td>
<td>29</td>
</tr>
<tr>
<td>4. What are homeowners and other stakeholders’ interest in reducing the impact of environmental issues which is one of the benefits of using double glazed windows?</td>
<td>Environment</td>
<td>20</td>
</tr>
</tbody>
</table>
The significant statements that comprised each of the four primary themes were subsequently classified into sub-themes. Each sub-theme explored different aspects of the manifestation of a primary theme. Tables 4.4, 4.5, 4.6, and 4.7 summarize the frequencies of the sub-themes cross-tabulated by the stakeholders for the primary themes Challenges, Interests, Benefits, and Environment, respectively. In terms of frequency of statements, Challenges was the largest primary theme, including 26 sub-themes extracted from a total of 60 significant statements. Interests included eight sub-themes extracted from a total of 22 significant statements. Benefits included seven sub-themes extracted from a total of 29 significant statements. Environmental Issues included eight sub-themes extracted from a total of 20 significant statements.

The subsequent four sections of this chapter, address the four research questions listed in Table 4.3, by summarizing and interpreting the empirical evidence used to identify each primary theme and sub-theme. Paraphrased statements provided by representative stakeholders were selected from Appendix A and quoted in the text to provide a rich description of the evidence. Consequently, the results were based primarily on the knowledge and attitudes of the stakeholders, and were not contaminated or distorted by the researcher’s own personal knowledge and attitudes regarding the action of retrofitting single glazed windows with double glazed windows for older homes in New Zealand.

The results are presented in order of magnitude of the frequencies of significant statements within each sub-theme. The implications are that sub-themes comprised of a high frequency of statements may be the most important, because they were endorsed by the most stakeholders; however, high frequency does not necessarily imply importance when evaluating significant statements in a thematic analysis (Braun & Clarke, 2013). Consequently, sub-themes identified by single statements are also included in the analysis, and given equal weight to those with a higher level of endorsement.
### Table 4.4 Frequencies of statements in 25 sub-themes within the primary theme

**Challenges** classified by stakeholders

<table>
<thead>
<tr>
<th>Sub-theme</th>
<th>Auckland Council</th>
<th>Eco advisor</th>
<th>Home owners</th>
<th>House builder</th>
<th>Manufacturer/Renovator</th>
<th>Window Association</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Consumers Needing more information</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Return on investment</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Accessing trades people</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Time consuming</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Inconvenience</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Alternatives</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Council approval</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Need advisors</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Weather</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Weight of units</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Large number of houses</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Age of house</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Number of house levels</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>More handling equipment</td>
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<td>0</td>
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<td>0</td>
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</tr>
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Table 4.5  
Frequencies of statements in eight sub-themes within the primary theme **Interests** classified by stakeholders

<table>
<thead>
<tr>
<th>Sub-theme</th>
<th>Stakeholders</th>
<th>Total</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Auckland Council</td>
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<tr>
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</tr>
<tr>
<td>Advertisements</td>
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</tr>
<tr>
<td>Age of windows</td>
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</tr>
<tr>
<td>Low interest</td>
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</tr>
<tr>
<td>Social media</td>
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</tr>
<tr>
<td>Growth in sales</td>
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</tr>
<tr>
<td>Total</td>
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</tbody>
</table>

Table 4.6  
Frequencies of statements in seven sub-themes within the primary theme **Benefits** classified by stakeholders

<table>
<thead>
<tr>
<th>Sub-theme</th>
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</tr>
</thead>
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</tr>
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<tr>
<td>Total</td>
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Table 4.7 Frequencies of statements in eight sub-themes within the primary theme Environmental Issues classified by stakeholders

<table>
<thead>
<tr>
<th>Sub-theme</th>
<th>Auckland Council</th>
<th>Eco advisor</th>
<th>Home owners</th>
<th>House builder</th>
<th>Manufacturer /Renovator</th>
<th>Window Association</th>
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</tr>
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<tr>
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4.3 Challenges

This primary theme explored the Challenges that were perceived by the stakeholders to hinder the retrofitting of single glazed windows to double glazed windows in New Zealand. The most frequent sub-theme was Cost, identified by 12 statements. For example, two homeowners stated “I would like to have our house double glazed. The only reason stopping us is really financing, i.e. cost. That would be the main thing”; and “I don’t think I will change to double glazed windows for the time being as I believe it is quite expensive. It is worth considering if budget is allowable, main thing is the budget”. The house builder replied that “Double glazed windows system for an average new house cost around $15,000. If customer wants to replace the whole house with double glazed unit, cost of retrofitting is the sad part of it as it cost a lot to remove, change the frame and install”. The eco advisor also agreed that “Largest challenge is cost and it is always going to be a barrier” as well as the Auckland Council member who stated “Biggest barrier is the cost. Cost of retrofitting existing joineries or removing existing joineries and putting in new joineries are significant cost”.

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The second most frequent challenge was **Consumers needing more information**, identified by nine statements. For example, one homeowner complained “Lack of information makes it quite difficult to approach the retrofitting process… There are so many things that unless you are very interested, you will have to search out the information”. Another homeowner complained that “One of the big challenges is lack of information on who are the reputable installers. How do you rank or how do you know who are the good installers?”. The Window Association member stated that “Education” and “Knowledge” were challenges. The manufacturer/renovator emphasized that “I believe the biggest challenge is removing the clutter and getting to the facts”.

The third most frequent challenge was **Return on investment**, identified by six statements. For example, the eco advisor argued that “People are now weighing the cost of energy against the cost of double glazing and finding that the energy cost is currently outweighed by the cost of installing double glazed window”; and also suggested that “The other challenge is to understand people’s expectation of the time frame for their return on investment. The reality is that the average return on investment for double glazing is around 20 years”. The house builder also suggested that “The cost to produce double glazed unit and retrofit into homes could offset the savings in energy cost, hence, there may be no saving in cost”. One homeowner was concerned about this issue, stating “I think people don’t recognise/ understand the cost saving involved (related to heat retention, particularly in winter) that could be quite convincing to have it done”.

The challenge of **Accessing trades people** was identified by four statements, including three homeowners complaining that “At the moment with structural building business boom in Auckland, it seems difficult to find trades people to get work done in the homes”; “When we were working on our own, we went to building centre and other centres to get ideas; we find that we don’t get contacted as a lot of these companies are having too much work which could be due to building boom”; and “I think people changing their windows would find it a big hurdle to find a reputable company”. The Auckland Council member confirmed that “If homeowners are prepared to invest in double glazing, then the
next challenge is around accessing trades people and building professionals to get the work done”.

Three homeowners were concerned that retrofitting was **Time consuming**, exemplified by one stating: “There was a long delay in starting the work that was supposed to start in February but waited until end May before they actually start to work on it” and another simply that “It’s time consuming”. The sub-theme **Inconvenience** was also identified by two homeowners, stating “Inconvenient, having to do the renovation and other stuff” and “I also expect a lot of disruption to my lifestyle during the retrofitting process”.

The sub-theme **Alternatives** referred to the Auckland Council member stating that “People will look at other options that cost less and so they might do other options first before considering double glazing”; and also by the eco advisor suggesting that “My advice is look at alternatives before you look at double glazing. Install secondary film or DIY window kits which are a cheap alternative, $35 per kit, to double glazed windows”. The challenge of **Council approval** was of concern to one homeowner stating that “…if you don’t get council approval, the insurance can be void. This is because something has been changed to the structure such as increased weight from the double glazed windows”. The Auckland Council member confirmed that “It does require consent (Auckland Council approval) in some cases and that can be a challenge. Any consents or activities always present a challenge for some homeowners”.

The sub-theme **Need advisors** was identified as a challenge by one homeowner stating that “Not like buying a house where there are many knowledgeable advisors in the market to guide me”; and also by the eco advisor confirming that “Cost analysis for decision making is undertaken by other stakeholders such as eco advisors or council energy wise officers. These advisors have to demonstrate the tipping point and persuade people to go for double glazing windows. As homeowners, they won’t do it unless they can be told that it is worthwhile”. The sub-theme **Weather** was identified as a challenge by one homeowner stating that “We are not too worried about single glazed windows because the weather is not extreme, still bearable”; and also by the house
builder suggesting that “Single glazed windows tend to be used up north, where the regulation is more relaxed as compared to the south which is much colder”; and by one homeowner.

Several challenges were reported by individual stakeholders concerned with the logistic and physical difficulties of retrofitting single glazed windows with double glazed windows for older homes. These challenges were identified by the following sub-themes. **Weight of units** was referred to by a homeowner claiming that “Our retrofitting process ended up changing new window aluminium frames for the double glazed windows as the old aluminium frames doesn’t fit as well as it cannot take the increased weight”. The house builder referred to a number of challenges that were not reported by the other stakeholders. **Large number of houses** was of concern because there is “Still huge number of houses with single glazed window”. **Age of house** was important, because “For older houses, we look at the joinery before replacing with double glazed unit”. **Number of house levels** was a challenge because “For single storey house, it is fairly easy to retrofit the windows, but for double or more level houses, it is more difficult process and will require additional equipment such as scaffolding”.

Other sub-themes identified by the house builder were that it is important to use double glazed unit **For whole building**, that it is **Difficult to retrofit doors**, and that **More handling equipment** is required to retrofit double glazed units”. The eco advisor suggested that **Not all windows suitable** “for double glazing, especially for windows that are hard to reach or windows that are triangular, circular, and other odd shaped windows”. One homeowner referred to the challenge of **Old style cladding**, stating that it is “a question of how it could be retrofitted as we do not want to change the cladding”.

Other challenges reported by individual stakeholders were identified by the following sub-themes. The house builder referred to how the **Regulation** has changed in New Zealand, and that **Geographical Location** is an issue, exemplified by “From north of Bombay, there is less demand for retrofitting double glazed unit as compared to the south of Bombay”. One homeowner suggested that **Government guidelines** were an issue, stating that
“Government must be able to create some general guidelines of cost and time, provide some kind of insights into starting points, or a common range”. The Auckland Council member suggested that Compliance was another issue, suggesting that “People will do it if there is a compliance requirement”.

One challenge referred to in detail by one stakeholder was identified by the sub-theme Misleading claims, referring to the manufacturer/renovator’s statement that “There are a lot of companies claiming performance equal to IGUs (insulated glass units, double glazed units is not the correct terminology). These products like film and applied liquid claim to perform as well as IGUs at a lower cost. In fact, they use misleading data in their claims. Most retro companies push Low E glasses which perform 10 times better than the other products”. The final challenge identified by one homeowner was No interest in developing the market “Given that the huge amount of construction currently going on, there is probably no major interest in developing the market, because they do not need to”.

4.4 Interests

The second primary theme explored the level of Interest exhibited by the stakeholders regarding the retrofitting of single glazed windows to double glazed windows in New Zealand. The most frequent sub-theme was Advice, indicated by seven statements, reflecting the interest in the amount of advice given to homeowners regarding retrofitting. For example, the eco advisor provided three statements, suggesting that “I think people who are interested in doing this should seek advice from glaziers or from eco-consultants”; that “I check the windows for retrofitting and how much it is going to cost” and “I also try to persuade homeowners to look at their own situation and break down the job by working from room to room without going to the expense of retrofitting the whole house with double glazed windows in one go”. The Auckland Council member suggested that “Double glazing is of very high of interest to people who came to see me and they commonly want to know more about double glazing”. The Window Association member stated that “When asked by these people what
they should do, we recommend that they upgrade their living room first and use that experience to guide them regarding the rest of the house”.

The second most frequent theme, with four significant statements, concerned the interests of Government. For example, one homeowner stated that “The government talk about rating systems for homes in term of comfort and sustainability” and another homeowner expressed a belief: “I think it will be the next big phase of housing upgrades (with subsidies probably - hopefully) coming from government”. The Window association member suggested that there is interest in “Promotion by government advertising”. The house builder confirmed that “Government energy savings from double glazed unit featured in television”.

Interest was also indicated by three significant statements in the sub-theme Advertisements, emphasized by the house builder stating that “Advertisement plays a part in raising awareness on the benefits of double glazed unit”. The house builder also identified the sub-theme Social media, suggesting that “In the neighbourhood where someone has double glazed unit house and post on YouTube, it creates more awareness and interest in the change”. Furthermore, the house builder stated “Because in new houses double glazed unit is now a norm and from this, retrofitting interest will continue to pick up” identifying the sub-theme Norm in new houses. He also identified the sub-theme Growth in Sales “which demonstrate increasing interest by the consumers”.

The sub-theme Age of windows, emphasized that homeowners with older houses were more likely to be interested in retrofitting, exemplified by the statement “To make my interest even higher, we have glazing problems in our house, some of our windows are failing” and “Our house is 15 years old, windows are only guaranteed for 5 years, the gap in the aluminium joineries are coming out, let water in”.

Only two homeowners expressed Low interest, reflected by the two statements “Not necessary to change at the moment in Auckland” and “I think that it (interest) is currently quite low”.
4.5 Benefits

The third primary theme explored the extent to which the stakeholders were aware of the **Benefits** that can be gained from the retrofitting of single glazed windows to double glazed windows. The most important benefit perceived by the stakeholder was identified by the sub-theme **Temperature Control**, indicated by eight statements. Examples of how **Temperature Control** was perceived to be beneficial were supplied by three homeowners stating that “I have lived in a cold house and retro-fitted the windows, experiencing first-hand the improvements retro-fitting brings so in my mind there is no doubt that the benefits are huge”; and “The house is much more comfortable and warmer. We know double glazed windows helps to keep the house warmer in winter, and keep heat out in summer. It does its job, in summer or winter”; and “Particularly important to older houses in Auckland is the issue of temperature control”. Furthermore, the house builder confirmed that “The double glazed unit make the house warmer in the winter and colder in summer”; and the Auckland Council member suggested that “This technology can reduce heat loss”.

The sub-theme **Moisture Control**, identified by six statements, emphasized that reduction in condensation was an important benefit. For example, one home owner stated that “Single glazed, unventilated windows contribute to the problem of ‘dripping panes’, causing water damage and unhealthy mould and mildew that I think could be eliminated with modern double glazing”. The eco advisor confirmed that “If you can’t get rid of condensation, then double glazing becomes an effective way of solving the issue”. The Auckland Council member suggested that “In some cases reduce condensation” and the house builder agreed that “Consumers are aware that double glazed unit keeps condensation away from glass which is one of its benefits”.

The next most frequent sub-theme, with five statements was **Noise reduction**. Statements endorsing the perceived benefits of using double glazing to reduce noise were supplied only by the homeowners. For example, “I feel that double glazing retrofits should be mandatory for all apartments with single glazing for
noise control”; and “There is some noise reduction”. **Energy savings** was similarly identified as a **Benefits** sub-theme only by the homeowners, for example by the statements “From energy point of view, using double glazed windows is good”; and “It can reduce energy use”; and “Quite sure double glazing would have bigger impact on power savings”. The sub-theme **Health** was also identified as a benefit by two homeowners, stating that “Everyone should have a healthy body, sleep better, happier in life, productivity goes up”; “Hospital might be too crowded, people less flu, due to better health”; and “Ultimately it is a healthy home that matters most”. Only one homeowner considered that **Property value** was a benefit, stating that “I think it does add value to the property”.

The eco-advisor contributed a further benefit, identified by the sub-theme **More effective than wall insulation**, highlighted by the statement “People should concentrate on the windows before they concentrate on the wall because there is a higher amount of heat loss through the windows. It’s easier and more effective to retrofit double glazed windows than retrofitting insulation on the walls”.

**4.6 Environmental Issues**

The final primary theme explored the attitudes of the stakeholders to address **Environmental Issues** through lower use of energy for heating that is made possible from the retrofitting of single glazed windows to double glazed windows in New Zealand. The most frequent sub-theme, identified by eight statements was **Energy efficiency**. The homeowners provided five statements, including “Less heating and using less energy is good benefit for the environment.”; “Now a lot of people are using heat pump, a lot of advantage if this is complemented by using double glazed windows as there will be less heat loss, hence, less energy used”. The eco advisor confirmed that “They will do it for energy efficiency which is also good for the environment. Most people, probably 50% are doing it for energy efficiency”. The manufacturer/renovator suggested that
“Retro does make houses warmer and cheaper to heat and cool therefore by default are doing exactly that, helping the environment”.

The next most frequent sub-theme, identified by six statements, was Climate change. The eco advisor suggested that “Don’t do it specifically for climate change or emissions of greenhouse gases or other kinds of environmental issues”. This suggestion was consistent with the views of the homeowners. One homeowner argued that “I would not support the action of controlling global warming as I do not believe that we have a great impact on global warming” and also that “People put in double glazed unit not because of global warming but because of social lifestyle. Motivation around retrofitting double glazed unit is more on lifestyle and most likely it is not for saving the planet”. Another homeowner stated that “Unusual weather is detrimental to lot of us. Question really is, have we reached a point where it scares all of us?”. The Auckland Council member confirmed that “It is not a primary driver for many people on the issue of climate change. In term of climate change or the environment being the main driver, I would say around 20 percent of the referrals that come to our service”. In contrast, the Windows Association member took a different point of view, stating that “Suppliers are people just like you and me - they too are concerned about the environment, global warming etc., and are keen to do their bit”.

The other sub-themes were identified by single statements from individual stakeholders. The sub-theme Not important was indicated by the eco advisor stating that “Very few homeowners make changes to their houses to prevent environmental issues”. The eco advisor also suggested that “Other stakeholders, such as council, government and private organisations, are more aware and have better understanding of the environmental issues” to identify the sub-theme Stakeholder awareness. The sub-theme Changing awareness was highlighted by the eco advisor suggesting that “Things are slowly changing, with people starting to see linkage with their actions to environmental issues and changing their attitude towards environmental issues”. Only one homeowner expressed such an attitude, indicated by the statement “Good for the environment”.
The Government was referred to by one homeowner stating “Government should quickly enforce DGW to help address environmental issues”. The final sub-theme was Profitability, indicated by the manufacturer/renovator suggesting that “Some really care about the environment issues while others are in business and profitability is the driving force”.

4.7 Conclusion

The transcriptions from the 12 stakeholders confirmed four primary themes, challenges, interests, benefits and environmental issues which are aligned to the four sub-research questions. The findings also showed that there are sufficient rich data collected from the interviews with a widespread of supporting statements for each of the primary themes from different stakeholders. This data showed that the participants chosen have the right knowledge and experience to sufficiently support the sub-research questions for this research.

4.8 Chapter Summary

Chapter four applies a qualitative research method with thematic analysis by extracting all the significant statements from the 12 stakeholders responses to generate four main themes, Challenge, Interest, Benefits and Environmental issues. With the homeowners being the majority of the participants, they dominate the results and provided more than half of the significant statements. The first main theme, Challenge, identified Cost as the most frequent sub-theme. The other significant findings in the sub-theme are Consumers needing more information, Return on investment, Accessing trades people, Time frame, Council approval and regulation. The next main theme, Interest revealed Advice as the most frequent sub-theme. The other significant sub-theme findings are Government which includes subsidies and promotion, Advertisement, Social media, Low interest and Growth of sales.
The third main theme, **Benefit**, identified *Temperature control* as the most frequent sub-theme. The other significant findings in the sub-themes are *Moisture control, Noise reduction, Energy savings, Health* and *Property value*. The final main theme, **Environmental issues**, has identified *Energy efficiency* as the most frequent sub-theme. The other significant findings in the sub-themes are *Energy efficiency, Climate change, Stakeholders awareness, Changing awareness, Not important* and *Profitability*.

The next chapter examines analyses and discusses the findings with reference to the literature review section to provide some understanding and possible answers to the main research and sub-research questions.
Chapter 5 - Discussion of Findings

5.1 Introduction

This chapter discusses the main themes from the findings by analysing them with the information provided in the literature to answer the main research question and sub-research questions. Linking the analysis to the literature review is an important part of this analysis as it contributes to, develops further, or challenges what we already know about the topic (Braun & Clarke, 2013). Figure 5.1 shows the number of statements as well as its weighting (%) against total statements in each of the primary themes used for discussion. The first part of this chapter looks at the primary theme of Challenge by evaluating the following sub-themes: Cost, Consumers needing more information, Return on investment, Accessing trade people, Time frame, and Regulation. Following this, it looks at the primary theme, Interest, and discusses sub-themes such as Advice, Government, Advertisement, Norm in new house and Low interest. Then it will study the primary theme, Benefits, by deliberating on sub-themes such as Noise reduction, Temperature control, Moisture control, Energy savings and Property value. The last section will assess the primary theme of Environmental issues by examining the sub-themes of Energy efficiency, Climate change, Stakeholder awareness, Changing awareness, Not important and profitability.

Figure 5.1: Frequencies of Statements aligned to primary themes
5.2 Challenges

This section reviews the findings of the Challenges faced by homeowners and other stakeholders in retrofitting DGW in older homes in New Zealand. It firstly discusses some of the major factors linked to sub-theme, Cost, as follows: materials and installation cost, economic impact on the total cost to retrofit DGW in all homes and strong perception of concept ‘expensive’. Secondly, this section assesses the sub-theme of Consumers needing more information by looking at participants’ responses about lack of information on the subject relating to retrofitting DGW and using the information from the literature to form the knowledge database to address this shortfall. Thirdly, it moves to the sub-theme of Return on investment and examines the ROI based on energy savings against the cost invested. Fourthly, this section weighs the reasons and problems associated with sub-theme of accessing trades people. Fifthly, it deliberates on activities that can create the following Time frame challenges: the retrofitting DGW process, Council consents approval and shortage of skilled labour. The final part of this section assesses the sub-theme Regulation by reviewing the legislation of energy efficient windows and Council consents requirements for retrofitting DGW.

5.2.1 Cost

One of the main challenges identified by most of the participants is the Cost of retrofitting DGW. There are 12 statements directly linked to cost (see table 4.4) with only one of the participants responding that cost is not the main factor stopping people from retrofitting DGW (see statement 12 in Appendix J). Some of the cost challenges directly associated with retrofitting DGW identified in the study are materials and installation cost, getting council consent cost, as well as escalating cost due to shortage of skilled workers in the construction sector. In addition, other cost challenges such as the perception of ‘expensive’ by homeowners and ‘major impact to the economy’ if all existing homes using SGW retrofitting with DGW are also evaluated.
In the literature, it is found that the average cost estimated for retrofitting a typical house in New Zealand with DGW, inclusive of materials, installation and 50 percent for replacing joinery cost, is $15,000 (Matheson, 2016). The estimated cost for installing DGW in a new house was identified in the findings as $15,000 (see statement 9 in Appendix J). However, the cost of retrofitting DGW in older homes would be much higher than installing DGW in new house as it is more expensive to remove the old windows and reinstall new DGW. As explained by Matheson (2016), the retrofitting cost could be doubled if replacing joinery for retrofitting DGW is required. Moreover, the additional costs that could be incurred for removing SGW, building new walls and joinery as well installing DGW were identified in the findings (see statement 9 and 48 in Appendix J). Furthermore, there are other costs associated with retrofitting DGW such as Auckland Council consent cost, escalating cost due to shortage of skilled labour, cost incurred for handling equipment especially multi-level houses (see significant statement 17 and 18 in Appendix J) and high cost to finance the project (see statement 19 in Appendix J). This difference could be attributed to the current typical new house being larger with more windows. This difference in cost as well as additional cost should be verified in future research.

The Cost challenge even at a minimum cost of $15,000 is viewed as high by most homeowners and other stakeholders. This is supported by statements such as “Largest challenge is cost and it is always going to be a challenge” (see statement 30 in Appendix J) and “Biggest barrier is the cost. Cost of retrofitting existing joineries or removing existing joineries and putting in new joineries are significant cost” (see statement 48 in Appendix J). As highlighted in the literature, more than one million houses in New Zealand need to be retrofitted with DGW. Similarly, in the findings, one participant commented that there are still a large number of houses using SGW in homes (see statement 15 in Appendix J). Therefore, the total cost using $15,000 per home to retrofit all existing houses in New Zealand with DGW is estimated to be around NZ$16 billion. This is a major cost when compared to New Zealand’s small economy with Real GDP of NZ$154.2 billion (New Zealand Trade & Enterprise, 2016) or the construction sector annual revenue of around $30 billion (MBIE, 2013).
The major project of retrofitting SGW in all existing homes with DGW in New Zealand could be implemented using the approach highlighted by Gulati, Nohria and Wohlgezogen (2010) and Sharma (2013). As pointed out by Gulati, Nohria and Wohlgezogen (2010), progressive companies and government should invest and develop new markets to increase their asset bases to take advantage of depressed prices during recession. As an example, during the 2008 global financial crisis, Singapore, with a gross domestic product (GDP) of SGD$281 billion in 2008 (Department of Statistics Singapore, 2015), allocated a budget of SGD$20.5 billion as its “resilience package”, dipping into its reserves, to sustain its economy (Sharma, 2013, p. 8). In the same report, it was asserted that policy makers recognized that public spending would have a higher economic multiplier effect; hence, the government brought forward several infrastructure projects which included Housing Developing Board lift upgrading, school upgrading and sewage/drainage projects (Sharma, 2013).

Therefore, the New Zealand government and other stakeholders could plan for, and support this project during recession to create wealth, generate work and spur economic growth by putting tax money to good social use. In addition, due to downturn, costs would be lower as supply would exceed demand, driving down the cost of materials with abundant supply, reduce cost and time with adequate supply of skilled labour as well as help the construction sector to retain its skilled labour in an industry that employs around 170,000 people in a wide variety of occupations (MBIE, 2013). The multiplier effects from the construction sector would flow through to the whole economy, including mining, logging and the manufacture of materials and fittings (MBIE, 2013). This retrofitting project can be considered similar to other government efforts to support the construction sector such as implementing a $1 billion financial package for leaky homes and ensuring that every state house built before 1978 that can be insulated is insulated by 2013 (MBIE, 2013). Furthermore, as identified in the literature as well as in the findings, the priority is to retrofit DGW instead of insulating the walls in homes as SGW is the greatest contributor of heat loss.
Another **Cost** related challenge is a strong perception of ‘expensive’ associated with retrofitting DGW among homeowners with statements such as:

- “really would like to have house double glazed and the only reason stopping them is cost” (see statement 1 in Appendix J)
- “do not even know how much it will cost, only that it cost a lot of money” (see statement 23 in Appendix J)
- “I don’t think I will change to DGW, I believe it is quite expensive” (see statement 42 in Appendix J)
- “I have heard that it is very expensive to retrofit DGW in my home” (see statement 44 in Appendix J)
- “It is an expensive process for a house like ours as we have majority of windows with arch shape” (see statement 54 in Appendix J)

However, the term ‘expensive’ is subjective and depends on the knowledge or awareness of the retrofitting DGW cost by participants. If we benchmark the cost of retrofitting DGW, including mortgage financing cost, against the current average value of a house in Auckland rising near to the million dollar mark (Gibson, 2016, July 5), then the cost is only around 1.5 percent\(^{32}\) of the house value. This could help to change homeowner’s perceptions of ‘expensive’ to ‘affordable and worth the money spent’ as DGW offer long term comfort and health in homes. This perception is supported by the house builder stating “I do not think cost is stopping people from changing to DGW” (see statement 12 in Appendix J. Thus, by exposing consumers to more information on the cost and benefits of retrofitting DGW in older homes through advertisements, social media and campaigns, the perception of ‘expensive’ can change to ‘worth the money’.

### 5.2.2 Consumers Needing More Information

The second most frequent challenge in the findings, **Consumers needing more information** was identified by nine statements. Some of the participants’ responses to this challenge are:

\(^{32}\) Assuming estimated cost to retrofit a house is $15,000 plus one year financing cost at 5% for mortgage, i.e. $15,000 + (5% of $15,000) equals to $15,225. Therefore, cost against market value is $15,225/$1,000,000 multiplied by 100%, equating to around 1.5%.
• “I do not know how effective it is, only hearsay” (see statement 21 in Appendix J).
• “I do not have a sense of what ways you could make it achievable” (see statement 24 in Appendix J).
• “Lack of information makes it quite difficult to approach the retrofitting process” (see statement 25 in Appendix J).
• “Education, knowledge” (see statement 56 in Appendix J)
• “I believe the removing the biggest challenge is removing the clutter and getting to the facts” (see statement 57 in Appendix J).

The sub-theme **Need advisors** also highlighted **Consumers needing more information** challenge with statements such as:

• “Not like buying a house where there are many knowledgeable advisors in the market to guide me” (see statement 47 in Appendix J).
• “Cost analysis for decision making is undertaken by other stakeholders such as eco advisors or council energy wise officers. These advisors have to demonstrate the tipping point and persuade people to go for double glazing windows. As homeowners, they won’t do it unless they can be told that it is worthwhile”.

Therefore, most homeowners have expressed their need for more information regarding retrofitting DGW. The information in the literature on home insulation and DGW, technology, comfort, health and safety, environmental issues as well as resources, time frame, more data from technical experts and future study can be used to form the knowledge base. This knowledge platform regarding retrofitting DGW in older homes, which could be under Auckland Council responsibility, can then be imparted to society through education, social media, television, schools, advertisements or campaigns. Addressing the challenge of **Consumers needing more information** through a knowledge platform can increase awareness and confidence homeowners on retrofitting their houses with DGW.
5.2.3 Return on Investment

The third most frequent challenge was *Return on investment* identified by six statements. The responses by participants on low ROI are:

- “*In a research about six years ago, it was found that the lower power bill was not motivating the people, even though it is a good thing*” (see statement 10 in Appendix J).
- “*The cost to produce double glazed unit and retrofit into homes could offset the savings in energy cost, hence, there is no saving in cost*” (see statement 14 in Appendix J).
- “*People are now weighing the cost of energy against the cost of double glazing and finding that the energy cost is currently outweighed by the cost of installing double glazed window*” (see statement 31 in Appendix J).
- “*The reality is that the average returns on investment for double glazing is around 20 years*” (see statement 33 in Appendix J).

Similarly, in the literature, a survey by BRANZ (Burgess, 1998) showed that it is difficult to offset the difference in purchase cost between single glazing and DGW purely against the cost of heating a home in New Zealand. The exception in the findings is that one of the participants stated “*I think people don’t recognise/ understand the cost saving involved (related to heat retention, particularly in winter) that could be quite convincing to have it done*”.

Therefore, it is confirmed that most homeowners and other stakeholders believe that ROI for cost invested for retrofitting DGW against energy saved is not an attractive option. Hence, to circumvent this belief, the cost invested should be compared to the advantages that DGW can bring to a home such as increased health, comfort, reduced environmental issues (Burgess, 1998) as well as increased property value.
5.2.4 Accessing Trades People

The challenge of *Accessing trades people* in the findings was identified by four statements. The statements from participants are:

- “Claims that with the current structural building boom in Auckland, it is difficult to find trade people to get work done in homes” (see statement 26 in Appendix J).
- “There were no responses from the building industries on enquiries giving the impression that a lot of these companies are having too much work due to building boom” (see statement 37 in Appendix J).
- “It would be a big hurdle to find a reputable company for retrofitting DGW” (see statement 39 in Appendix J).
- “If homeowners are prepared to invest in double glazing, then the next challenge is finding trades people and professionals to get work done” (see statement 50 in Appendix J).

Similarly, the literature has also identified a shortage of skilled workers in Auckland, and New Zealand as a whole, and that it is due to the current boom in the economic cycle in the construction sector. In ‘boom’ cycles, various problems associated with the industry include scarce labour supply, skill shortages, escalation of costs, quality of work, health and safety, as well as companies competing and poaching workers from one another (CSLG, 2013). In addition, during a downturn, experienced and skilled labour is often lost to the construction industry. Furthermore, the high volatility from ‘boom and bust’ cycle appears to be a disincentive to firms investing in training and in capital equipment (MBIE, 2013) which reduces the production of skilled labour.

It is reported by CSLG (2013) that the ‘boom and bust’ economic cycles in the construction sector are affecting the stability and sustainability of skilled labour supply in New Zealand. This issue is shown by the labour turnover figures for the year 2008 in the construction sector (MBIE, 2013). With a total of 132,240 employees (see Appendix S), there were outflows of 38,160 workers (see Appendix S) and inflows of 44,982 workers (see Appendix S). The high labour turnover occurred yearly from 2001 to 2009 suggesting that it is continuously
eroding the job skill, security and stability, both in bust as well as in boom economic cycles (MBIE, 2013).

Therefore, the concern exhibited by the homeowners is well supported by the literature that there is a skilled labour shortage. It should be noted that the tone of words used by some of the participants on this issue has negatively affected confidence levels so could lead to the loss of interest in retrofitting their homes. Thus, the authorities should mitigate the skilled labour shortages in ‘boom’ and ‘bust’ cycles, by funding major projects such as retrofitting DGW to increase demand in the bust cycles. This positive action, by funding the project during an economic crisis, can help to address the challenge of accessing trades people.

5.2.5 Time Frame

In the literature, **Time frame** challenges include:

- Remove SGW, existing window frames and replacing them with new DGW and window frames (Burgess & Bennett, 2006)
- Rebuilding the walls to fit the DGW size and weight could be necessary (Burgess & Bennett, 2006)
- Getting building consent and resource consent from Council can take more than 40 days (Auckland Council, 2016a) with high possibility of further delays in waiting for approval (Ryan, 2016, July 25).

The challenge of **Time frame** in the findings was identified by three statements. The statements from participants are:

- “It is time consuming” (see statement 2 in Appendix J).
- “Do not know how long it will take” (see statement 22 in Appendix J).
- “There was a long delay in starting the work that was supposed to start in February but waited until end May before they actually start to work” (see statement 38 in Appendix J).

In the findings, the first statement shows a perception, the second statement shows lack of information while the third statement reflected the experience of
more than two months delay before work started. There is another statement by a house builder “the reality is that the average ROI for double glazing is 20 years” which is also indirectly linked to the time frame challenge.

Therefore, a significant amount of time is involved for the retrofitting DGW process. This issue could be resolved by giving a complete breakdown of cost incurred and time taken for each process to mentally prepare homeowners in understanding and accepting the projected time frame. Other alternatives to help allay homeowners’ unnecessary fears or doubts are using eco-advisors or Council energy wise officers to prepare for the retrofitting DGW project time.

5.2.6 Regulation

The impact on energy efficient windows Regulation which resulted in most homes built after legislation using DGW is discussed as a similar regulatory approach could be adopted for retrofitting DGW in existing homes. The literature highlighted energy efficiency requirements stipulating that windows must meet building code R-value of 0.26 for homes built after September 2008 (Andric, 2011). According to Smarter Homes (2013a), standard DGW installed on thermally broken aluminium frames with R-value of 0.31 can meet the energy efficient windows requirement. This legislation has most likely influenced significant national market penetration in the use of DGW, which rose from 30 percent in 2007 to 90 percent in 2011 (Burgess, 2014). In addition, the legislation of a building code for energy efficiency windows, which was implemented on 30 September 2008, has resulted in a majority of the homes built or renovated after this period using DGW (Andric, 2011).

On the other hand, a survey by BRANZ before the legislation for energy efficient windows, showed that use of hermetically sealed insulated glazing units (DGW) for the New Zealand domestic market had increased from 6 percent in 1994 to 28 percent in 2006, and is expected to rise as public acceptance of DGW increases (Burgess & Bennett, 2006). However, it was reported recently that there were still approximately one million homes in New
Zealand without insulation (Edmunds, 2015) and that the figures did not change much between 2008 and 2013. Therefore, this demonstrated that low public acceptance still persisted in retrofitting DGW in older homes. This finding that regulation is an effective motivating driver for retrofitting DGW in existing homes is supported by the Auckland Council member who mentioned that “people will do it if there is a compliance requirement” (see statement 51 in Appendix M). Another participant, the house builder, stated that “…regulation has changed in New Zealand … with double glazing. In general, for new houses, double glazed units have become a norm” (see statement 5 in Appendix M).

Besides the homeowners’ resistance to change, landlords are also opposed to retrofitting DGW in their homes as it can lead to increases in rents. Bierre (2013) reported that although the largest national organisation of landlords support the insulation of rental properties, they are in opposition to the introduction of a minimal standard because of the likely increase in rents (New Zealand Property Investors Federation, 6 September 2012). Furthermore, as pointed out by Howell (2010), based on a study conducted with Council officers in New Zealand, policies that “promote”, “support”, or “encourage” sustainable home building choices are viewed as soft and inappropriate. In addition, when there are no rules to govern sustainable building choices, people are discouraged from choosing them as they do not want the added risk, time and cost associated with the consent requirements as well as having to prove that they meet the Council requirements (Howell, 2010).

Therefore, Regulation may have to be used as a motivating driver to change the mind-set of homeowners in retrofitting their homes with DGW. The strategy of implementing regulation of retrofitting DGW for older homes could emulate the way Auckland Council implement the new policy to regulate open burning as air quality in Auckland has exceeded health-based standards (Metcalfe, Sridhar, Wickham, & Emission Impossible Ltd, 2013) through enforcement and education. Enforcement measures are ‘point of sale rule’, ‘no new installations except replacements’ and ‘open fire ban’. Education strategies for best practice air quality management include regulating or influencing fuel quality,
encouraging good wood burner operation and flue maintenance, educating manufacturers, retailers, installers and the general public, as well as partnering with key stakeholders (Metcalfe et al., 2013). Hence, adopting the same approach, legislating for retrofitting DGW for all homes could be implemented with enforcement, education, and partnership with relevant stakeholders.

Another Regulation challenge is getting Council consents. There are ten statements by five participants relating to Council consent requirements (see Appendix M). Figure 5 shows the breakdown of statements that are all related requirements for a building consent. The other statements such as old style cladding, age of house, weight of units, and age of windows may require new joinery which could alter the building structure, thus be subject to Council consents. The number of levels in a home for renovation can also affect consents requirements as only buildings less than two storeys may be exempted (Auckland Council, 2016b).

Figure 5.2: Significant Statements linked to Regulation

Similarly, it is also identified in the literature that retrofitting DGW is a part of renovation works that may require Council consent to ensure safe and effective
implementation of building or renovation works (Auckland Council, 2016a). Auckland Council (2016a) recommended that homeowners engage a professional as applying for building and resource consents are complex. It also highlighted that the consequences of not getting Council consents may result in a fine, and trouble selling the property or insuring the building (Auckland Council, 2016c).

In view of the challenge of Council consents, it is likely to stop homeowners from retrofitting their homes with DGW. However, vacuum technology in DGW can be used to replace SGW as their overall thickness and weight are similar as well as providing similar thermal and acoustic performance. Therefore, Council consent may not be required with vacuum DGW which can fit into existing SGW joinery, for both aluminium frames as well as wooden frames, with no increase in the weight or width of the DGW.

In summary, the estimated cost of $15,000 for retrofitting homes with DGW is considered a major Cost challenge to homeowners and other stakeholders. Furthermore, the total cost to retrofit SGW in all older homes with DGW is estimated to be $16 billion, a key cost challenge to the New Zealand government when compared to its Real GDP of $154.2 billion. Hence, it is recommended to implement retrofitting DGW during financial crisis to sustain the economy. The perception of ‘expensive’ by homeowners is identified as lack of knowledge of the costs associated with retrofitting DGW in their homes. This could be changed to ‘affordable and worth the money spent’ through understanding, awareness and knowledge of the benefits from retrofitting DGW and that cost invested is only around 1.5 percent of current Auckland houses.

The information in the literature about home insulation and DGW, technology, comfort, health and safety, environmental issues, more data from experts and future study can form a knowledge platform to address the challenge of Consumers needing more information. The Return of investment of around 20 years is identified as an unattractive investment for most of the homeowners to retrofit their homes with DGW, hence, education campaigns on increased health and comfort are recommended to address this challenge.
The challenge of *Accessing trades people* is found to be due to the volatility from ‘boom’ and ‘bust’ cycles in the construction sector. This has resulted in high turnover and low production of skilled labour that lead to shortages of trades people. Some of the key factors identified in the *Time frame* challenge were lengthy time for Council consents, significant amount of time required for retrofitting DGW in older homes and ROI of around 20 years. Therefore, the establishment of a knowledge platform with details on time frame as well as use of eco-advisors or Council energy wise officers could increase the understanding and awareness of homeowners to alleviate homeowner concern with time frames.

### 5.3 Interests

This section discusses the findings on the level of *Interest* regarding the retrofitting of DGW in older homes by homeowners and other stakeholders. It first examines findings from sub-themes *Advice, Government, Advertisement, Norm in new houses, Growth in sales, Age of windows* and *Low interest*. Then, it reviews some of the sub-themes in *Challenges* such as *Geographical location, High cost, difficulty in Accessing trades people* and *Time consuming* that can directly influence the interest level of homeowners. It also considers the use of words in the interviews that showed the level of interest exhibited by participants.

In the findings, there are seven significant statements on sub-theme *Advice* relating to the interest level of homeowners. Four of these statements advised homeowners to consult eco-advisors or glaziers due to the complexity or lack of knowledge in retrofitting DGW. The remaining three statements showed that knowledge and awareness on retrofitting DGW should be made available to the homeowners through education and promotion. Examples are “Need more education and promotion. More awareness to get people interested” (see statement 75 Appendix J) and “Need more education and promotion, more awareness to get people interested” (see statement 75 Appendix J). The lack of knowledge was quoted by one of the participants - “not like buying a house
where there are many knowledgeable advisors in the market to guide me”. Therefore, these statements on seeking help from advisors, complexity and lack of knowledge, need for more education, promotion and awareness are found to have lowered the level of interest of homeowners in retrofitting DGW.

There are three significant statements in sub-theme Advertisement found to be related to the awareness of homeowners of retrofitting DGW in older homes. Similarly, three of the four statements in sub-theme Government also showed some of the efforts by government and related stakeholders to increase homeowners’ awareness of retrofitting DGW were promoting DGW to the public, explaining energy savings using DGW and using the rating system of DGW for home in terms of comfort and sustainability. These statements on advertisements and marketing campaigns by retrofitting companies and government agencies through television and social media (YouTube) should have increased the awareness and interest of DGW. In addition, in sub-theme Norm in new houses, participants highlight that the culture of using DGW in new houses will influence retrofitting DGW interest in existing houses. The sub-theme Growth in sales also indicates that there should be an increasing interest of consumers in retrofitting DGW in their homes.

However, contrary to all the above claims of an increase in retrofitting DGW, the figure of houses retrofitted with DGW does not seem to have changed much. The figure of around 1.04 million homes built before energy efficient windows regulation in 2008 (NZBCSD, 2008) and approximately 1.047 million homes in 2013 still without insulation and most likely without DGW (Statistics New Zealand, 2014b) showed there has been little interest in retrofitting DGW in existing homes. Thus, the advertisements and campaigns, culture of DGW in new homes and the growth DGW sales seem to have failed to make a significant difference in homeowners’ interest in retrofitting their homes with DGW.

There are two statements with sub-theme Low interest where participants state that their priority is on ceilings and walls and it is not necessary to retrofit DGW in their homes. Similarly, some of the low interest level is exhibited by
participants in their use of words in the statements. Some of these statements are:

- “I don’t think I will change to double glazed windows for the time being as I believe it is quite expensive” under sub-theme **Cost** (see statement 42 in Appendix J).
- “I also expect a lot of disruption to my lifestyle during the retrofitting process” (see statement 45 in Appendix J) under sub-theme **Inconvenience**.
- Statements made by participants expressing difficulty in sub-theme **Accessing trades people**.
- Statements made by participants expressing lengthy time frame in subtheme **Time consuming**.

All these statements point to expression of low interest level by homeowners in retrofitting their homes with DGW.

Furthermore, it was reported in the literature that the construction sector is now ‘booming’ in New Zealand generally and in Auckland specifically, resulting in a shortage of skilled labour. This can result in the construction companies not interested in taking on the retrofitting DGW jobs as they are running to full capacity. It can also lead to homeowners losing interest when they experience difficulty finding contractors to retrofit their homes with DGW. Other key challenges that reduce homeowners’ interest in retrofitting DGW were identified as high cost, council consent complexity and lengthy time frame.

The fourth statement sub-theme **Government** came from homeowner who anticipated housing upgrades and hoped for budget wish of government subsidies for retrofitting DGW. As the government has successfully funded some of the major project including insulation in homes (MBIE, 2013), it should also start to fund the retrofitting DGW in older homes. This is because retrofitting SGW with DGW will retain more heat than walls insulation (RETRO Double Glazing, 2016) and DGW can also provide more benefits such as temperature stability, noise reduction and moisture control. In addition, the
statements from sub-theme *Age of windows* emphasised that homeowners of older homes with windows that may be failing and need to be replaced are more likely to be interested in retrofitting DGW. Furthermore, the sub-theme *Geographical location* in Challenges which stated that “*From north of Bombay, there is less demand for retrofitting double glazed unit as compared to the south of Bombay*” (see statement 7 Appendix J) showed that location where weather is colder also attracted a higher interest of homeowners in retrofitting DGW in their homes. Hence, this study demonstrated that government subsidies, old windows that are failing and homes located in colder climates can increase homeowners’ interest in retrofitting DGW in their homes.

In summary, the complexity, lack of knowledge and low awareness are found to reduce homeowners’ interest in retrofitting their older homes with DGW. Furthermore, the marketing campaigns, advertisements, newly built DGW culture and growth in DGW sales have failed to generate a significant increase in homeowners’ interest in retrofitting DGW. In addition, some participants have indicated directly or indirectly by their words, such as “*a lot of disruption to my lifestyle during retrofitting DGW process*”, that they were not interested in retrofitting DGW. Furthermore, with the construction sector boom in Auckland, construction companies may be running at full capacity and so unable to cope with the retrofitting DGW works. Hence, homeowners may lose interest when they experience difficulty in sourcing for contractors to retrofit their homes. Other factors in primary theme *Challenge*, such as high cost and lengthy time frame, can reduce homeowners’ interest in retrofitting DGW in homes. Therefore, creating a knowledge platform that is easily accessible by homeowners is recommended to educate and increase their awareness and interest level in retrofitting existing homes with DGW.

However, some interest in retrofitting DGW was identified in the study that could persuade homeowners to retrofit their homes with DGW. The first interest expressed by a participant was retrofitting DGW in homes with a government subsidy. Since the government has successfully funded some major projects for home insulation and retrofitting DGW was identified in the literature and the findings as a priority over home insulation, some funding should also be
provided to encourage homeowners to retrofit DGW in their homes. In addition, houses with old windows that are failing as well as those located in colder climates were identified as having a higher interest in retrofitting.

### 5.4 Benefits

The homeowners’ and other stakeholders’ understanding of the benefits of using DGW for homes, are evaluated in this section. The main **Benefits** associated with retrofitting DGW identified by participants in the research are comfort, health and safety, energy savings as well as adding to property value. The source of benefits discussed in using DGW are **Noise Reduction**, **Temperature control**, **Moisture control** and preventing injury that can lead to comfortable, healthy and safe homes. In addition, DGW reduces heat loss that can lower energy used for space heating or cooling in homes. The cost of retrofit DGW in homes and its superior advantages can add value to the property.

In the literature, some of the comfort and health benefits from retrofitting DGW in homes are noise reduction, temperature control and moisture control. In findings, sub-theme **Temperature control** is identified by eight statements and was perceived to be beneficial by most of the participants. The next sub-theme, **Moisture control**, was further identified by six statements followed by **Noise reduction** which was identified by five statements. The sub-theme identified by eco-advisor that DGW is **More effective than wall insulation** is related to sub-theme **Temperature control**. The sub-theme **Health** was identified by two homeowners who emphasised that healthy home will result in higher productivity and prevent hospitals from overcrowding and are related to all sub-themes **Noise reduction**, **Temperature control** and **Moisture control**.

The findings identified that DGW reduces noise level and it should be mandatory for all apartments for **Noise reduction**. In the literature, reducing noise levels was identified as one of the most important benefits of DGW as it increases the comfort of a home (Window Association of New Zealand, 2010).
Noise is uncomfortable because it is too loud or is a mixture of annoying sounds that distract people such as distant conversations (McKinney et al., 2013). Furthermore, serious health hazards related to noise pollution were identified as hearing loss (Sankar, 2015), emotional trauma resulting in depression and high blood pressure (Chambers, 2009; El Nemr, 2010; Sankar, 2015; McKinney et al., 2013) and possibility of neurosis and nervous breakdown (El Nemr, 2010). Furthermore, hearing damage begins from long exposure to busy motorways at around 70 dB sound level and irreversible hearing loss can occur almost instantaneously from aircraft carrier deck jet operation with a sound level around 130 dB (McKinney et al., 2013).

As identified in literature, sound finds its way into a building easiest through windows (DuPont de Nemours, 2003). The minimum effective sound barrier in a building is STC rating of 50 but a typical 3mm SGW can only provide sound insulation with STC rating of 25 (Everest & Pohlmann, 2015). However, DGW can provide a minimum STC rating of 50 (Everest & Pohlmann, 2015). Furthermore, there are different design options that can reduce higher levels of noise. Some examples are using two glass panes of different thicknesses (Everest & Pohlmann, 2015), adding PVB interlayer in laminated glass (DuPont de Nemours, 2003) or triple glazing windows. In addition, Nolan, (2011), Pilkington (2015) and Zhang and Wang (2010) point out that noise is worsening with industrialisation, urbanisation and advances in technology.

Therefore, the current and increasing noise pollution clearly establishes the need for effective **Noise reduction** strategies and DGW can play that important role. As identified in the findings, five homeowners understood that reducing noise is one of the benefits but did not relate it to the comfort of a home or better health. This makes it important to educate the public on the role of DGW in reducing noise levels so as to provide a healthy and comfortable environment.

The keyword identified in the findings on sub-theme **Temperature control** are comfortable, warm in winter and cool in summer, and reducing heat loss. Another sub-theme **More effective than wall insulation** was identified by the
eco-advisor who highlighted that a higher amount of heat is lost through windows which makes retrofitting DGW more effective than wall insulation for temperature control. Similarly, it was identified in the literature that the use of DGW can reduce the impact of radiation by slowing the transfer of heat in and out of a house, resulting in a stable temperature (CCANZ, 2010). The Benefits associated with DGW identified in the literature on regulating temperature in a home, hot or cold, were increased level of comfort and health (Harley, 2012). Stable temperatures also contributed to a healthier living environment as cold temperatures for older people and the very young could aggravate asthma and other allergic attacks (CCANZ, 2010). Hence, the study showed that retrofitting DGW in existing homes can bring increased comfort and health to homes.

In the findings of sub-theme Moisture control, participants' statements showed their awareness of the benefits of moisture control from using DGW such as preventing condensation, water damage and mould. In the literature, a stable temperature in homes showed that it can provide health benefits by reducing the growth of mould and fungi that causes illnesses. Furthermore, mouldy homes are identified as one of the more serious health issues in New Zealand where 45 percent of the 1.6 million existing homes are mouldy and most of them would not meet the insulation levels in the new Building Code (NZBCSD, 2008). It is found that homes with well-insulated walls and DGW have a stable temperature that can reduce the risk of condensation in homes and can prevent the growth of mould and fungi (CCANZ, 2010). Moulds are identified as living organisms that can trigger asthma attacks for individuals who have compromised immune systems (Larsen, 2010).

In the literature, providing a safe environment is another important benefit that can be achieved by retrofitting DGW with laminated glass in homes. G. James Glass (n.d) explains that when an accidental human impact occurs, the bond between the glass and interlayer in the laminated glass combine to absorb the force of the impact with fragments typically remaining intact to prevent serious injury. In addition, laminated glass provides protection areas prone to hurricane and other natural disasters to prevent injury and damage from the glass fallout (Eastman Chemical Company, 2016a). Thus, it is identified that using
laminated glass on one or both panels in the DGW can increase the safety of a home.

Energy savings was identified by three statements in the findings. The common understanding by participants is that DGW helps to create an energy efficient home by reducing heat loss to save energy. However, they highlighted that they are not aware of quantum savings on their power bills. In the literature, RETRO Double Glazing (2016) claims that modern houses with insulation can lose up to 45 percent of their internal heat through SGW. KIWIDG (2016b) explains that heat losses can be reduced by around 56 percent with standard DGW and approximately 74 percent with Low-E DGW. Therefore, use of DGW makes homes energy efficient by collecting and retaining the natural source of energy from the Sun.

One of the participants identified Property value as a Benefit by stating that DGW will add value to the property. Therefore, the retrofitting DGW cost and intangible value associated with the benefits such as energy efficient, comfort, health and safety should be added to the Auckland Council capital valuation as they are similar to a good location of a house that can command a premium value on the property. The benefit of higher property value is recognising the superior quality of a home retrofitted with DGW.

In summary, most homeowners are aware that DGW can reduce the noise level in homes but do not relate Noise reduction to the benefits of health and comfort. It is identified that SGW do not provide adequate sound barriers while standard DGW provides sufficient sound barriers to reduce noise. The study showed that one of the health hazards associated with noise is hearing loss. People that are continuously exposed to sound level at 70dB can suffer from hearing loss and immediate irreversible hearing loss at a sound level of 130dB. Other noise related health issues identified were depression, high blood pressure, affects cardio-vascular system, neurosis and nervous breakdown.

Temperature control was identified in the findings as contributing to benefits such as comfort and health with retrofitting DGW in homes by the participants.
DGW provides comfort as regulating the temperature keep homes warm in winter and cool in summer. It also helps to prevent asthma and other allergic attacks on the elderly and the very young with warmer temperature. Furthermore, the moisture control from DGW can reduce condensation and inhibit the growth of mould that can exacerbate respiratory conditions in people suffering from such illnesses. Other significant findings identified as to the benefits from DGW were safety, energy savings and Auckland Council should add costs associated with retrofitting DGW to the home’s capital valuation.

5.5 Environmental Issues

This section explores the homeowners and other stakeholders’ interest in reducing the impact of Environmental issues which is one benefits of using DGW. The main sub-themes identified in the findings that are discussed in this section include Energy efficiency, Climate change, Changing awareness, Stakeholder awareness, Not important and Profitability.

The most frequent sub-theme Energy efficiency linked to environmental issues was apparent in eight statements. They identified that homes retrofitted with DGW used less heating in winter and less cooling in summer, hence, reducing energy consumption which is good for the environment. Furthermore, the eco-advisor suggested that most people will retrofit their homes with DGW for energy efficiency. In the literature, it was stated that using DGW results in energy efficient homes that used less energy required for heating in cold weather (RETRO Double Glazing, 2016). The findings showed that most homeowners are aware that using DGW is environmental friendly as less energy is used.

The next most frequent sub-theme, Climate change, was identified by six statements. Most of the homeowners suggested that they would not retrofit DGW in their homes for reasons of climate change, emissions of greenhouse gases or other kind of environmental issues. One homeowner did not support the action of controlling global warming due to his/ her belief that human activity
does not have a great impact on global warming. Another homeowner questioned whether the unusual weather had reached a point where it will scare most of the people. Similarly, Gilbert (2016), a sociologist in a recent article in *The New Zealand Herald*, also reported that since the 1960s, it has been known that heat-trapping gasses were increasing in the earth’s atmosphere, but no one knew what the effect would be. The Auckland Council member stated that climate change is not the primary driver for homeowners to retrofit their homes with DGW.

These findings showed that homeowners are more concerned with cost rather than the environment. Similarly, Raman, Gajbhiypedh and Khandeshwar (2014) pointed out that there is a growing concern in the world about the environmental effects of social and economic development efforts and that nations face tremendous costs in addressing these issues. However, human beings need to adapt to reducing their carbon impact on the environment to protect themselves against future extreme climates (Chivers, 2010). Furthermore, the challenge of tackling *Climate change* is not just a technical issue but involves politics, lifestyles, economics, power structures, culture and beliefs (Chivers, 2010).

In the literature, according to Cook (2012), greenhouse gases play a major role in absorbing some of the solar radiation and re-emitting it back to earth, keeping the Earth warm. However, one of the major components of greenhouses, CO₂, is increasing, making the earth warmer (Cook, 2012). Most of the energy used to heat up homes comes from the burning of fossil fuel that releases CO₂ and N₂O into the atmosphere (Skates, 2011). Furthermore, meta studies show that 97 percent of published climate scientists agree that global warming is occurring and that it is caused by human activities (Gilbert, 2016). It is also highlighted that global warming is now a generally recognized phenomenon and CO₂ has been identified as one of the main culprits blamed for this issue (Skates, 2011). Therefore, there is evidence that global warming is occurring, and using DGW in homes can reduce energy used for heating (RETRO Double Glazing, 2016) to cut CO₂ production and help to address the global warming issue.
The other sub-theme **Not important** indicated that very few people make changes to their homes to address **Environmental issues.** The sub-theme, **Profitability,** was raised by the manufacturer/renovator who suggested that while some people really care about the environment, profitability is still the driving force for other people. As one participant under sub-theme **Climate change** stated “**have we reached the point where climate has hit us badly to initiate changes?**” These sub-themes suggest that retrofitting DGW in homes to help address the environmental issues is not a priority. However, in the literature, it is evident that the consequences of global warming include significant climate change that has resulted in global temperatures rising, causing storms to be more violent, rainfall to be heavier, high tides and flooding to be more frequent than before with huge economic damage, spread of tropical diseases as well as loss of life (Quaschning, 2010). An example of frequent extreme weather in Taiwan is the category 4 storm, Nepartak on 8 July 2016 (Calvo, 2016) and the category 5 storm Meranti on 14 September 2016 (ABC NEWS, 2016) which within three months had devastated the country.

However, subtheme **Stakeholder awareness** suggests that other stakeholders are more aware and have better understanding of the environmental issues than homeowners. It is good to note in sub-theme **Changing awareness** that things are slowly changing and people are starting to link their action to and change their action regarding environmental issues. Only one homeowner expressed a positive attitude with “**Good for the environment**”. Furthermore, the Window Association member claimed that most suppliers are concerned and keen to help with the environment issues. Hence, the industries are found to be keen on environmental issues which could be due to regular training, education, regulation and practices related to saving the environment such as recycling. Therefore, through education and regulation, the mind-set of homeowners could be changed to help address environmental issues, as has been the case in the industries.
In summary, most homeowners are aware of the *Energy efficiency* that comes with DGW and that it is good for environment. It is confirmed that most of the people would retrofit their homes with DGW based on energy efficiency. In addition, *Climate change* is not an appealing factor to drive homeowners into retrofitting DGW in their homes even though there is some evidence of climate change with the example of frequent extreme storms in Taiwan. Furthermore, the findings also showed that very few people make changes to their homes to address environmental issues; profitability is still the main driving force. On the other hand, awareness of environmental concerns is slowly changing and people are starting to link and change their actions in light of environmental issues. Therefore, as is practised in industries, education and regulation can help to change the attitude of homeowners regarding environmental issues.

5.6 Conclusion

The *Challenges, Interest, Benefits* and *Environmental issues* were shown to be linked to each other. The *Challenges*, such as high *Cost* or difficulty in *Accessing trades people*, will reduce the *Interest* level of homeowners. On the other hand, understanding the *Benefits*, such as health and comfort, through *Noise reduction, Temperature control* and *Moisture control* can increase homeowner’s *Interest*. Regulating energy efficient windows for new houses is using *Regulation* under primary theme *Challenges* to ensure homes are healthy, comfortable and environmental friendly, to drive the *Interest* of using DGW in homes and help to address *Environmental issues*.

5.7 Chapter Summary

This chapter analysed the findings from the interviews in comparison with the literature in order to deliver the conclusions for the research. Each of the four primary themes was discussed to support the research sub-questions. It first looked at the sub-themes of high *Cost, Consumers needing more information*, low *Return on investment*, lengthy *Time frame* and complex *Regulation* which are sub-themes of the primary theme, *Challenges*. The
findings confirmed all these sub-themes were hindering homeowners from retrofitting their homes with DGW. The second primary theme, **Interest**, covered the sub-themes of *Advice, Government, Advertisement, Norm in new houses, Growth in sales, Age of windows* and *Low Interest* with regards to retrofitting DGW. The findings on the sub-themes, including tone of words used by the interviewees, exhibited low interest among most homeowners in retrofitting homes with DGW.

The next primary theme, **Benefits**, discussed the comfort, health and safety, energy savings as well as increased *Property value* from retrofitting DGW. The levels of knowledge and understanding of homeowners of the benefits linked to retrofitting of DGW in homes were found to be low. This low level of knowledge and understanding has resulted in low interest among homeowners to retrofit their homes with DGW. The final primary theme, **Environmental issues**, canvassed the sub-themes of *Energy efficiency, Climate change, Changing awareness, Stakeholder awareness, Not important* and *Profitability*. The findings were generally not favourable to addressing environmental issues as most homeowners were more interested in economic gain.

Chapter Six summarises the overall findings and suggests recommendations gathered from the discussion of the findings and literature in Chapter five. It also outlines the limitations associated with this research, proposes further research to enhance the knowledge platform, and concludes with a closing statement.
Chapter 6 - Conclusions and Recommendations

6.1 Introduction

This chapter draws together the research project and findings of this thesis. Firstly, it will summarise the overall findings about the challenges faced by homeowners and other stakeholders in retrofitting DGW in older homes in New Zealand. Based on this, the chapter will, secondly, provide some recommendations that could help deal with the challenges associated with retrofitting DGW. To close this thesis, the limitations faced by the researcher in carrying out this study will be highlighted and further research on this topic will be proposed. The chapter then concludes with a closing statement.

6.2 Research Conclusions

The research identified a number of challenges faced by homeowners and other stakeholders in retrofitting DGW in older homes in New Zealand. The first finding is the high cost of retrofitting DGW including materials costs, installation costs and Council consent costs. This is aggravated by the rising cost of retrofitting DGW due to skilled labour shortages. Closely related to the high cost of retrofitting DGW is the perception of homeowners that it is ‘expensive’ with many not knowing what the actual cost is likely to be. The next major finding relates to the lack of easily available knowledge associated with retrofitting DGW. The low ROI based on energy savings versus cost invested is another finding that has deterred homeowners from retrofitting their homes with DGW.

Furthermore, the study identified that it is difficult to access trades people due to the current housing ‘boom’ in Auckland and throughout New Zealand. The skilled labour shortages are highlighted as a major challenge for most homeowners in retrofitting their homes with DGW as they cannot find reputable contractors for the retrofitting work. The uncertain and lengthy time frame associated with retrofitting DGW as well as getting Council consent is found to have discouraged most homeowners from retrofitting DGW in their homes. The
last finding relates to the **complexity of regulation** that could be applicable to retrofitting DGW and thus is often viewed as a major challenge by homeowners.

The level of interest demonstrated by owners of old homes in retrofitting their homes with DGW was found to be generally low. *Advertisements and marketing campaigns* by the building companies and the government, as well as the accepted practice of using DGW in newly built homes were found to have failed to get the majority of the older homes retrofitted with DGW. Some of the homeowners also indicated low interest with comments about the disruption to their lifestyle during the retrofitting of DGW in their homes. Similarly, as mentioned above, the current construction ‘boom’ in Auckland and rest of the country has also resulted in construction companies being unable to take on the retrofitting DGW jobs as they are operating at full capacity. In addition, the findings showed that homeowners’ interest is affected by the **complexity and lack of knowledge** of the process of retrofitting DGW in homes. On the other hand, the research demonstrated that the provision of government subsidies, owning houses with old windows that need to be replaced and homes located in colder parts of New Zealand can influence homeowners’ decision to retrofit their homes with DGW.

The other stakeholders in this study were more aware than homeowners of the benefits of using DGW in homes such as how using a different design of DGW reduces levels of noise or heat losses. It was found in the study that **homeowners may lack understanding on the degree** of benefits that DGW can bring to their home; this point was substantiated by information from the literature. The first common benefit identified in this research is that DGW can **reduce noise** in homes to provide increased comfort and health. Long-term exposure to a busy motorway noise level of around 70dB can lead to hearing damage. The **temperature control** is another key finding that can bring benefits, such as comfort and health to homes. DGW is 56 percent to 74 percent more effective than SGW in slowing the transfer of heat and creating a stable temperature. The stable temperature keeps home warm in winter and cool in summer, making it more comfortable and healthy. A stable temperature can also **prevent condensation** and the growth of mould and fungi. It has
been found that around 45 percent of existing New Zealand homes were mouldy and mould can worsen respiratory conditions for people suffering from these disorders.

The next finding on benefit associated with DGW includes energy. Even modern homes with insulation can lose 45 percent of the heat from homes with SGW. The heat loss from SGW can be reduced by about 56 percent with standard DGW and approximately 74 percent with Low-E DGW thus saving energy from not having to heat homes. A benefit associated with DGW with laminated glass that is often overlooked by most homeowners is safety. Serious injury is prevented by the bond between the glass and interlayer holding onto the fragments of broken glass in cases of accidental human impact, hurricane, or other natural disasters. The final finding of benefit of retrofitting DGW in this study is that the retrofitting cost is not added to the property value. It is good for Council to recognise the increased property value with DGW by adding the cost of retrofitting DGW and intangible value associated with the benefits of DGW in the capital valuation. This concept is similar to a higher premium value associated with houses in desirable locations.

The finding on homeowners and other stakeholders’ interest in reducing the impact of environmental issues which is one of the benefits of using DGW was mixed. Homeowners were more interested in economic savings rather than reducing energy consumption through choosing DGW. Furthermore, not all homeowners believe human activities impact environmental issues while others believe environmental issues have not reached the critical stage. However, the other stakeholders are more concerned about the environmental issues. This finding is consistent with the low uptake of retrofitting DGW in older homes as this change is more of an environmental saving, health and comfort rather than economic savings.

In conclusion, the findings from the four sub-research questions have answered the main research question: “What are the challenges faced by homeowners and other stakeholders in retrofitting single glazed windows with double glazed windows for older homes in New Zealand?” The answers to the sub-questions
have revealed that some of the main challenges facing homeowners and other stakeholders associated with retrofitting DGW in older homes are high cost, complexity of regulation, lack of easily available knowledge, lengthy time frame, and difficulty in accessing trades people. Furthermore, the challenges, coupled with the lack of understanding about the benefits of increased health, comfort, safety and helping to address environmental issues that are offered by DGW, appear to have demotivated homeowners from retrofitting their houses with DGW. Therefore, with these research findings in mind, a number of key recommendations are proposed which could help to resolve some of the main challenges faced by homeowners in retrofitting DGW.

### 6.3 Recommendations

The recommendations below are proposed to deal with the challenges associated with retrofitting DGW. They can also be seen as providing business opportunities as well as leading to increased levels of social health and comfort. In combination, the proposed recommendations could, if implemented, spur overall economic growth and improve New Zealand’s standard of living.

1. A task force could be set up and include different stakeholders such as contractors, manufacturers, builders and the Council to study, design, propose and implement an efficient system to make retrofitting DGW cost effective and with minimal disruption to homeowner lifestyle. A proposed system could include pre-fabricated DGW within a reinforced structure that can take the increased loading without relying on the existing wall structure. This type of system could also be easily installed from outside the building. This will reduce complexity, time frames and cost to spur homeowners’ interest in retrofitting their homes with DGW.

2. The Council should add the cost associated with retrofitting DGW as well as intangible costs for benefits such as comfort, health and safety to the capital valuation of residential properties. Hence, the increased value of property with DGW will make it more appealing for the homeowner to retrofit their homes with DGW.
3. The New Zealand government should learn from, and collaborate with a country such as Japan that has successfully implemented DGW with similar climate conditions and challenges.

4. Stakeholders such as manufacturers, renovators, house building organisations as well as the government should explore retrofitting DGW using vacuum technology where the overall double glazing windows thickness is around 6mm and can fit into existing frames or joineries to be used. This technology has been used in Japan for more than ten years, hence, all stakeholders should be involved to make this option commercially and cost viable with providers located in New Zealand.

5. A knowledge platform on retrofitting DGW in older homes should be created by the government with contributions from stakeholders such as manufacturers, eco-advisors, house building organisations and the Council with details on cost structure, measurable benefits, rules and regulations, a breakdown of time frame and a list of reputable DGW specialists. This knowledge platform should be user friendly and promoted to consumers through education, social media, television, schools, advertisements or education campaigns.

6. The government authorities should help address skilled labour shortages by mitigating the 'boom and bust' of the building industry cycle with funding major projects such as retrofitting DGW to increase demand in the 'bust' phase of the cycle. This positive venture can help to maintain the stability, security and skill of jobs in the construction sector.

7. The Council should look into regulating energy efficient windows for existing homes to motivate homeowners to retrofit their homes with DGW.

6.4 Contribution of this Research

This research makes a significant contribution to the knowledge given that no research had specifically focussed on retrofitting DGW in the New Zealand context. Stakeholder knowledge and understanding gaps were found in this study and recommendations were proposed to fill these gaps. Hence, the
contributions of this research to the homeowners, Council, DGW manufacturers, house building organisations and the government arise through the identification of specific approaches to address the key challenges associated with retrofitting DGW.

A significant gap identified in this study was the lack of knowledge about retrofitting DGW in older homes in New Zealand. Hence, it is recommended that a knowledge platform be created by the government with useful information regarding DGW retrofitting from DGW manufacturers, eco-advisors, house building organisations and the Council such as:

- Details on the different types of DGW that can be designed to reduce different levels of sound from entering a home depending on its location.
- Laminated glass in DGW can offer higher safety levels in windows or walls than tempered glass in the event of spontaneous breakage of tempered glass.
- Other benefits related to energy savings, temperature control and moisture control.
- The processes of retrofitting DGW including time frame, cost and regulation.

When the homeowners are equipped with adequate knowledge about retrofitting their homes with DGW, they are able to decide the best options according to their environment and needs. The more knowledge available to homeowners in deciding the best option, the more likely it is that their interest in retrofitting DGW in their homes will be boosted. They can then enjoy the benefits of comfort and health that come with DGW in their homes. Furthermore, the homeowners’ increased understanding of DGW arising from the knowledge platform will also benefit other stakeholders as they do not have to spend time on, and accrue the costs of promoting the use of DGW in homes.

Another gap in the knowledge about DGW is the complexity, lengthy time frames, shortage of skilled labour and high cost associated with the challenges of retrofitting DGW in older homes in New Zealand. There were several recommendations made in the study to address these identified challenges. It is recommended that the contractors, DGW manufacturers, builders and the
Council collaborate, study, design, propose, and implement an efficient pre-fabricated DGW for retrofitting into homes with a reinforced structure that could take the increased weight loading without relying on the existing walls. This pre-fabricated design should be consented to, and pre-approved by Council. It should also be easy to install from outside the building and available at a competitive price.

The next major recommendation is for the DGW manufacturers, renovators, house building organisations as well as the government to explore the use of retrofitting DGW with vacuum technology that can fit into the existing joineries of SGW. This technology has been used in Japan for more than ten years and all stakeholders should be involved in ensuring this product is commercially manufactured in New Zealand. The other major recommendation in this study is for the government to provide subsidies during a financial crisis to mitigate the skilled labour shortages caused by the ‘boom and bust’ cycle. A further recommendation is that Council add the cost associated with retrofitting to the house property valuation as well as legislating for energy efficient windows to make DGW a norm in all houses in New Zealand.

Overall, the recommendations proposed in this research would bring business opportunities to the New Zealand Government and the other stakeholders as local facilities could be built in New Zealand to implement the proposals. Furthermore, the homeowners would also benefit from the proposals with competitive prices for retrofitting DGW in homes to enjoy the health and comfort that come with the use of DGW.

In addition to informing the recommendations, the insights gained have met the objectives set at the beginning of the research project. In meeting the objectives, this research has identified that high cost, difficulty in accessing trades people, low ROI, lack of easily available knowledge about retrofitting DGW and uncertain time frame are the main challenges that are hindering the homeowners from retrofitting SGW with DGW. This research has also revealed a low level of interest in retrofitting DGW among the homeowners and other stakeholders due to the above mentioned challenges. Moreover, the study
showed that other stakeholders are more aware than the homeowners of the benefits that can be gained from retrofitting DGW in homes. The research also indicated that the homeowners’ attitudes leaned more towards economic gain than attending to the environment, whereas other stakeholders, who were exposed to the environmental friendly practices in their trades, were concerned about addressing environmental issues.

6.5 Limitations of the Research

Due to the limitations of time and scope for this research, several topics on retrofitting DGW in relation to old style cladding, lack of suitability of some window shapes or designs, alternatives and misleading claims are important but could be not be discussed in this research. This research is limited to the Auckland region hence the findings may differ for different location in New Zealand. The researcher also experienced difficulty in recruiting more participants from the stakeholder groups such as the Auckland Council, house renovators, DGW manufacturers and house building organisations for interviewing. Hence, the outcomes may have differed slightly as views from more stakeholders could not be included for analysis in this research. Nonetheless, this study did seek information from a range of individuals and one representative from each stakeholder’s group associated with retrofitting DGW that provided rich data to complete this research successfully.

6.6 Future Research

Further studies on this research topic to extend or verify the results of the findings, recommendations and limitations are proposed as follows:

- To enhance this study by engaging more representatives from each stakeholder group associated with retrofitting DGW in existing homes such as DGW manufacturers, Auckland Council, house building organisations, renovation companies and eco-advisors. The findings from analysing a higher representation of participants from stakeholders group could be
enhanced with more comprehensive knowledge and experiences of challenges of retrofitting DGW in existing homes.

- To verify the cost of retrofitting DGW in older homes as this study shows that installing DGW in new houses is about the same as retrofitting DGW in older homes. However, retrofitting DGW would be higher than installing DGW in new houses due to the additional processes of removing SGW, old windows frames as well as putting in new joineries. This difference could be attributed to the current typical new house being larger with more windows than the typical older homes which are smaller with fewer windows.

- To study the estimated cost associated with retrofitting DGW to include additional costs such as the Auckland Council consent cost, escalating costs due to the shortage of skilled labour and costs incurred in using a lot more handling equipment, especially homes with double or more levels.

- To study the development of a knowledge platform by the government on retrofitting DGW in existing homes with information on home insulation and DGW, technology, comfort, health and safety, environmental issues as well as resources and time frame. It should also include methods of imparting the knowledge platform to the wider society through education, social media, television, schools, advertisements or education campaigns.

- To study how Auckland Council could take on the role of developing the knowledge platform and provide the information to the public.

- To research further into some of the important topics that appeared, but were not discussed in the findings such as Old style cladding, Not all windows suitable, and misleading claims.

- To study the implications of regulating energy efficient windows for all existing homes such as high cost, capacity of building companies involved in retrofitting DGW and shortage of skilled labour. This study is necessary as more than a million homes are involved. Furthermore, there is the issue of resistance amongst landlords. As discussed in the research, the largest organisation of landlords supports insulation of rental properties, but they oppose the introduction of minimal standards because rent would increase. In addition, homeowners may also resist retrofitting their homes with DGW.
• To research further into the impact of homeowners’ interest with higher Council rate due to proposed increased property values for retrofitting DGW in older homes.

6.7 Closing Statement

There is so much to be gained from using DGW in terms of health, comfort and helping to protect the environment. There is also a lot that the homeowners, the New Zealand government and other stakeholders can gain from making the change to DGW in existing homes. However, these gains can only be realised if the pace picks up on retrofitting DGW through the use of vacuum technology, increasing awareness through a knowledge platform, government mitigation of costs through subsidies, adding value to capital valuation by Council and making DGW a norm for all houses in New Zealand. This would increase the standard of housing to a level that result in more comfortable and healthier homes.
Reference List


Bierre, S. (2013). Unaffordable and unhealthy: Rental housing standards and policy drift. In S. Bierre, P. Howden-Chapman & L. Early (Eds.), Homes people can
afford: How to improve housing in New Zealand (pp. 41-48). Wellington, New Zealand: New Zealand Centre for Sustainable Cities.


Larsen, L. (2010). *Environmental health sourcebook: Basic consumer health information about the environment and its effects on human health, including facts about air, water and soil contamination, hazardous chemicals, foodborne hazards and illnesses, household hazards such as radon, mold and carbon monoxide, consumer hazards from toxic products and imported goods* (3rd ed.). Detroit, MI: Omnigraphics.


New Zealand Property Investors Federation. (6 September 2012). Rental property WOF not needed [Press release]


Tapaleao, V. (2016, July 7). Consumer NZ reports 38% have their home colder than they would like as they try to keep power bills down. *The New Zealand Herald.*


Appendix A – Flyer

RESEARCH STUDY: THE CHALLENGES OF RETROFITTING SINGLE GLAZED GLASS WINDOWS WITH DOUBLE GLAZED GLASS WINDOWS FOR OLDER HOMES IN NEW ZEALAND

What is the study about? To find out from different stakeholders (manufacturers, builders, renovators/contractors and home owners) what are the challenges in retrofitting single glazed windows with double glazed windows for older homes in New Zealand.

What does the study involve? One to one interview for around 40 minutes discussions on the challenges of the above retrofitting change.

What do I get out of it? The opportunity to understand, help and contribute to identify the challenges that could lead home owners and environment benefiting from this research study.

Comment: We would like to talk to people about how they view the challenges of retrofitting single glazed windows with double glazed windows in their homes in New Zealand. From this, we hope to understand the main challenges and develop appropriate measures to guide and motivate relevant parties on the right path to refitting all homes in New Zealand with double glazed windows.

This study is being conducted by Kim Chai, Student, Master of Business, Management and marketing Department, at Unitec Institute of Technology.

139, Carrington Road, Mount Albert, Auckland

Phone: 027 6706722
E mail: khchai28@yahoo.com

If you are interested in taking part, please contact Kim Chai as above.
Appendix B – Invitation to Potential Participants

To whom it may concern

Subject: Request to participate in research study on retrofitting double glazed windows

My name is Kim Chai and I am a postgraduate student at Unitec Institute of Technology, New Zealand. As part of the Master of Business Course, I am conducting a research project on “the challenges of retrofitting single glazed glass windows with double glazed glass windows for older homes in New Zealand.” This research project will help to identify some of the challenges that owners of older homes are facing in retrofitting their single glazed windows with double glazed windows. The outcome of this research is to help make double glazed glass windows a norm for all homes in New Zealand thereby contributing to better use of resources and creating more comfortable homes. I am seeking to interview people who are working in the following areas:

- Manufacturers/ importers of double glazed windows
- Builders of new homes
- Renovators/ contractors of existing homes
- Auckland Council

I also wish to interview owners of older homes.

The interview will include questions about retrofitting’s challenges, level of interest of stakeholders in retrofitting, benefits and environment issues. An interview is expected to take approximately 40 minutes at a time and place convenient to you. The information provided by you will only be used for the purposes of this research. A hard copy or soft copy of the summarized discussion will be sent to you for verification and confirmation. You may delete, add or change any information in the summarized discussion.

Please contact me if you are interested in participating in the research study at my email address or on my phone number below to arrange for an interview:

- mob: 027-0706722
- email: khchai28@yahoo.com

Attached are two documents that contain more information about this study. I really appreciate your valuable time and contribution in helping me with the research by participating in this study.

Kind regards

Kim Chai
Appendix C – Information for Participants

Research Project Title

“The challenges of retrofitting single glazed glass windows with double glazed glass windows for older homes in New Zealand.”

Synopsis of project

My name is Kim Chai and I am a postgraduate student at Unitec Institute of Technology, New Zealand. As part of the Master of Business Course, I am conducting a research project on “the challenges of retrofitting single glazed glass windows with double glazed glass windows for older homes in New Zealand.” This research project will help to identify some of the challenges that owners of older homes are facing in retrofitting their single glazed windows with double glazed windows. This is important as heat is lost through single glazed glass windows which can be minimized by using double glazed glass windows. There are also many other benefits associated with double glazed glass windows such as reducing condensation in cold weather, improving thermal comfort and reducing external noise. Although most of the new homes are built with double glazed glass windows through new building legislation, majority of the older homes remain fitted with single glazed glass windows. The outcomes of this research are to help make double glazed glass windows a norm for all homes in New Zealand thereby contributing to better use of resources and creating more comfortable homes.

What we are doing?

The aim of this research is to find out the main challenges hindering owners from changing from single glazed glass windows to double glazed glass windows. The research based in Auckland will involve interviewing participants from builders of new homes, manufacturers and importers of double glazed glass windows, renovators/contractors of old homes, Auckland Council and owners of older homes. By collecting and analysing the responses, the researcher could identify some of the main challenges associated with the retrofitting change. Understanding the challenges on this change would help provide relevant parties such as the New Zealand government the necessary impetus to effectively implement the change to retrofit older homes with double glazed glass windows. The interview will find out:

- The challenges hindering retrofitting single glazed glass windows with double glazed glass windows
- The level of interest exhibited by the participants on homeowners enjoying better health and comfort with this change
• If stakeholders, that is, house owners, builders of new homes, Auckland Council, manufacturers and importer of double glazed glass windows and contractors, are aware of the benefits that can be gained from this modification
• The concern of the participants towards reducing global warming and relevant environmental issues as less heating is used with double glazed glass windows during cold weather.

By participating in the project, you will provide useful information that will be for the benefit of all homeowners and the society.

**What it will mean for you?**

If you agree to participate, you will be asked to sign a consent form. This does not stop you from changing your mind if you wish to withdraw from the project. However, withdrawal can only occur up to two weeks after all data has been collected.

The interview will take approximately 40 minutes at a time and place convenient to you. The information provided by you will only be used for the purpose of this research. The researcher will audio record the discussion and take notes during the interview.

A hard copy or soft copy of the summarized discussion will be sent to you for your comments. You may delete, add or change any information in the summarized discussion.

Your name and information that may identify you will be kept completely confidential. All information collected from you will be stored on a password protected file and only the researcher and the supervisor will have access to this information. This information will be kept by the supervisor at Unitec for five years and will be destroyed or erased after five years.

Please contact us if you need more information about the project. At any time if you have any concerns about the research project you can contact my supervisor:

My supervisor is Dr. K. Asoka Gunaratne, phone 815-4321 ext. 7035 or email agunaratne@unitec.ac.nz

Researcher: Kim Chai, phone 027-0706722 or email at khchai28@yahoo.com

**UREC REGISTRATION NUMBER: 2015-1080**

This study has been approved by the UNITEC Research Ethics Committee from 12/01/2016 to 12/01/2017. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 8551). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Appendix D – Participant Consent Form

Participant Consent Form

Research Project Title:

“The challenges of retrofitting single glazed glass windows with double glazed glass windows for older homes in New Zealand.”

I have had the research project explained to me and I have read and understand the information sheet given to me.

I understand that I don't have to be part of this research project and should I choose not to participate, I may withdraw two weeks after all the data has been collected. There will be no adverse impact on my withdrawal from this project with regards to my business interests, personal identity or privacy and all data will be erased forthwith.

I understand that everything I say is confidential and none of the information I give will identify me and that the only persons who will know what I have said will be the researcher and his supervisor. I also understand that all the information that I give will be stored securely at Unitec for a period of 5 years.

I understand that interview will take approximately 40 minutes at a time and place convenient to me. Notes will be taken during my discussion with the researcher and it will also be audio recorded and transcribed. If I do not agree to be audio recorded, then only notes will be written in the conversation and the statement “audio recorded and transcribed” will be cancelled and signed by the researcher.

I understand that I can see a transcription of our discussion and that I have the ability to make changes to what I have said if need be. I understand that I can also see the finished research document if I wish to do so.

I have had time to consider everything and I give my consent to be a part of this project.

Participant Name: ………………………………………………………………………

Participant Signature: ……………………… Date: ………………………………

Project Researcher: ……………………………. Date: ……………………………

UREC REGISTRATION NUMBER: 2015-1080

This study has been approved by the UNITEC Research Ethics Committee from 12/01/2016 to 12/01/2017. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 8551). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Appendix E – Organisational Consent

Re: Organisational Consent

I, ___________________ , ___________________ of ________________________________

(Name) (Position in organisation) (Organisation)

give consent for Kim Chai to undertake research in this organisation as discussed with the researcher.

This consent is granted based on the approval for research ethics application number 2015-1080 by the Unitec Research Ethics Committee, a copy of the approval letter is attached.

Signature:

Date:
Appendix F – Discussion topics for interview

Question 1

Main question: What do you think are the main challenges faced by homeowners or other stakeholders in retrofitting single glazed windows with double glazed windows in home?

Sub questions to guide in the discussion:
 a) Understanding the function of double glazed glass windows
 b) Understanding the benefits of double glazed glass windows
 c) Cost and time factor
 d) Supply factor
 e) Government funding
 f) Regulation
 g) Others

Question 2

Main question: What are your/the public interests in retrofitting single glazed windows with double glazed windows?

Sub questions to guide in the discussion:
 a) What is your opinion on retrofitting single glass windows with double glazed windows
 b) Others

Question 3

Main question: What is your/the public understanding of the benefits of using double glazed windows for homes?

Sub questions:
 a) Help in insulation
 b) Comfort and health
 c) Others

Question 4

Main question: What is your interest in reducing the impact of environmental issues which is one of the benefits of using double glazed windows?

Sub questions:
 a) Are you keen on saving environment?
 b) Do you believe that we should do more to protect environment?
 c) Should the government be involved in protecting the environment?
 d) As double glazed windows can help to reduce global warming as it uses less energy for heating in cold weather, would you consider retrofitting single glazed window with double glazed window for your home?
 e) Any there other factors that you would like to relate to environmental issues?
Appendix G – Interview Summary Form

Interview Summary Form

Interviewee: __________________________ Date of Interview: __________________________

Time and Duration: __________________________ Place: __________________________

Was the time and place for interview suitable? Were there any significant events that it requires a change for future interviews?

How easy was it to get the interview going? Were there any issues or ideas that could help with the next interview?

Did the interview schedule go according to plan? Was there any changes? Is follow-up adequate for the arrangement of the interview?

What were the main themes discussed in the interview? Was there any shortfall that requires further strengthening or changes to the topics being discussed for the next interview?

Did the interviewee agree to be contacted for the summarised discussion and transcript? Have I agreed to send summarised copy of the thesis?
Appendix H – Confidentiality Agreement for Transcriptionist

Confidentiality Agreement

Transcriptionist

In accordance with the Research Ethics Committee at Unitec Institute of Technology (UREC), all participants in the above-named study are anonymised. Therefore any personal information or any of the data generated or secured through transcription will not be disclosed to any third party.

By signing this document, I ______________________________ transcriptionist, agree to maintain full confidentiality in regards to any and all audiotapes and documentations received from researcher, Kim Chai, related to his research study on “The challenges of retrofitting single glazed glass windows with double glazed glass windows for older homes in New Zealand “. Furthermore, I agree:

1. To hold in strictest confidence the identification of any individual that may be inadvertently revealed during the transcription of audio-taped interviews, or in any associated documents.

2. To not make copies of any audiotapes or computerized titles of the transcribed interviews texts, unless specifically requested to do so by the researcher, Kim Chai.

3. To store all study-related audiotapes and materials in a safe, secure location as long as they are in my possession.

4. To return all audiotapes and study-related materials to Kim Chai in a complete and timely manner.

5. To delete all electronic files containing study-related documents from my computer hard drive and any back-up devices.

I am aware that I can be held legally responsible for any breach of this confidentiality agreement, and for any harm incurred by individuals if I disclose identifiable information contained in the audiotapes and/or files to which I will have access.

Transcriber’s name (printed) __________________________________________________

Transcriber’s signature __________________________________________________

Date ___________________________________________
Appendix I – Copy of Ethics Approval

Kim Chai
268 Eversleigh Road
Belmont
Auckland 0622

18.2.15

Dear Kim,

Your file number for this application: 2015-1080
Title: The challenges of retrofitting single glazed glass windows with double glazed glass windows for older homes in New Zealand.

Your application for ethics approval has been reviewed by the Unitec Research Ethics Committee (UREC) and has been approved for the following period:

Start date: 12.1.16
Finish date: 12.1.17

Please note that:

1. The above dates must be referred to on the information AND consent forms given to all participants.

2. You must inform UREC, in advance, of any ethically-relevant deviation in the project. This may require additional approval.

You may now commence your research according to the protocols approved by UREC. We wish you every success with your project.

Yours sincerely,

Sara Donaghey Deputy Chair, UREC

cc: Asoka Gunaratne
Cynthia Almeida
### Appendix J – Coded Thematic Analysis of Significant Statements

<table>
<thead>
<tr>
<th>ID#</th>
<th>Stakeholder</th>
<th>Q#</th>
<th>Statement #</th>
<th>Significant Statement</th>
<th>The me#</th>
<th>Primary Theme</th>
<th>Sub-theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Home owner</td>
<td>1</td>
<td>1</td>
<td>I would to have our house double glazed. The only reason stopping us is really financing, i.e. cost. That would be the main thing.</td>
<td>1</td>
<td>Challenges</td>
<td>Cost</td>
</tr>
<tr>
<td>1</td>
<td>Home owner</td>
<td>1</td>
<td>2</td>
<td>It is time consuming.</td>
<td>1</td>
<td>Challenges</td>
<td>Time consuming</td>
</tr>
<tr>
<td>1</td>
<td>Home owner</td>
<td>1</td>
<td>3</td>
<td>If we retrofit our single glazed windows to double glazed windows, will it still work with the old style cladding. That would be big concern to us. So it is a question of how it could be retrofitted as we do not want to change the cladding.</td>
<td>1</td>
<td>Challenges</td>
<td>Old style cladding</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>4</td>
<td>Single glazed windows tend to be used up north, where the regulation is more relaxed as compared to the south which is much colder.</td>
<td>1</td>
<td>Challenges</td>
<td>Weather</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>5</td>
<td>Around 2011, regulation has changed in New Zealand ... with double glazing although you can still see pocket in Auckland and north where climate is more conducive than cold weather. In general, for new houses, double glazed units have become a norm.</td>
<td>1</td>
<td>Challenges</td>
<td>Regulation</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>6</td>
<td>For older houses, we look at the joinery before replacing with double glazed unit.</td>
<td>1</td>
<td>Challenges</td>
<td>Age of house</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>7</td>
<td>From north of Bombay, there is less demand for retrofitting double glazed unit as compared to the south of Bombay.</td>
<td>1</td>
<td>Challenges</td>
<td>Geographical location</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>8</td>
<td>The joinery window system for single glazing may not work for retrofitting double glazed unit as the double glazed unit is very heavy, hence it may not take its weight.</td>
<td>1</td>
<td>Challenges</td>
<td>Weight of units</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>9</td>
<td>Double glazed windows system for an average new house cost around $15,000. If customer wants to replace the whole house with double glazed unit, cost of retrofitting is the sad part of it as it cost a lot to remove, change the frame and install.</td>
<td>1</td>
<td>Challenges</td>
<td>Cost</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>10</td>
<td>In a research about six years ago, It was found that the lower power bill was not motivating the people, even though it is a good thing.</td>
<td>1</td>
<td>Challenges</td>
<td>Return on investment</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>11</td>
<td>It is easier to retrofit double glazed unit windows than retrofitting double glazed unit door new double glazed unit door.</td>
<td>1</td>
<td>Challenges</td>
<td>Difficult to retrofit doors</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>12</td>
<td>I do not think cost is stopping people from changing to double glazed unit.</td>
<td>1</td>
<td>Challenges</td>
<td>Cost</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>13</td>
<td>Huge differences in term of costing which have to be addressed.</td>
<td>1</td>
<td>Challenges</td>
<td>Cost</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>14</td>
<td>The cost to produce double glazed unit and retrofit into homes could offset the savings in energy cost, hence, there may be no saving in cost.</td>
<td>1</td>
<td>Challenges</td>
<td>Return on investment</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>15</td>
<td>Still huge number of houses single glazed window, hence, free retrofitting of double glazed unit should start with state housing schools and community building</td>
<td>1</td>
<td>Challenges</td>
<td>Large number of houses</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>16</td>
<td>Without double glazed unit even if you got insulation in the ceiling, insulation under the floor, you will certainly going to have draft and cold, hence it is important to use double glazed unit for the whole building.</td>
<td>1</td>
<td>Challenges</td>
<td>For whole building</td>
</tr>
</tbody>
</table>

---

**Note:**
- **ID#** indicates the identifier for each statement.
- **Stakeholder** refers to the type of respondent.
- **Q#** represents the question number.
- **Statement #** denotes the statement number.
- **Significant Statement** contains the statement text.
- **The me#** refers to the thematic analysis code.
- **Primary Theme** and **Sub-theme** categorize the themes and sub-themes identified in the analysis.
<table>
<thead>
<tr>
<th></th>
<th>Role</th>
<th>Challenges</th>
<th>1</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>House builder</td>
<td>A lot more handling equipment is required to retrofit double glazed unit</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>For single storey house, it is fairly easy to retrofit the windows, but for double or more level houses, it is more difficult process and will require additional equipment such as scaffolding.</td>
<td>1</td>
<td>Number of levels</td>
</tr>
<tr>
<td>3</td>
<td>Home owner</td>
<td>Financing, ask before it is too expensive</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>3</td>
<td>Home owner</td>
<td>Inconvenient, having to do the renovation and other stuff</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>3</td>
<td>Home owner</td>
<td>I do not know how effective it is, only here say.</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>3</td>
<td>Home owner</td>
<td>Do not know how long it will take</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>More handling equipment is required to retrofit double glazed unit</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>I do not even know how much it will cost to retrofit to DGW, only that it costs lot money and is expensive...</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>I do not have a sense of what ways you could make it achievable or any if there is government support to change windows to DGW.</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>Lack of information makes it quite difficult to approach the retrofitting process... There are so many things that unless you are very interested, you will have to search out the information</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>At the moment with structural building business boom in Auckland, it seems difficult to find trade people to get work done in the homes.</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>Government must be able to create some general guidelines of cost and time, provide some kind of insights into starting points, or a common range</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>Given that the huge amount of construction currently going on, there is probably no major interest in developing the market, because they do not need to</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>I wonder if there is the possibility of making retrofitting DIY package with on-site training and video, making it a lot cheaper and more feasible.</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>Largest challenge is cost and it is always going to be a barrier</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>People are now weighing the cost of energy against the cost of double glazing and finding that the energy cost is currently outweighed by the cost of installing double glazed window.</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>Cost analysis for decision making is undertaken by other stakeholders such as eco advisors or council energy wise officers. These advisors have to demonstrate the tipping point and persuade people to go for double glazing windows. As homeowners, they won’t do it unless they can be told that it is worthwhile</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>The other challenge is to understand people’s expectation of the time frame for their return on investment. The reality is that the average return on investment for double glazing is around 20 years.</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>Not all windows are suitable for double glazing, especially for windows that are hard to reach or windows that are triangular, circular, and other odd shaped windows</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>My advice is look at alternatives before you look at double glazing. Install secondary film or DIY window kits which are a cheap alternative, $35 per kit, to double glazed windows.</td>
<td>1</td>
<td>Challenges</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>1</td>
<td>36</td>
<td>One of the big challenges is lack of information on who are the reputable installers. How do you rank or how do you know who are the good installers?</td>
</tr>
<tr>
<td>----</td>
<td>------------</td>
<td>----</td>
<td>-----</td>
<td>---------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>1</td>
<td>37</td>
<td>When we were working on our own, we went to building centre and other centres to get ideas; we find that we don’t get contacted as a lot of these companies are having too much work which could be due to building boom.</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>1</td>
<td>38</td>
<td>There was a long delay in starting the work that was supposed to start in February but waited until end May before they actually start to work on it</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>1</td>
<td>39</td>
<td>I think people changing their windows would find it a big hurdle to find a reputable company</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>1</td>
<td>40</td>
<td>Our retrofitting process ended up changing new window aluminium frames for the double glazed windows as the old aluminium frames doesn’t fit as well as it cannot take the increased weight</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>1</td>
<td>41</td>
<td>An architect who drew up our renovation plan, said that we don’t need to get council approval since we are not changing the frames or windows sizes for retrofitting with double glazed windows. But if you don’t get council approval, the insurance can be void. This is because something has been changed to the structure such as increased weight from the double glazed windows</td>
</tr>
<tr>
<td>7</td>
<td>Home owner</td>
<td>1</td>
<td>42</td>
<td>I don’t think I will change to double glazed windows for the time being as I believe it is quite expensive. It is worth considering if budget is allowable, main thing is the budget.</td>
</tr>
<tr>
<td>7</td>
<td>Home owner</td>
<td>1</td>
<td>43</td>
<td>We are not too worried about single glazed windows because the weather is not extreme, still bearable.</td>
</tr>
<tr>
<td>8</td>
<td>Home owner</td>
<td>1</td>
<td>44</td>
<td>The cost factor is the primary factor in my mind as I have heard it is very expensive to retrofit double glazed windows in my home.</td>
</tr>
<tr>
<td>8</td>
<td>Home owner</td>
<td>1</td>
<td>45</td>
<td>I also expect a lot of disruption to my lifestyle during the retrofitting process.</td>
</tr>
<tr>
<td>8</td>
<td>Home owner</td>
<td>1</td>
<td>46</td>
<td>I would not know how to get started; it seems to be a tough process.</td>
</tr>
<tr>
<td>8</td>
<td>Home owner</td>
<td>1</td>
<td>47</td>
<td>Not like buying a house where there are many knowledgeable advisors in the market to guide me.</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>1</td>
<td>48</td>
<td>Biggest barrier is the cost. Cost of retrofitting existing joineries or removing existing joineries and putting in new joineries are significant cost</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>1</td>
<td>49</td>
<td>People will look at other options that cost less and so they might do other options first before considering double glazing.</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>1</td>
<td>50</td>
<td>If homeowners are prepared to invest in double glazing, then the next challenge is around accessing trade people and building professionals to get the work done.</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>1</td>
<td>51</td>
<td>It does require consent (Auckland Council approval) in some cases and that can be a challenge. Any consents or activities always present a challenge for some homeowners.</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>1</td>
<td>52</td>
<td>People will do it if there is a compliance requirement.</td>
</tr>
<tr>
<td>10</td>
<td>Home owner</td>
<td>1</td>
<td>53</td>
<td>It is an expensive process for houses like our that have a lot of windows, that are almost all arch shaped windows, would need bespoke fittings (again, more cost involved).</td>
</tr>
<tr>
<td>Email 1</td>
<td>Homeowner</td>
<td>1</td>
<td>54</td>
<td>I think people don’t recognise/understand the cost saving involved (related to heat retention, particularly in winter) that could be quite convincing to have it done.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Email 2</td>
<td>Window Association</td>
<td>1</td>
<td>55</td>
<td>Fairly assessing how good the deal being offered really is.</td>
</tr>
<tr>
<td>Email 2</td>
<td>Window Association</td>
<td>1</td>
<td>56</td>
<td>Education. Knowledge</td>
</tr>
<tr>
<td>Email 3</td>
<td>Manufacturer/ Renovator</td>
<td>1</td>
<td>57</td>
<td>I believe the biggest challenge is removing the clutter and getting to the facts</td>
</tr>
<tr>
<td>Email 3</td>
<td>Manufacturer/ Renovator</td>
<td>1</td>
<td>58</td>
<td>There are a lot of companies claiming performance equal to IGU’s (insulated glass units, double glazed units is not the correct terminology). These products like film and applied liquid claim to perform as well as IGU’s at a lower cost. In fact, they use misleading data in their claims. Most retro companies push Low E glasses which perform 10 times better than the other products.</td>
</tr>
<tr>
<td>Homeowner</td>
<td>2</td>
<td>59</td>
<td>I feel that double glazing would even it out the hot and the cold, i.e. reduce the thermal difference This makes my interest on retrofitting with double glaze high</td>
<td>2</td>
</tr>
<tr>
<td>Homeowner</td>
<td>2</td>
<td>60</td>
<td>To make my interest even higher, we have glazing problems in our house, some of our windows are failing Our house is 15 years old, windows are only guaranteed for 5 years, the gap in the aluminium joineries are coming out let water in</td>
<td>2</td>
</tr>
<tr>
<td>Housebuilder</td>
<td>2</td>
<td>61</td>
<td>There is a huge growth in sales, sales double, which demonstrate increasing interest by the consumers</td>
<td>2</td>
</tr>
<tr>
<td>Housebuilder</td>
<td>2</td>
<td>62</td>
<td>Advertisement of benefit of double glazed unit in television</td>
<td>2</td>
</tr>
<tr>
<td>Housebuilder</td>
<td>2</td>
<td>63</td>
<td>Government energy savings from double glazed unit featured in television</td>
<td>2</td>
</tr>
<tr>
<td>Housebuilder</td>
<td>2</td>
<td>64</td>
<td>In the neighbourhood where someone has double glazed unit house and post on YouTube, it creates more awareness and interest in the change</td>
<td>2</td>
</tr>
<tr>
<td>Housebuilder</td>
<td>2</td>
<td>65</td>
<td>Because in new houses double glazed unit is now a norm and from this, retrofitting interest will continue to pick up</td>
<td>2</td>
</tr>
<tr>
<td>Homeowner</td>
<td>2</td>
<td>66</td>
<td>Good for the country, good for the environment</td>
<td>2</td>
</tr>
<tr>
<td>Homeowner</td>
<td>2</td>
<td>67</td>
<td>Everyone should have a healthy body, sleep better, happier in life, productivity goes up</td>
<td>3</td>
</tr>
<tr>
<td>Homeowner</td>
<td>2</td>
<td>68</td>
<td>The government talk about rating systems for home in term of comfort and sustainability</td>
<td>2</td>
</tr>
<tr>
<td>Eco advisor</td>
<td>2</td>
<td>69</td>
<td>It depends on the age of the windows and the type of frames as to whether retrofitting is a suitable option and whether people will be interested in doing that</td>
<td>2</td>
</tr>
<tr>
<td>Eco advisor</td>
<td>2</td>
<td>70</td>
<td>I think people who are interested in doing this should seek advice from glaziers or from eco-consultants</td>
<td>2</td>
</tr>
<tr>
<td>Eco advisor</td>
<td>2</td>
<td>71</td>
<td>I check the windows for retrofitting and how much it is going to cost</td>
<td>2</td>
</tr>
<tr>
<td>Eco advisor</td>
<td>2</td>
<td>72</td>
<td>I also try to persuade homeowners to look at their own situation and break down the job by working from room to room without going to the expense of retrofitting the whole house with double glazed windows in one go</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Home owner</td>
<td>2</td>
<td>73</td>
<td>What drive us was to try get heat efficient house, to cut down on heat losses</td>
</tr>
<tr>
<td>---</td>
<td>---------------------</td>
<td>---</td>
<td>----</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Home owner</td>
<td>2</td>
<td>74</td>
<td>I am not that interested. Budget constraint. Not necessary to change at the moment in Auckland</td>
</tr>
<tr>
<td>8</td>
<td>Home owner</td>
<td>2</td>
<td>75</td>
<td>Need more education and promotion More awareness to get people interested</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>2</td>
<td>76</td>
<td>Good list of homeowner’s awareness of this system as a solution</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>2</td>
<td>77</td>
<td>So double glazing is of very high of interest to people who came to see me and they commonly want to know more about double glazing</td>
</tr>
<tr>
<td>10</td>
<td>Home owner</td>
<td>2</td>
<td>78</td>
<td>I think that it is currently quite low – batt insulation in the form pre-cut panels in the ceiling and walls has been one priority and the other have been ventilation (or air circulation) and people have addressed that in various ways</td>
</tr>
<tr>
<td>10</td>
<td>Home owner</td>
<td>2</td>
<td>79</td>
<td>I think it will be the next big phase of housing upgrades (with subsidies probably (hopefully) coming from government</td>
</tr>
<tr>
<td>11</td>
<td>Window Association</td>
<td>2</td>
<td>80</td>
<td>Because of promotion by government advertising (Energy Efficiency and Conservation Authority) and commercial promotion of companies selling the products and services</td>
</tr>
<tr>
<td>11</td>
<td>Window Association</td>
<td>2</td>
<td>81</td>
<td>When asked by these people what they should do, we recommend that they upgrade their living room first and use that experience to guide them regarding the rest of the house</td>
</tr>
<tr>
<td>12</td>
<td>Manufacturer/Renovator</td>
<td>2</td>
<td>82</td>
<td>New builds are in the majority now all have IGU’s</td>
</tr>
<tr>
<td>12</td>
<td>Manufacturer/Renovator</td>
<td>2</td>
<td>83</td>
<td>The level of marketing from the retro companies has increased awareness and therefore demand</td>
</tr>
<tr>
<td>1</td>
<td>Home owner</td>
<td>3</td>
<td>84</td>
<td>Know that double glazing is energy savings but do not know the statistics, in terms of percentage Quite sure double glazing would have bigger impact on power savings</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>3</td>
<td>85</td>
<td>The double glazed unit make the house warmer in the winter and colder in summer</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>3</td>
<td>86</td>
<td>Consumers are aware that double glazed unit keep condensation away from glass which is one of its benefits</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>3</td>
<td>87</td>
<td>Advertisement plays a part in raising awareness on the benefits of double glazed unit</td>
</tr>
<tr>
<td>3</td>
<td>Home owner</td>
<td>3</td>
<td>88</td>
<td>Cut out the noise</td>
</tr>
<tr>
<td>3</td>
<td>Home owner</td>
<td>3</td>
<td>89</td>
<td>Hospital might be too crowded, people less flu, due to better health</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>3</td>
<td>90</td>
<td>It is about a warmer and drier home</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>3</td>
<td>91</td>
<td>Reduce condensation</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>92</td>
<td>Noise reduction</td>
<td>3</td>
</tr>
<tr>
<td>------------</td>
<td>---</td>
<td>----</td>
<td>----------------</td>
<td>---</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>93</td>
<td>I think it does add value to the property</td>
<td>3</td>
</tr>
<tr>
<td>Eco advisor</td>
<td>3</td>
<td>94</td>
<td>If you can’t get rid of condensation, then double glazing become an effective way of solving the issue</td>
<td>3</td>
</tr>
<tr>
<td>Eco advisor</td>
<td>3</td>
<td>95</td>
<td>People should concentrate on the windows before they concentrate on the wall because there is a higher amount of heat loss through the windows It’s easier and more effective to retrofit double glazed windows than retrofitting insulation on the walls</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>96</td>
<td>Retaining the heat</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>97</td>
<td>There is some noise reduction</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>98</td>
<td>The house is much more comfortable and warmer We know double glazed windows helps to keep the house warmer in winter, and keep heat out in summer It does its job, in summer or winter</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>99</td>
<td>Can help to reduce noise</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>100</td>
<td>It can reduce energy use</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>101</td>
<td>It can increase my house value</td>
<td>3</td>
</tr>
<tr>
<td>Auckland Council</td>
<td>3</td>
<td>102</td>
<td>This technology can reduce heat loss</td>
<td>3</td>
</tr>
<tr>
<td>Auckland Council</td>
<td>3</td>
<td>103</td>
<td>In some cases reduce condensation</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>104</td>
<td>Particularly important to older houses in Auckland is the issue of temperature control</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>105</td>
<td>Single glazed, unventilated windows contribute to the problem of ‘dripping panes’, causing water damage and unhealthy mould and mildew that I think could be eliminated with modern double glazing</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>3</td>
<td>106</td>
<td>I feel that double glazing retrofits should be mandatory for all apartments with single glazing for noise control</td>
<td>3</td>
</tr>
<tr>
<td>Window Association</td>
<td>3</td>
<td>107</td>
<td>There are instances where the retrofit is not properly researched and the consumer is disappointed with the results</td>
<td>1</td>
</tr>
<tr>
<td>Window Association</td>
<td>3</td>
<td>108</td>
<td>Double glazing is not a magic bullet – for example it can help reduce the appearance of condensation, but moisture control is a much bigger subject than just double glazing</td>
<td>3</td>
</tr>
<tr>
<td>Manufacturer/Renovator</td>
<td>3</td>
<td>109</td>
<td>I have lived in a cold house and retro-fitted the windows, experiencing first-hand the improvements retro-fitting brings so in my mind there is no doubt that the benefits are huge.</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>4</td>
<td>110</td>
<td>I would not support the action of controlling global warming as I do not believe that we have a great impact on global warming.</td>
<td>4</td>
</tr>
<tr>
<td>Home owner</td>
<td>4</td>
<td>111</td>
<td>From energy point of view, using double glazed windows is good</td>
<td>3</td>
</tr>
<tr>
<td>Home owner</td>
<td>4</td>
<td>112</td>
<td>People put in double glazed unit not because of global warming but because of social lifestyle. Motivation around retrofitting double glazed unit is more on lifestyle and most likely it is not for saving the planet.</td>
<td>4</td>
</tr>
<tr>
<td>Home owner</td>
<td>4</td>
<td>113</td>
<td>Ultimately it is a healthy home that matters most.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3</td>
<td>Home owner</td>
<td>4</td>
<td>114</td>
<td>Government should quickly enforce DGW to help address environmental issues.</td>
</tr>
<tr>
<td>4</td>
<td>Home owner</td>
<td>4</td>
<td>115</td>
<td>Less heating and using less energy is good benefit for the environment.</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>4</td>
<td>116</td>
<td>Very few homeowners make changes to their houses to prevent environmental issues</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>4</td>
<td>117</td>
<td>They will do it for energy efficiency which is also good for the environment. Most people, probably 50% are doing it for energy efficiency</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>4</td>
<td>118</td>
<td>Don’t do it specifically for climate change or emissions of greenhouse gases or other kinds of environmental issues</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>4</td>
<td>119</td>
<td>Things are slowly changing, with people starting to see linkage with their actions to environmental issues and changing their attitude towards environmental issues.</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>4</td>
<td>120</td>
<td>Other stakeholders, such as council, government and private organisations, are more aware and have better understanding of the environmental issues.</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>4</td>
<td>121</td>
<td>We should save energy. Yes, we do need to save all we can</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>4</td>
<td>122</td>
<td>Global weather is an issue where everybody has to put their effort into their future. Unusual weather is detrimental to lot of us. Question really is, have we reached a point where it scares all of us?</td>
</tr>
<tr>
<td>7</td>
<td>Home owner</td>
<td>4</td>
<td>123</td>
<td>Definitely we are concerned about environment because New Zealand is a clean environment and we are very concerned about this issue. Now a lot of people are using heat pump, a lot of advantage if this is complemented by using double glazed windows as there will be less heat loss, hence, less energy used</td>
</tr>
<tr>
<td>8</td>
<td>Home owner</td>
<td>4</td>
<td>124</td>
<td>Environmentally aware that we should reduce the impact. Reduce energy use</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>4</td>
<td>125</td>
<td>It is not a primary driver for many people on the issue of climate change. In term of climate change or the environment being the main driver, I would say around 20% of the referrals that come to our service</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>4</td>
<td>126</td>
<td>These people have a direct interest in house performance, looking at energy efficiency/resource efficiency</td>
</tr>
<tr>
<td>10</td>
<td>Email1 Home owner</td>
<td>4</td>
<td>127</td>
<td>It needs to be affordable (or at least competitive with other options out there that are more environmentally detrimental or not as environmentally friendly) otherwise people will prioritise other things ahead of it</td>
</tr>
<tr>
<td>10</td>
<td>Email2 Home owner</td>
<td>4</td>
<td>128</td>
<td>I think that people want to ‘protect the environment’</td>
</tr>
<tr>
<td>11</td>
<td>Window Association Manufacturer/Renovator</td>
<td>4</td>
<td>129</td>
<td>Suppliers are people just like you and me - they too are concerned about the environment, global warming etc. and are keen to do their bit.</td>
</tr>
<tr>
<td>12</td>
<td>Email3 Manufacturer/Renovator</td>
<td>4</td>
<td>130</td>
<td>Retro does make houses warmer and cheaper to heat and cool therefore by default are doing exactly that helping the environment.</td>
</tr>
<tr>
<td>12</td>
<td>Email3 Manufacturer/Renovator</td>
<td>4</td>
<td>131</td>
<td>Some really care about the environment issues while others are in business and profitability is the driving force.</td>
</tr>
</tbody>
</table>
Appendix K – Auckland Council Resource Consent Process

1.4 An overview of the resource consent process

Resource consent process

Contact council and/or consultant

Prepare application materials

Lodge application for resource consent

Council decides whether application is to be non-notified, publicly notified or notified only to affected parties

Notified

Council receives submission and may hold a hearing, then makes a decision on consent and includes any conditions

Non-notified

Council makes decision on consent and includes any conditions

Upon decision, a 15-day appeal period follows. You may object to council over costs or conditions, or appeal to the Environmental Court

*Note that processing time depends on the quality and completeness of information and documents that have been submitted by the applicant. If the council requests additional information, the application is put on hold until the requested information has been received.

Retrieved from Auckland Council (2016a)
Appendix L – Auckland Council Building Consent Process

Retrieved from Auckland Council (2016a)
## Appendix M – Significant Statements related to Consent Requirements

<table>
<thead>
<tr>
<th>ID#</th>
<th>Stakeholder</th>
<th>Q#</th>
<th>Statement #</th>
<th>Significant Statement</th>
<th>Theme #</th>
<th>Primary Theme</th>
<th>Sub-theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Home owner</td>
<td>1</td>
<td>3</td>
<td>If we retrofit our single glazed windows to double glazed windows, will it still work with the old style cladding. That would be a big concern to us. So it is a question of how it could be retrofitted as we do not want to change the cladding.</td>
<td>1</td>
<td>Challenges</td>
<td>Old style cladding</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>6</td>
<td>For older houses, we look at the joinery before replacing with double glazed unit.</td>
<td>1</td>
<td>Challenges</td>
<td>Age of house</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>8</td>
<td>The joinery window system for single glazing may not work for retrofitting double glazed unit as the double glazed unit is very heavy, hence it may not take its weight.</td>
<td>1</td>
<td>Challenges</td>
<td>Weight of units</td>
</tr>
<tr>
<td>2</td>
<td>House builder</td>
<td>1</td>
<td>18</td>
<td>For single storey house, it is fairly easy to retrofit the windows, but for double or more level houses, it is more difficult process and will require additional equipment such as scaffolding.</td>
<td>1</td>
<td>Challenges</td>
<td>Number of levels</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>1</td>
<td>40</td>
<td>Our retrofitting process ended up changing new window aluminium frames for the double glazed windows as the old aluminium frames doesn’t fit as well as it cannot take the increased weight.</td>
<td>1</td>
<td>Challenges</td>
<td>Weight of units</td>
</tr>
<tr>
<td>6</td>
<td>Home owner</td>
<td>1</td>
<td>41</td>
<td>An architect who drew up our renovation plan, said that we don’t need to get council approval since we are not changing the frames or windows sizes for retrofitting with double glazed windows. But if you don’t get council approval, the insurance can be void. This is because something has been changed to the structure such as increased weight from the double glazed windows.</td>
<td>1</td>
<td>Challenges</td>
<td>Council approval</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>1</td>
<td>51</td>
<td>It does require consent (Auckland Council approval) in some cases and that can be a challenge. Any consents or activities always present a challenge for some homeowners.</td>
<td>1</td>
<td>Challenges</td>
<td>Council approval</td>
</tr>
<tr>
<td>9</td>
<td>Auckland Council</td>
<td>1</td>
<td>52</td>
<td>People will do it if there is a compliance requirement.</td>
<td>1</td>
<td>Challenges</td>
<td>Compliance requirement</td>
</tr>
<tr>
<td>1</td>
<td>Home owner</td>
<td>2</td>
<td>60</td>
<td>To make my interest even higher, we have glazing problems in our house, some of our windows are failing. Our house is 15 years old, windows are only guaranteed for 5 years, the gap in the aluminium joineries are coming out let water in.</td>
<td>2</td>
<td>Interests</td>
<td>Age of windows</td>
</tr>
<tr>
<td>5</td>
<td>Eco advisor</td>
<td>2</td>
<td>69</td>
<td>It depends on the age of the windows and the type of frames as to whether retrofitting is a suitable option and whether people will be interested in doing that.</td>
<td>2</td>
<td>Interests</td>
<td>Age of windows</td>
</tr>
</tbody>
</table>

Total of 10 significant statements were recorded relating to building consents from 2 homeowners, Auckland Council, Eco Advisor and housebuilder.
Appendix N – Building Consent Fees

<table>
<thead>
<tr>
<th>Building consent fees (including GST)</th>
<th>Description</th>
<th>Type</th>
<th>Fee</th>
<th>Processing</th>
<th>Issuing</th>
<th>Compliance</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application fee</td>
<td>Per application (fixed fee)</td>
<td>$287</td>
<td>$287</td>
<td>$287</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fee for engineering plans</td>
<td>For engineering plans (fixed fee)</td>
<td>$252</td>
<td>$252</td>
<td>$252</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waiver fee for engineering plans</td>
<td>Waiver for engineering plans (fixed fee)</td>
<td>$176</td>
<td>$176</td>
<td>$176</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building consent for alterations</td>
<td>Building application (National Multi - Project - led) (standard fee)</td>
<td>$1280</td>
<td>$1280</td>
<td>$1280</td>
<td>$1280</td>
<td>$1280</td>
<td>$1280</td>
</tr>
<tr>
<td>Solid waste application</td>
<td>Application fee (standard fee)</td>
<td>$646</td>
<td>$646</td>
<td>$646</td>
<td>$646</td>
<td>$646</td>
<td>$646</td>
</tr>
<tr>
<td>Sewerage or water supply</td>
<td>Sewerage or water supply (standard fee)</td>
<td>$546</td>
<td>$546</td>
<td>$546</td>
<td>$546</td>
<td>$546</td>
<td>$546</td>
</tr>
<tr>
<td>Temporary structures</td>
<td>Temporary structures (standard fee)</td>
<td>$441</td>
<td>$441</td>
<td>$441</td>
<td>$441</td>
<td>$441</td>
<td>$441</td>
</tr>
<tr>
<td>Insulation</td>
<td>Insulation (standard fee)</td>
<td>$337</td>
<td>$337</td>
<td>$337</td>
<td>$337</td>
<td>$337</td>
<td>$337</td>
</tr>
<tr>
<td>Fire spread</td>
<td>Fire spread (standard fee)</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
</tr>
<tr>
<td>Extinguishing water</td>
<td>Extinguishing water (standard fee)</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
</tr>
<tr>
<td>Roofing</td>
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<td>$228</td>
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<tr>
<td>Swimming pool</td>
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<tr>
<td>Pest management</td>
<td>Pest management (standard fee)</td>
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<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
</tr>
<tr>
<td>Building consent for new house</td>
<td>Building consent for new house (standard fee)</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
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<td>$228</td>
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<td>Building consent for alterations</td>
<td>Building consent for alterations (standard fee)</td>
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<td>$228</td>
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<td>$228</td>
<td>$228</td>
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<td>Building consent for extensions</td>
<td>Building consent for extensions (standard fee)</td>
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<td>$228</td>
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<td>$228</td>
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<td>Building consent for extensions</td>
<td>Building consent for extensions (standard fee)</td>
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<td>$228</td>
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<td>$228</td>
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<td>$228</td>
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<td>Building consent for new house</td>
<td>Building consent for new house (standard fee)</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
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<tr>
<td>Building consent for new house</td>
<td>Building consent for new house (standard fee)</td>
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<td>$228</td>
<td>$228</td>
<td>$228</td>
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</tr>
<tr>
<td>Building consent for new house</td>
<td>Building consent for new house (standard fee)</td>
<td>$228</td>
<td>$228</td>
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</tr>
<tr>
<td>Building consent for new house</td>
<td>Building consent for new house (standard fee)</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
</tr>
<tr>
<td>Building consent for new house</td>
<td>Building consent for new house (standard fee)</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
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</tr>
<tr>
<td>Building consent for new house</td>
<td>Building consent for new house (standard fee)</td>
<td>$228</td>
<td>$228</td>
<td>$228</td>
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</tbody>
</table>

Retrieved from Auckland Council (2016e)
### Appendix O – Resource Consent Fees

#### Resource consent lodgement deposits (including GST)

<table>
<thead>
<tr>
<th>Consent</th>
<th>Description</th>
<th>Lodgement Deposit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-application meeting *</td>
<td>Standard</td>
<td>$287*</td>
</tr>
<tr>
<td>Land-use</td>
<td>Minor elements, retaining wall, below 4m (LCA)</td>
<td>$300</td>
</tr>
<tr>
<td></td>
<td>Erosion control, driveway, solar tubes, roof drain</td>
<td>$2,550</td>
</tr>
<tr>
<td></td>
<td>Residential (4 or more dwelling) or Non-Residential: Trees (where district plan requires payment)</td>
<td>$4,350</td>
</tr>
<tr>
<td>Subdivision</td>
<td>All (with the exception of those below)</td>
<td>$3,500</td>
</tr>
<tr>
<td></td>
<td>Combined Land Use Subdivision 1-10 lots</td>
<td>$4,000</td>
</tr>
<tr>
<td></td>
<td>Combined Land Use Subdivision 11 or more lots</td>
<td>$5,000</td>
</tr>
<tr>
<td></td>
<td>Cross-access, unit title, Right of Way</td>
<td>$1,200</td>
</tr>
<tr>
<td>Regional</td>
<td>Controlling structures, activities and occupations affecting comment, water bodies, wetlands, drains, works in or under rivers, streams or drains, discharge of stormwater, domestic wastewater or other contaminants, transfer of coastal, water or discharge permit to another site</td>
<td>$3,500</td>
</tr>
<tr>
<td></td>
<td>Discharge contaminants to air or water (smoke rise)</td>
<td>$10,355</td>
</tr>
<tr>
<td></td>
<td>Contaminated sites, landfills, discharge (all other than above)</td>
<td>$7,000</td>
</tr>
<tr>
<td>Other</td>
<td>For example: Certificates of compliance, existing use, AS/NZS, outline plan, extension of time</td>
<td>$1,000</td>
</tr>
<tr>
<td></td>
<td>Alcohol Licensing Naming Certificate</td>
<td>$500*</td>
</tr>
<tr>
<td></td>
<td>Variation, review of conditions</td>
<td>$2,000</td>
</tr>
<tr>
<td></td>
<td>Permitted Activity Review (reviewing of any proposal or query to determine if it is a permitted activity)</td>
<td>$250</td>
</tr>
<tr>
<td></td>
<td>Consent transfer or consent surrender</td>
<td>$220</td>
</tr>
<tr>
<td></td>
<td>Annual coastal licence – removed</td>
<td>$150</td>
</tr>
</tbody>
</table>

* Please refer to Notes section for more information.
** Fixed charge

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Retrieved from Auckland Council (2016e)
### Appendix P – Council Hourly rates

#### Hourly rates (including GST)

<table>
<thead>
<tr>
<th>Description</th>
<th>Speciality</th>
<th>Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager/project manager/legal services</td>
<td>All areas</td>
<td>$190</td>
</tr>
<tr>
<td>Team leader</td>
<td>All areas</td>
<td>$180</td>
</tr>
<tr>
<td>Specialist/senior</td>
<td>Planning, engineering, subdivisions, environmental health, compliance and monitoring, urban designer, arborist, licensing, incident investigators, other</td>
<td>$180</td>
</tr>
<tr>
<td>Senior building processing and inspections</td>
<td>Building processing and inspections</td>
<td>$176</td>
</tr>
<tr>
<td>Planning, engineering, subdivisions, urban designer, arborist, other (excluding specialist/senior)</td>
<td>Planning, engineering, subdivisions, arborist, other</td>
<td>$156</td>
</tr>
<tr>
<td>Building processing and inspections, compliance, monitoring, environmental health</td>
<td>Building, compliance, monitoring, environmental health, licensing, incident investigators, other</td>
<td>$149</td>
</tr>
<tr>
<td>Administration</td>
<td>All areas</td>
<td>$105</td>
</tr>
</tbody>
</table>

**Note:**
1. The categories denote descriptions of work performed by council officers.
2. Position titles vary across the Auckland Council regulatory division.
3. External specialists are charged at cost.

Retrieved from Auckland Council (2016e)
Appendix Q – Recruitment Survey on Construction Sector

Retrieved from MBIE (2013)
# Appendix R – Performance of Selected Glass and Frame Options

This table compares the performance of some glass and frame options.

<table>
<thead>
<tr>
<th></th>
<th>Single glazing</th>
<th>Standard double glazing</th>
<th>Double glazing with low-E glass</th>
<th>Double glazing with low-E glass plus argon gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium frames</td>
<td>R0.15</td>
<td>R0.25</td>
<td>R0.31</td>
<td>R0.32</td>
</tr>
<tr>
<td>Thermally broken aluminium frames</td>
<td>R0.17</td>
<td>R0.31</td>
<td>R0.39</td>
<td>R0.41</td>
</tr>
<tr>
<td>Timber / uPVC</td>
<td>R0.19</td>
<td>R0.36</td>
<td>R0.47</td>
<td>R0.50</td>
</tr>
</tbody>
</table>

Retrieved from Smarter Homes (2013a)
Appendix S – Total Number of Employees in the Construction Sector

Retrieved from MBIE (2013)
Appendix T – Labour Outflows from Construction Sector

Retrieved from MBIE (2013)
Appendix U – Labour Inflows to Construction Sector

Retrieved from MBIE (2013)
Full name of author: KIM HIAN CHAI

Full title of thesis/dissertation/research project ('the work'):
The challenges faced by homeowners and other stakeholders in retrofitting double glazed windows in older homes in New Zealand

Practice Pathway: Management and Marketing
Degree: Master in Business
Year of presentation: 2016

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Date: 12/12/2016