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Improving Residential Solar Photovoltaic Uptake within the Moreland Municipality

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IMPROVING RESIDENTIAL SOLAR PHOTOVOLTAIC UPTAKE

WITHIN THE MORELAND MUNICIPALITY

Moreland Energy Foundation

WPI

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WITHIN THE MORELAND MUNICIPALITY

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Abstract:

The goal of our project was to assist the Moreland Energy Foundation (MEFL) in expanding the use of residential solar photovoltaic (PV) systems in the City of Moreland in north metropolitan Melbourne by identifying major drivers and barriers that shape the PV market. We interviewed PV installers and surveyed households to identify what affects consumers’ decisions to install PV systems. Moreland has the potential to offset most of its residential electricity usage through PV, but to achieve this potential MEFL and other organizations and agencies need to develop regulations for landlords to encourage PV installations, educate owners of multi-unit dwellings about PV options, educate consumers about upfront costs and finance options, and enhance community engagement through targeted outreach.

Acknowledgements:

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To Paul Murfitt, CEO at MEFL: Thank you for inviting us to MEFL. We have had a wonderful time working on this project and hope that it provides a start to overcoming the challenges of promoting solar PV throughout Moreland.

Executive Summary:

To combat climate change and protect against rising electricity prices, consumers are increasingly interested in renewable energy sources such as solar power. Over the past five years, Australia has seen rapid uptake of residential solar photovoltaic (PV) systems: in 2013, roughly 10% of Australian households owned a PV system, compared to 0.2% in 2008 (Vorrath, 2013). In the city of Moreland, approximately 3,000 out of over 50,000 occupied residential dwellings (roughly 6%) have PV systems installed. Recently, with the decrease in government incentives, such as the feed-in tariff, and changes in government policies, the PV market in Australia has seen a significant decrease in uptake. The goal of our project was to assist the Moreland Energy Foundation to expand the use of residential solar photovoltaic (PV) systems in the City of Moreland in north metropolitan Melbourne by identifying major drivers and barriers that shape the PV market. We also calculated the residential PV carrying capacity based on current technologies.

Methodology:

Our project comprised four main tasks and objectives:

1. We calculated the potential carrying capacity for PV in Moreland using Nearmap™ to assess the physical, residential roof space that could support PV, integrating current technology and installation guidelines.
2. We identified the key market forces and technical constraints that affect the adoption of residential PV technologies based on interviews with representatives from four PV installation companies that operate nationwide.
3. We conducted surveys of 22 homeowners that had previously installed PV systems to determine the factors that shaped their decision and the obstacles that they overcame.
4. We surveyed 320 homeowners and renters that had not installed PV systems in order to identify factors that may encourage consumers to install PV systems in the future.

Findings:

We determined that if all occupied residential dwellings had the largest solar PV systems their roofs could support, Moreland could produce 215.2 GWh of solar-generated electricity per year and offset 91% of its yearly electricity usage through residential dwellings. Excluding rented dwellings, heritage overlay, and using a maximum of 5 kW systems per house, Moreland

could produce 126.2 GWh of solar electricity per year, and offset 86% of the consumption of these dwellings. We estimated the average system size for these dwellings to be 3.20 kW. In order to realize this potential, however, the City of Moreland will need to overcome a series of obstacles and capitalise on some of the key drivers that are likely to shape the PV market in the foreseeable future. We discuss these obstacles and market drivers below from the perspectives of the installers, homeowners with PV systems already, and households (homeowners and renters) that do not presently have PV systems installed.

Key Drivers and Barriers from Installers Perspective:

PV installers noted that costs and financing, consumer knowledge, and the split incentives between landlords and renters are three major barriers in the PV market. Installers also reported that the three factors driving the uptake of PV are community engagement, referral programs, and the interest of particular age groups, who are most likely to install PV in the future. There is a plethora of information, not all of it correct, available on solar panel installations, pricing, and payment options. This can confuse and overwhelm homeowners, resulting in many people being misinformed about PV financing options and the return on investment. Installers generally do not target renters, since they need approval from the landlord to install PV, and also typically do not stay long enough to receive the benefits. Furthermore, installers identified retirees and young families as their most prevalent customers and likely targets for PV uptake. They also informed us that community events and referrals have been successful in driving uptake of PV.

PV Households' Perspective:

Surveying homeowners with PV systems led us to identify key factors that motivated people to install PV systems, particularly environmental consciousness and the desire for self-sufficiency. We discovered that multi-unit dwellings, including apartment blocks, can have PV systems installed on their roofs as long as they get majority approval from the Owners' Corporation and split up the roof space above their unit evenly among all dwelling. PV homeowners also reinforced the finding from the installers that the upfront cost is a main barrier and that many people are misinformed or uninformed about financing options.

Non-PV Households' Perspective:

In our survey of non-PV households, we investigated the main drivers and barriers for installing PV, and analysed whether responses differed according to demographic details. We separately considered seven demographic categories (income, mortgage, parenthood, homeownership, age, education, and length of homeownership) by dividing participants into two groups for each category. We then analysed if the responses of the two groups differed. Our results supported findings from the parts of our study that upfront cost was the key barrier for people installing PV. Our responses, however, were not consistent with other recent literature on the primary reasons for installation. While previous studies indicated that people are most incentivised to install for energy bill savings, our results showed an inclination to reduce personal greenhouse gas emissions. We found few statistically significant differences among different demographic views. However, we found that renters are more receptive than homeowners to case studies on installation. This information aided in the development of specific recommendations for MEFL.

Conclusions and Recommendations:

Based on our findings, we make six recommendations in five areas: appealing to landlords, spreading awareness of the suitability of multi-unit dwellings for PV installations, increasing awareness of financing options, overcoming the consumer knowledge barrier, and promoting community engagement effectively.

Regulatory Barrier on Rented Dwellings

Recommendation #1. We recommend MEFL to **educate landlords on how they can benefit economically from installing a PV system** on their dwelling. If the landlord purchases a system, they could increase their rent by justifying that the tenant will recoup the difference through savings in their energy bills.

Currently, there is no mandatory disclosure of energy ratings for rental properties, preventing landlords from being publically acknowledged for increasing the energy performance of their rental property, which makes it harder for them to increase rents. This needs to be overcome in order for the landlord to fully benefit from the capital costs of such upgrades.

Multi-Unit Dwellings

Recommendation #2. We recommend that MEFL **educates Owners' Corporations of multi-unit dwellings** to improve understanding of the process and feasibility of installing solar PV. We recommend that they primarily focus on smaller apartment dwellings. The main difference in the process when compared to installing on a fully detached dwelling is that the owner must get majority approval from the Owners' Corporation. Additionally, the owner must accept responsibility for any damages done to the roof by the system, or pay to remove the system if this later becomes necessary.

Financial Barrier

Recommendation #3. We recommend MEFL to **educate individuals on the various payment options available for solar PV**.

We suggest that MEFL further emphasizes the education of **communities with higher percentages of people with mortgages**, because our survey results indicate that people with mortgages are significantly more likely than people without mortgages to lack sufficient information on the various financial options.

We suggest that MEFL **educates communities on the financial options in areas with more schools**, since our data indicates that parents are significantly more likely than non-parents to have initial cost as the greatest reason discouraging them from installing solar PV.

Consumer Knowledge Barrier

Recommendation #4: We recommend that MEFL creates an **interactive webpage showing potential savings** a homeowner can make through purchasing PV.

This tool could also be used to **determine an appropriate sized system and would incorporate financing options, incentives, and current cost of electricity,** in order to improve financial awareness.

Community Engagement

Recommendation #5: We recommend that MEFL promotes PV adoption to **older individuals who do not have a mortgage through word-of-mouth recommendations and marketing**.

Since these individuals are older, they **may be less tech-savvy** than younger members of the community. Because of this, they may be more likely to prefer word-of-mouth recommendations instead of utilising case studies or other information about PV that can be found on the Internet. These individuals are likely to already trust family and friends, indicating that **community events where PV homeowners provide personal testimonials about uptake to their neighbours and friends** could be a viable way to increase the potential for PV adoption to older individuals who are not paying a mortgage.

Recommendation #6: We recommend that MEFL hosts family-friendly community events to **promote PV uptake to younger families**.

A way to outreach to young families is through **school fundraisers**. These fundraisers could help raise money to put PV on schools while also offering **incentives to the homeowners of the children attending these schools**. By promoting solar PV to young families, **children will also be exposed to pro-environmental behaviours**, which could be beneficial to the future PV market as the children grow into independent adults and future homeowners.

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5.2: Unit-Type Dwellings	TB		NT	EM
5.3: Financial Barrier	TB		NT	EM
5.4: Knowledge Barrier	EM	TB	NT	EM
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Contents:

Abstract: ... i

Acknowledgements: ... ii

Executive Summary: ... iii

Authorship: ... viii

Contents: ... ix

List of Figures: ... xii

List of Tables: ... xiii

Chapter 1: Introduction ... 1

Chapter 2: Literature Review ... 2

2.1 History of PV ... 2

2.1.1 The Origins of PV ... 2

2.1.2 Recent PV Market Trends ... 3

2.1.3 Australian PV Market ... 6

2.2 Government Programs and Incentives ... 10

2.2.1 Feed-in Tariffs ... 10

2.2.2 International PV Markets ... 11

2.3 Socio-Demographic Drivers for Residential Investment in PV Systems ... 14

2.3.1 Pro-environmental Behaviours Relevant to Solar PV ... 15

2.3.2 Technology Adoption Life Cycle ... 16

2.3.3 Internal Drivers, Consumer Attitudes, Socio-Demographics and their Effects on the PV Market ... 17

2.3.4 External Drivers in the PV Market: Decision-Making, Peer Effects, and Visibility ... 22

2.3.5 Australian Socio-Demographics and Motivation for Solar PV Uptake ... 22

2.3.6 Marketing Strategies to Promote PV Installation ... 24

Chapter 3: Methodology ... 25

3.1 Objective 1: Estimated the potential Carrying Capacity for Moreland ... 25

3.1.1 Measured Roofs within Three Selected Postcodes in Moreland Using Nearmap™ ... 25

3.1.2 Calculated the Carrying Capacity within Three Sampled Postcodes and for entirety of Moreland ... 28

3.2 Objective 2: Determined key market forces and technical constraints affecting the adoption of PV ... 30

3.2.1 Interview Instrument Development ... 30

3.2.2 Interview Sample and Recruitment 30
3.2.3 Interview Implementation 31
3.2.4 Data Collection and Analysis 31
3.3 Objective 3: Identify and survey households with PV installations to determine what factors influenced their decision to install a PV system and the barriers they overcame 32
3.3.1 Survey Instrument Development: 32
3.3.2 Survey Sample and Recruitment: 33
3.3.3 Survey Implementation: 34
3.3.4 Data Entry and Analysis: 35
3.4 Objective 4: Survey MEFL and Zero Carbon Moreland members within the local community to identify potential influencing factors for installing a PV system 35
3.4.1 Survey Instrument Development: 35
3.4.2 Survey Sample and Recruitment: 36
3.4.3 Survey Implementation & Data Analysis: 37
3.5 Objective 5: Provide recommendations and strategies to MEFL to promote future expansion in Moreland 37
Chapter 4: Findings 39
4.1 Carrying Capacity Calculations 39
4.1.1 Realistic Calculation with Restrictions 39
4.2 Installer Perspectives on Key Drivers and Barriers 41
4.2.1 Price and Financing Barrier 41
4.2.2 Consumer Knowledge Barrier 42
4.2.3 Regulatory Barriers on Rented Dwellings 42
4.2.4 Target Age Groups: Retirees and Young Families 43
4.2.5 Driving the Market through Community Engagement and Referrals 44
4.3 Understanding the PV Homeowner Perspective: Motivations and Challenges behind Investment 45
4.3.1 Results Summary 45
4.3.2 Challenges to Installation 47
4.3.3 Perspective of Installation on Multi-Unit Dwellings 48
4.4 Critical Reasons why Non-PV homeowners have not invested 49
4.4.1 Analytical Strategy: 49
4.4.2 Primary Reason for not Pursuing PV Installation: 50
4.4.3 Preferred Payment Option 52

4.4.4 Perception of Cost: 53
4.4.5 Greatest Gain from Owning a PV System 54
4.4.6 Preferred Source of Information 55
4.4.7 Comparisons to Previous Studies: 56
Chapter 5: Conclusions & Recommendations 58
5.1 Regulatory Barrier on Rented Dwellings 58
5.2 Multi-Unit Dwellings 59
5.3 Financial Barrier 59
5.4 Consumer Knowledge Barrier 60
5.5 Community Engagement 61
5.6 Limitations of Our Study, Potential Uses of the Recommendations, and Areas for Future Expansion 62
5.6.1 Limitations of Our Study: 62
5.6.2 Use of Our Recommendations: 63
5.6.3 Areas for Future Expansion: 63
References 64
Appendix 1: Sponsor Description 68
Appendix 2: Installer Interview Supporting Documents 73
Appendix 3: Email to MEFL AGM Contacts 77
Appendix 4: Email to “Pub Night” Contacts 78
Appendix 5: PV Homeowner Questions 79
Appendix 6: PV Homeowner Data Collection Sheet 80
Appendix 7: Map of PV Households for Door-to-Door Surveying 81
Appendix 8: Email to Positive Charge Members with PV systems 82
Appendix 9: PV Homeowner Preamble 83
Appendix 10: Letter to Absentee Homeowners 84
Appendix 11: Socio-Demographics Chart 85
Appendix 12: Online Survey of Households without Solar Power Systems 86
Appendix 13: Email to MEFL/ZCM Subscribers for Non-PV Household Survey 91
Appendix 14: Mapping Calculations 92
Appendix 15: Example Demographic Tabulation 96
Appendix 16: Tabulated Online Survey Results 97

List of Figures:

Figure 1. Installed PV Capacity in Europe 4
Figure 2. PV Production from 2000 to 2010. 4
Figure 3. PV System Sales Price. 5
Figure 4. Installations and Average kW Capacity 6
Figure 5. 2012 Global Average PV Installation Cost (Parkinson, 2013). 7
Figure 6: Weekly Installation of Solar PV systems under Small-scale Renewable Energy Schemes 8
Figure 7. Four Stages of PV Market Development. 12
Figure 8. Side-by-side comparison of Melbourne PV uptake in December 2011 and August 2013 20
Figure 9. Primary Motivation for Installing Solar PV Systems. 23
Figure 10. Key Technology Attributes, Proportion of Choices as Most Important. 23
Figure 11. Example of measurements on a typical rooftop in Moreland. 27
Figure 12. PV Homeowner Respondents Categorized by Age 45
Figure 13. PV Homeowner Respondents Categorized by Income Bracket 46
Figure 14. Biggest Motivation/Greatest Satisfaction Responses from PV Homeownership 47
Figure 15. Factors Most Likely to Discourage Installation 51
Figure 16. Preferred Payment Options 52
Figure 17. Perception of PV System Cost 54
Figure 18. Greatest Gain from Owning a System 55
Figure 19. Most Preferred Information Sources on PV Installation 55
Figure 20. Comparison between Literature and Our Results 57
Figure 21. MEFL Hierarchy of Organisational Bodies. 71
Figure 22. Map of Moreland and surrounding areas 72
Figure 23. Nearmap image of Pascoe Value Homes with Solar Panels Installed 81

List of Tables:

Table 1. Various Feed-in Tariffs in Victoria. 11
Table 2. Summary of Classifications within the Technology Adoption Life Cycle, Modified.... 17
Table 3. Variables effecting PV Uptake. 19
Table 4. Brunswick Conversion Ratios for peak sun hours times derating factor.................... 29
Table 5. Summary of Installer Interviewees and Companies 31
Table 6. Responses from Door-to-Door Surveying 35
Table 7. Response Rates for Online Survey 37
Table 8. Carrying Capacity Results (No Restrictions) for Three Sample Postcodes and Entirety of Moreland 39
Table 9. Carrying Capacity Results (With Restrictions) for Three Sample Postcodes and Entirety of Moreland.................... 40
Table 10. Key Drivers and Barriers from Installer Interviews. 41
Table 11. Membership Options 69
Table 12. Installer Interview Questions Sorted by Most Applicable Question to Respective Interviewee and Category 76
Table 13. Brunswick Carrying Capacity Calculation Results 92
Table 14. Pascoe Vale Carrying Capacity Calculation Results 93
Table 15. Fawkner Carrying Capacity Calculation Results.................... 93
Table 16. Moreland Census Data Used to Weight Data from Each Postcode 93
Table 17. Moreland Full Carrying Capacity Results 94
Table 18. Moreland Dwellings Breakdown by Postcode and Results of Verification Tests.................... 95
Table 19. Tabulation of Main Reason for not Installing vs. Income Comparison.................... 96

Chapter 1: Introduction

Increasing awareness of climate change and the adverse impacts of fossil fuel combustion is driving the effort to develop reliable sources of renewable energy. Solar photovoltaic (PV) has the potential to play a major role in reducing reliance on fossil fuels by catalysing the overall transition to renewable energy. Past government incentives, in conjunction with high feed-in tariffs, encouraged a substantial increase in the adoption of PV systems in Australia within recent years. Additionally, energy retail prices have increased, on average, by 40% from 2009 to 2012, providing another reason for desired independence from electricity bills (DRET, 2012). According to the Clean Energy Council CEO, David Green, the number of PV installations has increased 50 fold since 2008 with PV systems now installed in over one million homes across Australia, as compared to approximately 20,000 in 2008 (Bretherton, 2013; Vorrath, 2013). From November 2009 to the end of 2011, a high feed-in tariff in Victoria, which paid consumers $0.60/kWh for the electricity their system put into the grid, was driving the market along with the decreasing prices of solar PV systems. However, in January 2013 the feed-in tariff was reduced significantly to $0.08/kWh and others government incentives including the solar credit multipliers were withdrawn in Victoria throughout the year. Without the previous incentives in place, there exists a new challenge to continue improvements to sustainability and to encourage the continued adoption of PV systems.

The Moreland Energy Foundation, Ltd (MEFL) has been promoting sustainable energy at the community level since 2000. Since the overall rate of uptake has declined in recent months, MEFL established a subsidiary, Positive Charge, which is particularly interested in knowing the most effective methods to promote PV uptake in Moreland. Given the current situation of the PV market, our goal is to identify the most effective methods to encourage more households in Moreland to install PV systems.

In order to formulate recommendations and gain an understanding of the potential consumers within Moreland, we identified the drivers and barriers to installing residential PV systems. To do so, we reviewed previous studies and analysed information gathered from the perspectives of PV installers, in addition to both PV and non-PV households. We conducted various interviews and surveys to obtain these perspectives and supplemented this data with calculations of physical roof space to obtain the carrying capacity of solar power and potential yearly electricity production in Moreland. Lastly, based on our findings, we have provided recommendations to MEFL as to how to implement programs which would complement the drivers of the PV market and help overcome its barriers.

Chapter 2: Literature Review

Solar photovoltaic (PV) systems have become increasingly popular worldwide as prices have continued to fall and concerns about climate change and the other adverse effects of fossil fuel combustion have grown. In Australia, an estimated one million households have taken advantage of installing PV systems in the past decade. Unfortunately, the decrease in government incentives has caused a sudden and recent drop in the number of purchases. Understanding the history of the PV market and the impacts of governmental policies, incentives and regulations, along with other key social drivers will lead to a more informed decision about how to target the second million investors in solar PV systems in Australia.

2.1 History of PV

2.1.1 The Origins of PV

Charles Fritts invented the first primitive solar cell in 1833, but it was not until after the Second World War that Bell Laboratories' scientists developed the first PV cell to produce a substantial amount of electric power (Jones & Bouamane, 2012). The World Symposium on Applied Solar Energy displayed Bell's PV cell to representatives of 37 countries in 1955. Later that year, *The New York Times* released an article stating that PV would lead "to the realization of one of mankind's most cherished dreams - the harnessing of the almost limitless energy of the sun" (Jones & Bouamane, 2012). Arguably, this dream is still to be realised.

The United States and Soviet Union held the initial markets of PV systems during their space race in the 1960s. Due to the high production and maintenance costs of PVs, the public market remained very small and NASA was the primary target for sales and development (Jones & Bouamane, 2012). A major drawback throughout the space race was the limited power efficiency of the prototype PV systems (Tyagi, Rahim, Rahim, & Selvaraj, 2013).

The oil crises of the 1970s stimulated a second phase in the development of PV systems, turning attention from satellites and rockets to on-ground applications, and funded primarily by major oil and gas companies (Platzer, 2013). Within the United States, the Carter Administration introduced the Energy Tax Act (ETA) in 1978, which provided tax credit incentives for consumers who purchased solar. (Platzer, 2013).

The development of PV technologies in Japan and Europe focused more on building a commercial PV industry in the 1970s. Such initiatives resulted in the 1974 development of

Project Sunshine to explore alternative energy options in Japan as well as the first formal renewable energy program within Europe. This program, established in Germany, grew from 10 million EUR to 60 million EUR over the course of four years (Jones & Bouamane, 2012).

The world PV market fluctuated substantially from the 1980s through early 2000. Ronald Reagan's Tax Reform Act of 1986, which reduced the Investment Tax Credit to 10% from 30%, combined with the substantial drop in petroleum prices, hindered the development of the PV market in the US until 2005 (Jones & Bouamane, 2012). Meanwhile, the PV market in Europe and Japan remained relatively strong, and even expanded under government incentives. European and Japanese governments "engaged in massive programs to subsidize rooftop PV systems... [.] [By] 1988 [Japanese and European] firms dominated PV production" (Jones & Bouamane, 2012). For example, Germany launched a program in 1990, installing approximately 2,250 PV systems on roofs, with 70% of installation fees funded by the government. Building on Germany's success, Japan launched its *Seventy Thousand Roofs Program,* providing one-third the installation price and requiring local electric companies to purchase the surplus energy generated. By the year 2000, Japan had installed over 50,000 rooftop PV systems (Jones & Bouamane, 2012). The expansion of Japanese production and success throughout Europe in rooftop PV installation encouraged other countries to adopt similar policies.

2.1.2 Recent PV Market Trends

In the early 2000s, the PV market entered a new generation of growth attributed to "technological improvement, cost reductions in materials and government support for renewable energy" (Tyagi et al., 2013). Spain, Italy, and France followed the example set by Germany’s Renewable Energy Sources Act and the installed capacity of PV in Europe grew exponentially (refer to Figure 1). To meet this growing demand, worldwide PV production increased by 40% to 90% per year (refer to Figure 2), and China became the dominant producer (Tyagi et al., 2013).

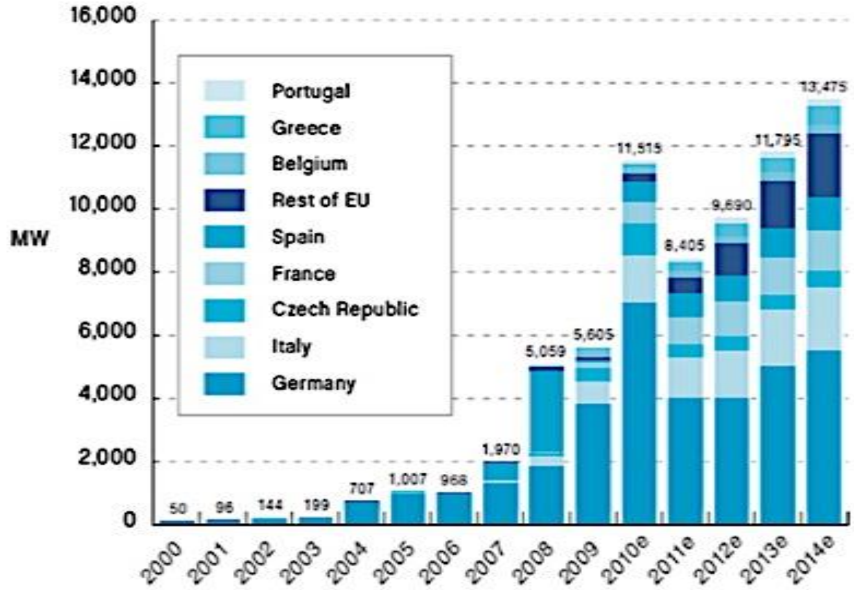


Figure 1. Installed PV Capacity in Europe. (Tyagi et al., 2013).

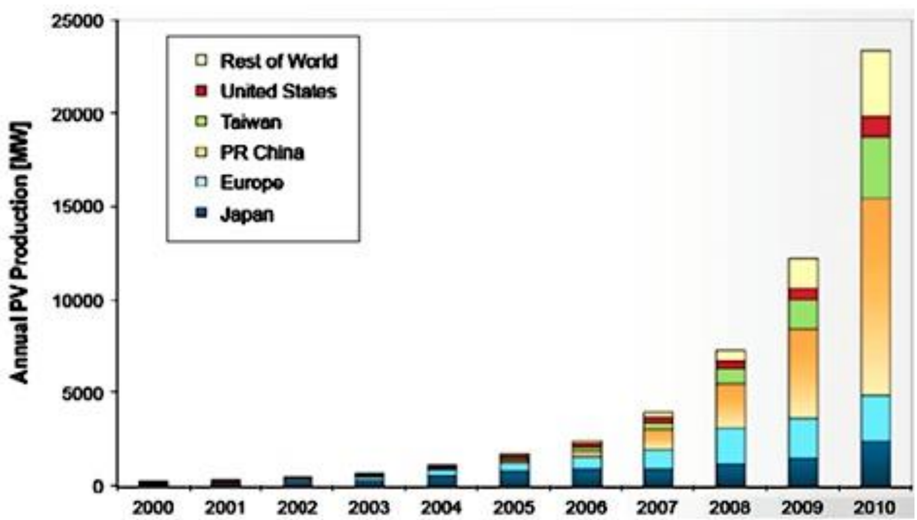


Figure 2. PV Production from 2000 to 2010. (Tyagi et al., 2013).

With government support and incentives, PV installation has also grown in India, Malaysia, Taiwan, Korea, and Thailand (Tyagi et al., 2013). India's recent PV installation expansion has led to a national effort for implementation of 500 GW of solar panels by 2013. They plan to accomplish this goal, in part, by placing PV systems in distant communities to minimize transmission losses associated with distribution from more distant electrical stations (Tyagi et al., 2013).

As PV production has increased, prices per kW capacity have declined and government incentives have reduced. For example, in Germany alone, the fixed rate that power companies purchased solar energy from producers was reduced by 30% in 2012, leading major manufacturers such as Solon, Solar Millennium, and Q-Cells to go bankrupt in quick succession (Jones & Bouamane, 2012).

Fortunately for the consumer, PV system prices have fallen substantially since 2008 (refer to Figure 3) and PVs with an operating efficiency near 28% are now extremely affordable (Tyagi et al., 2013). With the decline in system costs, Germany, Italy, and the United States have dramatically curtailed government incentives for PV installations (Tyagi et al., 2013).

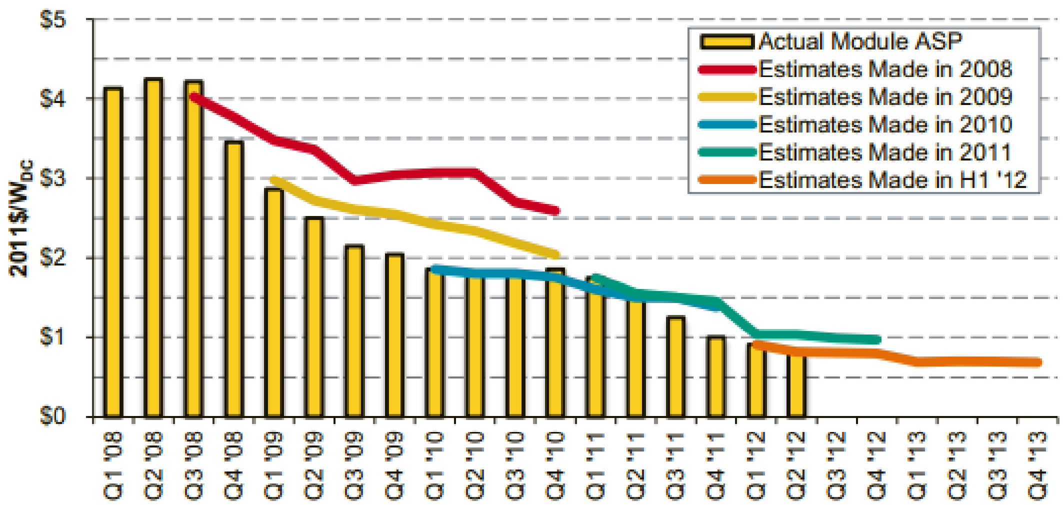


Figure 3. PV System Sales Price. (Feldman et al., 2012).

As the PV market expands, variety and style of PV options have grown as well. Building-integrated and building-applied PV systems are of growing interest because they offer aesthetic benefits, flexibility in installation, and reduced costs compared with standard rooftop systems. This offers a solution to physical constraints of particular roofs, such as tin roofs or roofs without proper support to withstand a system. Solar tiles and shingles are much easier to install and blend into the original housing style, improving PV installation companies' ability to expand ("Building Integrated Photovoltaics," 2010). As sustainability groups strive to improve alternative energy adoption, PV alternatives to roof-integrated systems may lead to the next generation of expansion.

2.1.3 Australian PV Market

The Australian PV consumer market has grown substantially in recent years, initially driven by government programs and incentives but more recently by the decline in capital costs. By June of 2013, 1,054,156 small-scale, domestic PV systems had been installed throughout Australia (Noone, 2013). Nearly one out of ten households have 'gone solar' in Australia, as compared to one out of fifty, only two years ago (Thompson, 2013). The major growth of the market began during 2010, peaking in Quarter 1 of 2011 and Quarter 2 of 2012, due to changes in government incentive programs, with a drastic drop in recent months (refer to Figure 4).

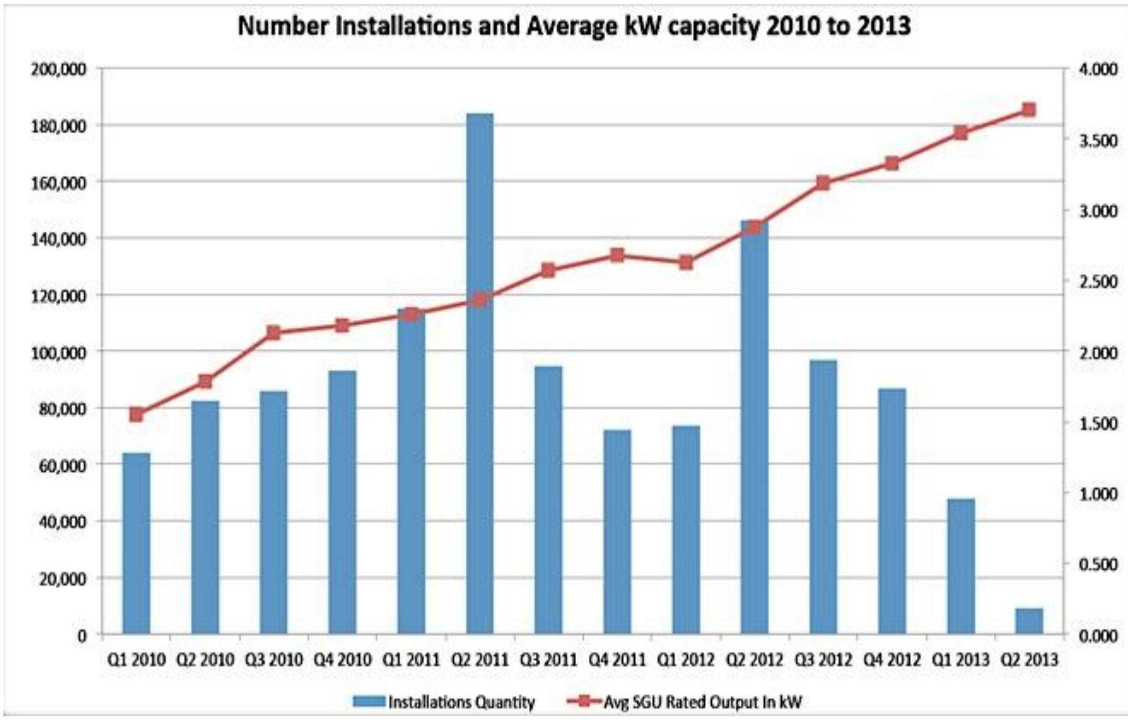


Figure 4. Installations and Average kW Capacity. (Richetin et al., 2012).

The influx of cheap PV systems in recent months may be contributing to a decline in consumer confidence and desire to purchase. That being said, Australia offers lower installation costs than in the US, Japan, and France (refer to Figure 5) (Parkinson, 2013).

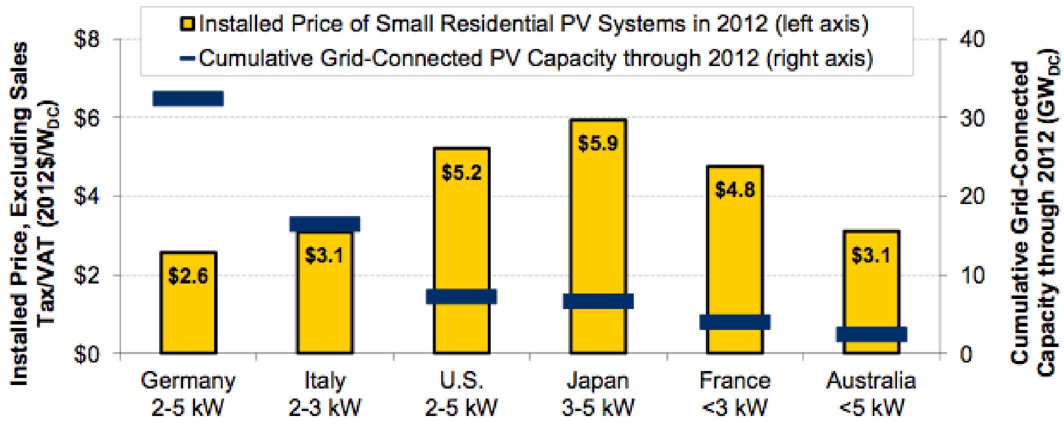


Figure 5. 2012 Global Average PV Installation Cost (Parkinson, 2013).

Recently, consumers and analysts have begun to worry that systems are experiencing failures, much earlier than their rated lifetime (Peacock, 2013). The Australian Photovoltaic Association (APVA) has begun to address this issue, but recognizes that few data are available on collective public experiences and opinion. In association with numerous other sustainability organizations, they have begun the three-year project called *Climate Based PV System Performance & Reliability Project.* The primary goal is to gather information pertaining to quality problems and product life of PV systems (Pulsford, 2012). This study may reveal a change in the public's opinion of PV as a whole, as well as declining confidence in PV as a worthwhile investment.

To combat these growing problems, community groups such as MEFL, and their Positive Charge Initiative [1] in particular, aim to end the "boom and bust" cycle (refer to Figure 6) and stabilize the PV market as soon as possible by promoting consistent growth and technical standards. Their primary goal as a community-based organization is "to make it easier for households and businesses across Victoria [to] take practical and effective actions" to act sustainably (Thompson, 2013). Building on recent success, their new plan is to extend their reach beyond the Moreland community throughout Victoria and engage with 40,000 households in upcoming years to directly link households to their range of products, service, and support (Thompson, 2013).

[1] The Positive Charge Initiative is a subsidiary of MEFL that offers sustainable energy answers for homes and businesses.

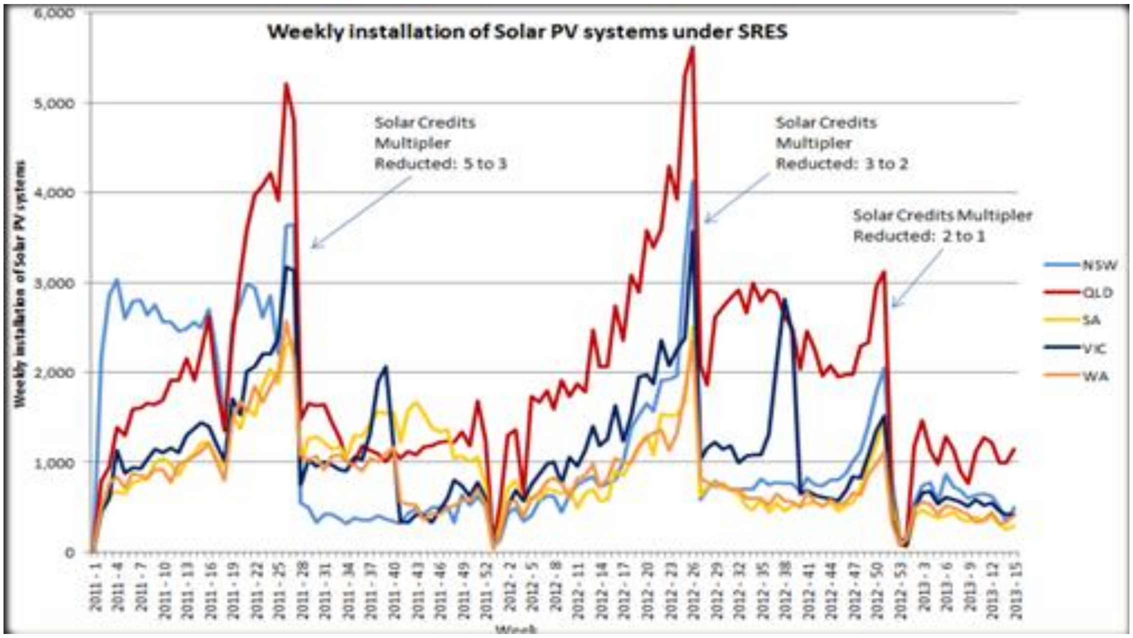


Figure 6: Weekly Installation of Solar PV systems under Small-scale Renewable Energy Schemes. (MEFL, 2013)

In 2012, MEFL managed the Delivering Clean Energy Solutions (DCES) project in conjunction with the Northern Alliance for Greenhouse Action (NAGA)[2] to design a business strategy, which coordinated bulk buying of clean energy technology. Such technology included solar electricity systems, solar hot water systems, and electric bicycles. The primary objectives of DCES were to increase the consumption of clean and energy efficient products across NAGA and establish a ‘self-funding’ business model for future use and development (Moreland Energy Foundation [MEFL], 2012b).

Their business model was designed for community engagement through information sessions and local festivals to provide the necessary information for uptake of the technology. Marketing in Moreland, with its diverse demographics and housing styles, requires a wide range of products to accommodate all levels of interest and economic feasibility. In order to engage the community, information provided about products must be “simple, easy to understand, and persuasive” (MEFL, 2012b). MEFL found that website postings and regular emails were the most effective forms of communication to engage the entire community. The study found that the primary barriers for PV uptake were lack of confidence when working with suppliers, lack of

[2] NAGA is a network consisting of nine city councils and MEFL in order to share information and coordinate sustainable, local actions for emission reduction.

information pertaining to the supplying company, confusion about government incentive programs, and the overall cost of installation (MEFL, 2012a). Throughout the study, uncontrollable factors such as the suppliers' inability to manage high demand, government policy changes, and landlord-tenant relations deterred installation (MEFL, 2012a). As a whole, DCES was effective in terms of improving PV uptake, but it was also able to provide key findings pertaining to market barriers and solutions to overcome them.

In addition to internal reviews of the business model, Positive Charge administered online surveys to evaluate the overall customer experience when referred to PV installers. One survey, conducted in June 2013, was sent to approximately one hundred members, with twenty-one respondents. When asked why they utilised Positive Charge's PV services and pursued the installation of a PV system, the three most common responses were that the Positive Charge services were easy to use, the program was supported by Moreland Council, and Positive Charge is an independent, not-for-profit organisation. In contrast, the major reasons given for not pursuing an installation were that respondents received no response from the installers they contacted, did not own their dwelling, or were prevented by council regulations, such as a heritage overlay (Positive Charge, 2013b).

Businesses such as Sungevity and Energy Matters have introduced "pay-as-you-go" financing options in order to help consumers overcome the barrier of upfront cost of PV installation. This payment option may be preferred by some consumers, particularly those with lower income or more assets they are paying, because it avoids having to pay capital and installation costs up-front in one large sum (Energy, 2013; Sungevity, 2013). This option allows for investment in a reliable asset that will, over time, return the initial investment and save money on electricity bills.

As illustrated, government policies and programs have played a key role in the development of the PV in different countries. As the PV market continues to mature and prices of high quality systems decrease, government incentives will likely play a smaller role, but it is clear that the market is not yet self-sustaining, and it is likely that programs and incentives will remain important market drivers for the foreseeable future. In the next section, we examine the role of particular government policies in more detail.

2.2 Government Programs and Incentives

Government programs, regulations, and incentives play a critical role in the growth of PV markets in various countries. There are three different types of incentives used in Australia to promote this market: feed-in tariffs, Small-scale Renewable Energy Scheme, and various rebate programs.

2.2.1 Feed-in Tariffs

The major incentive in European countries is the utilisation of feed-in tariffs to provide planning security to consumers (Sandeman, 2010). Various other rebate programs on the upfront cost of PV are used throughout the world, although many of these have expired or reached their funding limit (Platzer, 2013). With an uncertain future in terms of funding and incentives, the PV industry in numerous countries (including Germany, the United States, and Australia) is looking to other means to attract consumers to the PV market.

Zahedi (2010) claims that feed-in tariffs in Australia have been "one of the most effective ways to encourage residential sector[s] and small businesses to install solar PV technology." Feed-in tariffs provide the consumer a price for the electricity their PV system gives back to the grid. There are two different metering methods for tariffs: net and gross. In net metering, you are paid for any surplus power that you feed into a grid, instantaneously, for which you receive payment by a credit on your bill or a cheque once a year, depending on the retailer. Gross metering is when generation and consumption are viewed independent of each other; you are paid for all of the energy your system generates and charged for all of the energy you consume. New South Wales, the Northern Territory, and ACT have a gross feed-in tariff, while the other states and territories in Australia have a net tariff. Feed-in tariffs were introduced in Victoria in late 2009 with the net Premium feed-in tariff at a rate of $0.60/kWh. Over the past several years, different tariffs have been introduced and the values of the tariffs have diminished (refer to Table 1). Homeowners that signed into a tariff still remain eligible for that rate until 2024 for the Premium and 2016 for the others, but new PV homeowners are only eligible for the energy retailer funded rate of $0.08/kWh. The cost of electricity to homeowners currently is $0.25/kWh in Victoria. There is a large gap between the cost of electricity and the feed-in tariff, making PV adoption less attractive because the consumers are not being paid the value of electricity. With the reduction in the tariff, it has become more cost effective to size your system such that it matches your demand.

Name of Tariff	Rate of Tariff	Date Closed	Program Duration
Premium	$0.60/kWh	Dec 29th, 2011	Until 2024
Transitional	$0.25/kWh	Dec 31st, 2012	Until end of 2016
Standard	Same as price you buy on energy plan	Dec 31st, 2012	Until end of 2016
Current	$0.08/kWh	N/A	N/A

Table 1. Various Feed-in Tariffs in Victoria. (Department of State Development Business and Innovation, 2013).

Feed-in tariffs in Germany vary from other countries in the method of payment due to their use of the Shared Burden Principle, where local grid operators can transfer the cost of their payments to the next higher grid level. This helps balance the costs from feed-in tariffs throughout the region since each provider will have similar costs and there will be less of a burden on an individual provider. This prevents a stop-and-go policy caused by budget constraints since costs are more evenly distributed to each provider (Lüthi, 2010). These tariffs are also guaranteed for 20 years, giving the consumers a sense of planning security. There is an annual reduction in feed-in tariffs between 8% and 10% which helps exert cost pressure on manufacturers, giving them an incentive for technological development. (Post, 2012).

2.2.2 International PV Markets

Japan and Germany have been dominant manufacturers and consumers in the PV market since their initial stages due to government regulations. Both countries have now reached their 'take-off phase' (refer to Figure 7) and have a profitable PV installation industry (Lüthi, 2010). With the help of government programs and incentives, Germany has successfully transitioned through the first three out of the four stages of PV market development and has become home to almost a third of the solar modules in the world (Grigoleit, 2013) (refer to Figure 7). In their PV market's early growth in 2000, Germany's government created the Renewable Energy Sources Act (EEG), which set a clear goal for the expansion of renewable energy sources, primarily through guaranteed feed-in tariffs.

Japan is also in the later stages of PV market development. Japan's research and development in PV took off dramatically after 1980. Based on extensive market analysis, the Japanese government decided to continue with the expansion of the PV market through various programs in the 1990s, including the "New Sunshine Program" and "70,000 Roofs" (Mortarino & Guidolin, 2010). Given the duration of the policies in Germany and Japan, many of them have reached, or are close to reaching, their funding capacity. Due to this and other recent policy actions by these governments, energy consumers can expect smaller incentives to install solar PV in the future. Consequently, it is uncertain whether these markets will experience continued growth or have reached saturation (Platzer, 2013).

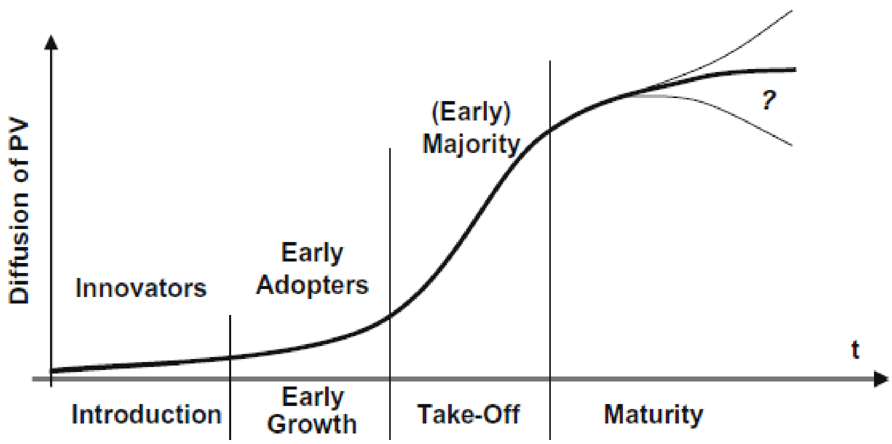


Figure 7. Four Stages of PV Market Development (Lüthi, 2010).

Similarly, the United States' PV market faces uncertainty because funding for various programs has terminated or will terminate in the coming years. Renewable energy manufacturers previously benefited from the Manufacturing Tax Credit (MTC), but its funding cap was reached in 2010. For investors, the Investment Tax Credit (ITC) provides a 30% tax credit as a financial incentive for commercial and residential investments. Because this policy is due to expire at the end of 2016, commercial investments will be given an incentive of only 10%, without a rate for residential investments if the policy is not renewed (Platzer, 2013). These tax incentives, along with the cash grant program, helped the annual growth rate of PV installations reach over 10%, but questions about future growth remain. Additional potential barriers for the US PV market result from the lack of a coordinated national program to develop this market since energy policies are set at a state level without a common aim. Australia and the US have this barrier in common due to the lack of homogeneity in policies between their states (Mortarino & Guidolin, 2010).

2.2.3 Australian PV Government Incentives

Through the years 2007 to 2011, The Solar Homes and Communities Plan (SHCP) provided a major stimulus to the PV market in Australia. This program provided upfront rebates of up to $8,000 for small-scale PV systems. Funding for this program ended in June 2009, but a large number of pre-approval applications were received in the closing day so installations continued through 2011. Overall, a total of 155.62 MW of PV were installed through this program (Watt, 2011). Another very important government-funded program for the Australian PV market was the Renewable Remote Power Generation Program (RRPGP). This program provided rebates of up to 50% for the systems and committed around $300 million to renewable energy generation in remote and regional areas. More than 9,000 residential and medium-scale projects up to 20 kW in size were installed due to the RRPGP (Watt, 2011).

Australian state and territorial governments spent $104.6 million in 2012 on PV R&D, demonstration, and market stimulation (Watt, 2012). The Clean Energy Regulator (CER), an Australian government body, is responsible for building a clean energy future. To work towards this goal, the CER expanded on the Renewable Energy Target (RET), which was established in 2001 to reach a goal of 9,500 GWh of new generation. The enhanced RET operates as two parts: Large-scale Renewable Energy Target (LRET) and Small-scale Renewable Energy Scheme (SRES). The LRET provides incentives for the deployment of large-scale renewable energy projects such as wind farms, while the SRES provides incentives for the installation of small-scale systems such as solar panels. Australia's goal in utilizing various schemes for the promotion of PV systems is to aid in its aim of having a combined 20% renewable energy of total electricity generation by 2020 ("Renewable Energy Target," 2013).

Through the SRES, consumers are eligible for financial benefits (such as a discount off the price of purchase and installation) if they have a new system that complies with all local, state, and federal requirements for its type of installation. This scheme operates by entitling the owners of these systems to create small-scale technology certificates (STCs) worth between $15-$40. The STCs can be sold to RET liable entities, who have the legal liability to purchase a certain amount of STCs a year, or to the STC Clearing House. STCs can be viewed as green energy stocks that are traded among registered agents or on a market known as the Clearing House. The STC Clearing House offers a fixed price of $40 for the certificates, but there is no guarantee as to how long it will take for the STCs to sell in this market. Alternatively, they can be sold to registered agents for, generally, less than $40, depending on the state of the PV market. The number of STCs a PV system can create is based on the amount of MWh it generates over the course of its lifetime of up to 15 years. In addition to the STCs, there is a mechanism known as the Solar Credits multiplier, which increases the number of STCs able to be created for the first 1.5 kW of on-grid capacity installed in an eligible location. For example, a 3 kW system in Melbourne with a 2x Solar Credit multiplier would generate 79 STCs, providing a financial benefit between $1,185 and $3,160 ("Renewable Energy Target," 2013). The Solar Credits multiplier was designed to shrink annually so that subsidies would be strategically wound back as the prices of PV systems decreased (Martin, 2013).

When this program started in the beginning of 2011, the Solar Credit multiplier was set at five, but it decreased over the past years and now has been removed altogether. The announcements of reduction of the multiplier caused enormous peaks in sales, followed by a large decline in sales after the reduction came into effect (Figure 6). This stepped reduction has led to a “boom-bust” cycle, known as the “Solar Coaster,” which makes it very difficult to run a renewable energy or PV business (Peacock, 2013).

Sales and installations of PV systems have decreased as of late due to the reduction of the Solar Credits and other government incentives; there was a 31% decrease in PV systems creating STCs in the past 12 months as compared to the same period in 2012 (ARENA, 2013). The newly elected government is trying to increase the PV market over the next 10 years through the million solar roofs program designed by the Australian Renewable Energy Agency. This program offers a $500 rebate, on top of the existing government supported financial incentives, to households who buy a PV system or solar hot water system. The main focus for this rebate program is on low-income households, which currently is a market sector that has not been developed due to initial cost of system investment. In order to prevent a “boom-bust” cycle similar to ones that other incentives have generated, there is a limit of no more than 100,000 grants (i.e., AU$5,000,000) per year (Brazzale, 2013).

With increasing dependency on market forces, rather than government programs and incentives, understanding how future markets may work and the role that socio-demographic variables might play becomes increasingly important.

2.3 Socio-Demographic Drivers for Residential Investment in PV Systems

The motivations behind the act of purchasing solar PV systems can help identify particular consumer profiles, an understanding of which can help to improve marketing and adoption of PV. Answering the following questions helped us to better understand the types of people buying solar PV:

1. What common drivers or motivating trends are behind the purchasing of residential PV systems?

2. How can we identify the differences between early PV adopters and early majority PV adopters to understand drivers for each?

3. What kinds of market strategies are in place to promote PV installation?

To answer each of these questions, we identified relevant case studies that support theoretical models of the key drivers behind residential investment in PV. They identified several types of drivers, such as pro-environmental behaviours, internal drivers such as attitudes, and external influences such as peer effects.

Everett Rogers studied the attributes that affect the PV market and created a series of hypotheses and diffusion models that we use to explore further the motives for PV installation (Mikulina, 2007). We explored several of the top hypotheses relevant to the development of our project and utilised case studies that have drawn conclusions on the main variables effecting PV adoption to test our data.

2.3.1 Pro-environmental Behaviours Relevant to Solar PV

Many experts within the environmental field have researched pro-environmental behaviours (also known as green behaviours). Pro-environmental behaviour "…means the behaviour that consciously seeks to minimize the negative impact of one's actions on the natural and built world (e.g. minimize resource and energy consumption, use of non-toxic substances, reduce waste production)" (Kollmuss & Agyeman, 2002). While there are numerous works on how green behaviour affects the solar PV market, there is little work on researching the psycho-demographic determinants of green consumption. Investing in residential solar PV is a passive behaviour; people spend the money to invest in a PV system, have the system installed, and the panels provide energy for the homeowner. Solar PV does not have a direct impact on the actions of a person's life. This led us to question why someone would go through the trouble of investing in PV and what their motivations are.

Reasoning behind investment in PV systems stems back to environmental motivation. Based on research into environmental behaviours, "some adopters may have high levels of environmental motivation and may bypass the knowledge or persuasion stages all together and simply adopt [the innovation]" (Mikulina, 2007, p. 53). Therefore, environmental motivations may have a great effect on adoption rates. Rogers also has theoretical hypotheses pertaining to solar PV investment. His Hypothesis 8 suggests the following:

> Hypothesis 8: The propensity of a homeowner to adopt GPV (grid connected PV) is positively correlated with homeowner's pro-environmental orientation and level of involvement in other pro-environmental behaviours (Mikulina, 2007, p. 37).

Rogers makes a sound point by relating the homeowner's attitude of environmental conscious behaviours to the purchasing of solar PV systems. However, it is difficult to fully classify "pro-environmental behaviours" because current studies use different methods to classify this. With this in consideration, we can now take a look at how consumer attitudes affect the success of the PV market.

2.3.2 Technology Adoption Life Cycle

The Technology Adoption Life Cycle (refer to Table 2) provides a model behind the types of people purchasing products and when they choose to make their investment. This model determines the 5 different types of adopters and what percentage of the population they make up. The percentages are all derived from the standard deviations of a normal distribution. The *Innovators*, only a small percentage of the population (2.5%), are the first group to invest money into the development of the product. Oftentimes, these people are of higher social status and are involved with financing the initial prototypes and set the stage for the intial value of the product. The *Early Adopters* are next to purchase and are the following 13.5% of the population. They typically wait to buy the product until they know they can break even with their initial investment. The *Early Majority*, the next 34% of the population, are more deliberate before adopting a new idea and wait unil there is more certainty in the investment. The *Late Majority*, or the following 34% of the population, wait until the product is a standard in society before purchasing. This group wants to be certain that the product is widely used, works as desired, and others within their geographical location also have the product. Finally, the *Laggards*, or the last 16% of individuals, tend to hold on to traditional values and have a greater resistance to innovations. They are the last group of people to adopt an innovation (Mikulina, 2007, p. 29). Table 2 summarizes the classifications of the Technology Adoption Life Cycle through an overview of the types of people that purchase products and when they purchase them.

Adopter Category	Characteristics
Innovators *First 2.5%*	Venturesome and eager to try new ideas; have more years of formal education; higher social status; have substatial financial resources; able to cope with high degree of uncertainty
Early Adopters *Following 13.5%*	Respected by peers; more integrated part of the local system; opinion leaders; role models for other members of social system
Early Majority *Following 34%*	Deliberate before adopting new idea; Adopt new ideas just beore the average member of a system; interact frequently with peers
Late Majority *Following 34%*	Approach innovations with caution and skepticism; adopt new ideas just after the average member of a system; adoption may be due to economic necessity or peer pressure
Laggards *Final 16%*	Hold on to traditional values; resistance to innovation; near isolates in the social networks of local system

Table 2. Summary of Classifications within the Technology Adoption Life Cycle, Modified. (Mikulina, 2007, p. 29).

2.3.3 Internal Drivers, Consumer Attitudes, Socio-Demographics and their Effects on the PV Market

A study conducted in the U.K. used two methods to analyse people's perceptions of solar PV. These methods identified descriptors of solar panels and compared people's perceptions of them through ranking how negatively or positively they perceived them in a survey. Ten previous *Early Adopters* were interviewed first to identify characteristics of solar power. One hundred *Early Adopters* of PV were then surveyed along with 1000 *Early Adopters* of other energy-efficient products for comparison of the two surveyed groups (Faiers & Neame, 2006). The interviewed *Early Adopters* were retired or approaching retirement, and had large amounts of disposable income. They were mostly motivated by concern for future financial situations, environmental impact, and desire to live sustainably (Faiers & Neame, 2006).

The analysis revealed contrasting perceptions between the *Early Adopters* and the *Early Majority* of payback periods, grant levels, solar PV as a home improvement, and the impact of solar systems on visual landscape. This demonstrates a "chasm," or a difference, between the *Early Adopters* and *Early Majority* in their perceptions of PV. It is shown that people in the *Early Majority* have the perception that solar power systems are unattractive, unaffordable, and that the grant levels are not high enough. This study suggested that PV sales personnel could convince the *Early Majority* that solar systems do not affect the visual landscape, that installation is simple and the system requires no maintenance, and that it adds value to the property. Added property value is necessary since it will attract consumers who may move out of their house before the payback period ends (Faiers & Neame, 2006). In order to further the expansion of the PV market, the external drivers need to be understood in order to develop strategic marketing programs geared towards targeting new solar PV system customers.

The *Drivers of Domestic PV Uptake* study, conducted by ACIL Allen Consulting and commissioned by the Australian Renewable Energy Agency, examined the extent of the effects of several socio-economic and socio-demographic variables on the likelihood of households to uptake PV systems. The study used data collected through the Clean Energy Regulator (CER) on PV installation numbers over the duration of the Small-Scale Renewable Energy Scheme (SRES), socio-economic data from the 2011 Australian Census, and income data from the Australian Taxation Office. The CER data provides a snapshot of PV installations in December 2011 and August 2013, and the Australian Census data is from August 2011 (Allen, 2013).

Between the two times observed by the study, owner occupation rates were found to be the most consistently significant variable in the prediction of PV installations, with a strong positive correlation, meaning higher percentages of owner occupied dwellings resulted in greater numbers of PV installations. Other strong positive correlations were: the number of bedrooms per dwelling, the proportion of occupants in a given neighbourhood over 53 years of age, increasing unemployment rates, and proportion of households in single and semi-detached houses (Allen, 2013). Household income was found to be positively correlated with predicted PV uptake, but this relation stabilizes at higher household yearly incomes, after $78,000 (Allen, 2013). Other important variables that effect PV uptake that we will be comparing to our data are described in Table 3.

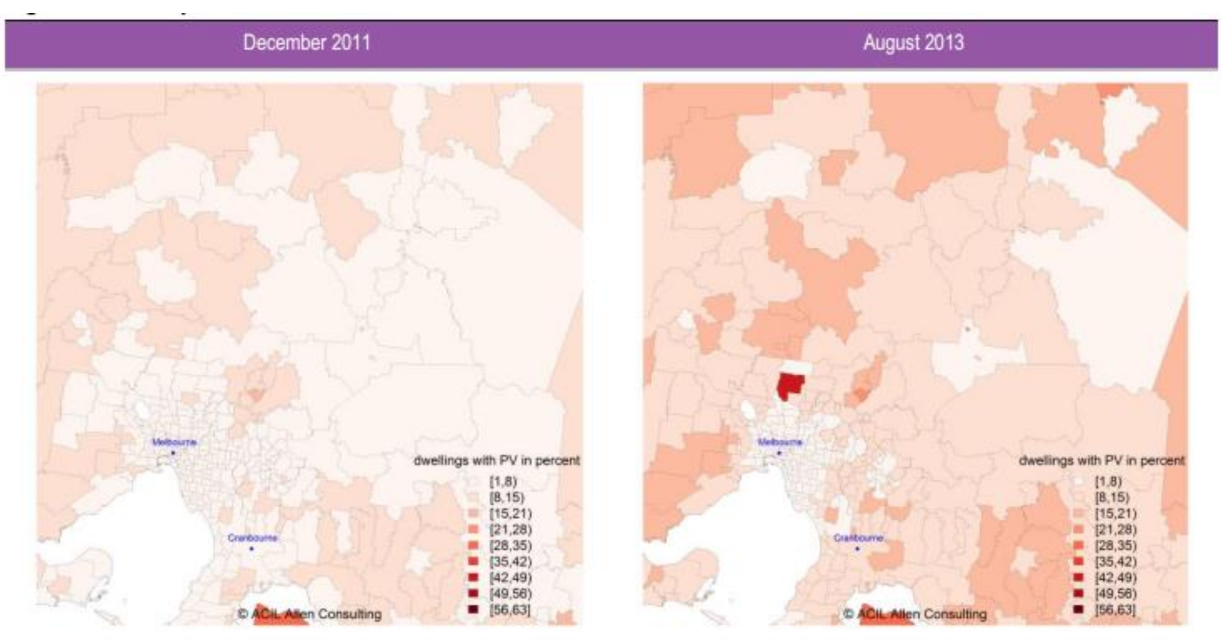
Variable	Effect on PV Uptake
Income	Generally increasing effect on PV uptake
Age	Higher proportions of older residents and lower proportions of children suggest higher PV uptake
Dwelling type	Higher uptake where more dwellings are detached or semi-detached
Dwelling size	Higher where more dwellings are owner occupied
Dwelling location type	Higher uptake in rural and regional locations
Proportion of children	Negative effect
Tertiary education	Positive effect
Unemployment rate	Positive effect
Proportion of people who lived at the same address five years ago	Negative effect

Table 3. Variables effecting PV Uptake. (Allen, 2013).

The duration of an owner's occupation at the same address was found to have a strong negative correlation with PV uptake prediction. This study concluded that new homeowners may desire to stay in their current house for a long period of time, and thus will be more willing to make a long-term investment in the purchase of a PV system. As the number of children in a house increases, there is less of a chance for PV uptake. Since the end of 2011, college education rates went from being positively related to being negatively related to PV uptake. This report suggests this may be due to areas with high proportions of college educated residents being saturated with solar power since the end of 2011 (Allen, 2013).

Along with the analysis of demographic factors, part of the study included mapping total uptake by postcode across Australia to gauge the increase in uptake from December 2011 to August 2013 (Consulting, 2013). The rate of uptake in Melbourne increased more slowly over the past two years compared with Brisbane and Adelaide areas, but was on par with uptake in the Perth area. Side-by-side comparisons of uptake in the Melbourne area at these times are in Figure 8. Side-by-side comparison of Melbourne PV uptake in December 2011 and August 2013. (Consulting, 2013). The maps indicate an increase in uptake since the end of 2011 in and around Melbourne. This could be misleading since in less populated postcodes a small amount of uptake would represent a larger proportion of that area's population.

The uptake of solar PV throughout Australia is also shown within a different investigation. Alice Solar City (ASC) looked at the widespread adoption of PV along with demographic drivers for installation. A study of 268 of households that were customers of ASC, which all had PV systems installed, and a control group of 169 households, which had little participation with ASC other than initial sign-up, was conducted to analyse demographic effects on the likelihood of becoming an *Early Adopter* (see Section 2.3.4). Socio-economic and socio-demographic data were collected from all subjects of these samples over the course of a two-year period (June 2008 to June 2010) (Havas, Latz, Lawes, Pemma, Race, 2012).



Source: ACIL Allen analysis of ABS and CER data

Figure 8. Side-by-side comparison of Melbourne PV uptake in December 2011 and August 2013. (Allen, 2013).

Findings from this study included links between willingness to adopt and income, house size, and house style. There was a positive relationship between household income and energy use. Higher income households tended to be high-energy users and have more disposable income available to invest in renewable energy. Therefore, higher income homeowners would be more likely to adopt solar PV than lower-income households. However, there tended to be fewer high-income households than low-income households, and it was concluded that low-income households are not significantly more likely to take up PV. Therefore, to achieve greater uptake, according to Havas et al (2012), middle-income households should be targeted to take up PV since they make up a large proportion of the overall population. Mikulina (2007) also suggested that annual income alone was not an appropriate measure of a household's likelihood of adopting PV. A more appropriate method, rather, is to measure a household's wealth based upon the individual's perception of how much of an impact a large purchase would have on his or her lifestyle. It has been shown that people who think they have an ability to spend a large amount of money with little impact on their economic standing are both more interested in and would be more willing to invest in PV than people who cannot spend this much money (Mikulina, 2007).

House size and style has also shown to be a reliable predictor of likeliness to adopt early (Havas et al., 2012). Apartments and flats are least likely to adopt early since roof space is often shared between occupants and approvals required from Owners' Corporations complicate installation. A tenant, either renter or owner-occupier, would need approval from the Owners' Corporation to install a solar panel on the property and reap its benefits (Whittles, 2013). Semi-detached housing and terrace housing may also have the issue of dealing with an Owners' Corporation or homeowner's association.

Renters face the additional barrier of dealing with their landlords when negotiating a PV installation. Some Australian states such as Queensland introduced legislation in 2010 mandating the disclosure of energy efficiency ratings when putting properties up for sale or rent as a way to ensure energy efficiency and to aid buyers in their decision-making processes (Bryant & Eves, 2012). Mandates such as these have the potential to incentivise landlords to have PV systems installed on their properties by adding another variable to their competition for tenants. Legislation such as this has not been presented yet in Victoria, but it is currently being discussed (King, 2011).

A negative trend between increasing house size and likelihood to adopt early was found (Havas et al., 2012). Havas et al., (2012) suggest that this may be due to owners of large houses having less available income as a result of it being invested in a larger house, which agrees with the *Drivers of Domestic PV Uptake* study. Higher levels of education were also shown to significantly influence willingness to adopt early (Havas et al., 2012). These findings support Rogers' second hypothesis that PV adopters are more likely to exhibit high income (Mikulina, 2007).

2.3.4 External Drivers in the PV Market: Decision-Making, Peer Effects, and Visibility

Bollinger and Gillingham analysed the "peer effect" on households without PV systems in proximity to other households with installed PV systems (2012). Using statistical analyses within a single zip code, it was found that household size contributes to the peer effect. The existence of more people in a household results in increased visibility of installed PV systems. For example, longer commutes to work taken by more members of a household can contribute to the peer effect since they allow for visibility of more installed houses. Large PV installations increase visibility and may enhance the peer effect, but it is likely that the same wattage spread across several homes in the form of smaller solar panels further enhances the peer effect. Any visible installation within a zip code was found to increase the probability of another adoption within the same zip code by 0.78%. PV installers have been known to put up signs indicating where solar panels have been installed, which is also a form of increasing visibility of PV systems. From this, we can interpret that awareness and the level of innovativeness is important to further uptake in the PV market (Bollinger & Gillingham, 2012). The level of innovativeness, or "the degree to which an individual … is relatively [early] in adopting new ideas than … other members of the system," can be shown through another common model, the Technology Adoption Life Cycle (Mikulina, 2007).

2.3.5 Australian Socio-Demographics and Motivation for Solar PV Uptake

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) conducted a national survey titled *Australian householders' interest in the distributed energy market*, in which they examined households' likelihood to adopt solar PV, along with other solar energy products. They determined that householders' primary motivation for installing solar PV systems was to save money on their power bills. Reducing their houses' carbon emissions or benefiting from the government rebates only consisted of around 20% combined (Figure 9) (Romanach & Ashworth, 2013).

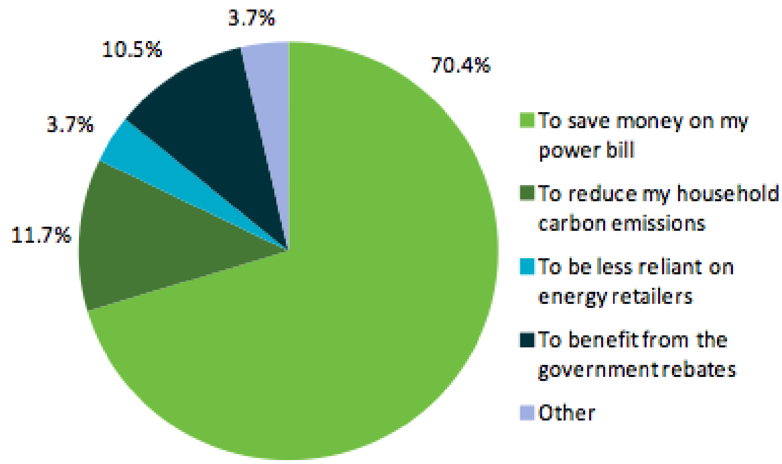


Figure 9. Primary Motivation for Installing Solar PV Systems. (Romanach & Ashworth, 2013).

Older age groups and males were found to have more overall knowledge of PV systems through a test conducted in this survey, and there was no statistically significant difference of knowledge scores among high income and low income. From their studies, they found that the main reason for choosing solar PV was that it reduces electricity costs. Only 9.6% of householders said benefiting the environment was the most important attribute (refer to Figure 10).

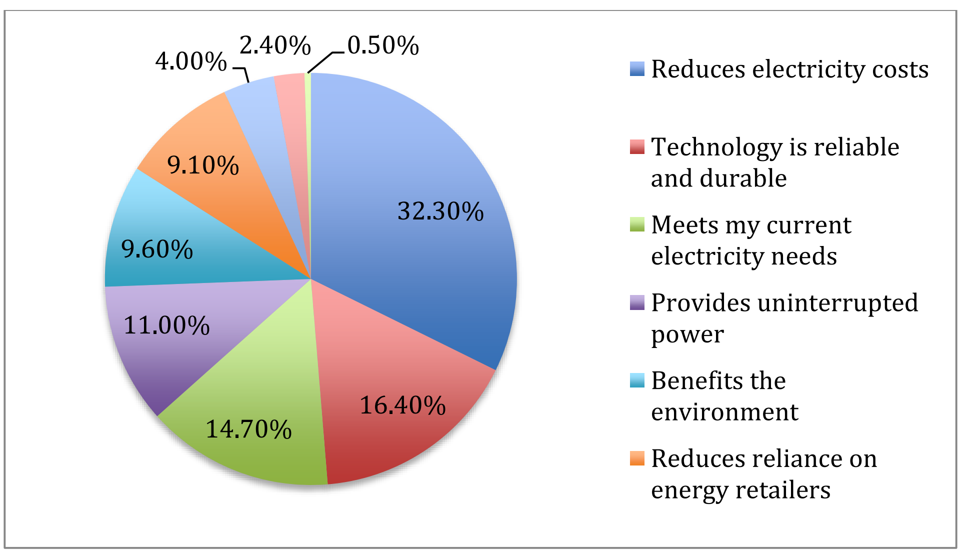


Figure 10. Key Technology Attributes, Proportion of Choices as Most Important (Romanach & Ashworth, 2013).

Overall, householders most preferred paying for a solar device upfront. The effect of age was statistically significant in the importance score for buying upfront, and it was indicated that buying upfront is most preferred for respondents in older age groups than it is for younger respondents. The younger age groups were more likely to choose financial and leasing options than the older age groups. Across the full sample, respondents trusted CSIRO, consumer organisations, scientists/engineers, and experts in solar technology the most to provide honest and accurate information about the use of solar energy. Some of the least trusted sources included the media, electricity and gas companies, and government departments. The most preferred means of information were case studies showing advantages and disadvantages of investing in solar, and online information through a solar industry website. According to this study, phone calls from the energy supplier, the newspaper, and magazine/TV advertising were the least preferred means of information (Romanach & Ashworth, 2013).

2.3.6 Marketing Strategies to Promote PV Installation

Bird and Swezey conducted research on green power marketing within the United States and had great success using Grassroots marketing tactics (Haas, 2002). Grassroots marketing relies on the effort of targeting a smaller audience in the hopes that the message will be spread to a larger audience. This method is less conventional than other marketing efforts, but due to the ripple effect and diffusion of innovation through peer-effects, it can influence a larger population.

In summary, focus areas such as pro-environmental behaviours, consumer attitudes towards investing in residential PV systems, external drivers such as peer effects and visibility, and strategic marketing tactics are key components to understanding the socio-demographics behind potential PV adopters. While many models and Australian solar PV case studies exist, Rogers' models provide us with the greatest understanding of the adoption process of solar power (Mikulina, 2007, p. 52). Conceptually, his hypotheses provide an organized, theoretical foundation to set the stage for our research and methodology.

Overall, it is crucial to understand the socio-demographic and socio-economic factors that both motivate and discourage households to adopt solar PV in order to determine a potential consumer profile. An understanding and synthesis of the history of solar PV, the PV market, impacts of ongoing and future government policies, incentives and regulations, pro-environmentalism, and corresponding marketing strategies will play a key role in determining the second million solar PV investors.

Chapter 3: Methodology

The Positive Charge Initiative, driven by the Moreland Energy Foundation Ltd. (MEFL), is striving to promote greater adoption of residential solar photovoltaic (PV) systems in Moreland, Australia. Positive Charge and MEFL hope to aid in the expansion of the total number of households with PV systems in Australia by another million. The goal of this project was to identify the factors that affect the adoption of residential PV systems in Moreland. In order to achieve this goal, we:

1. Estimated the potential carrying capacity for PV in Moreland;
2. Determined key market forces and technical constraints affecting the adoption of PV based on interviews with installers and other key stakeholders;
3. Identified and surveyed households with PV installations to determine what factors influenced their decision to install a PV system and the barriers they overcame;
4. Surveyed MEFL and Zero Carbon Moreland members within the local community to identify potential influencing factors for installing a PV system; and,
5. Provide recommendations and strategies to MEFL to promote future expansion in Moreland

3.1 Objective 1: Estimated the potential Carrying Capacity for Moreland

We estimated the potential carrying capacity of solar PV for Moreland by determining the maximum total roof space available for solar panels. We conducted a mapping analysis with Nearmap ™[3] on three selected postcodes: Fawkner, Pascoe Vale and Brunswick. These postcodes were chosen to represent the different economic backgrounds of Moreland: Fawkner represents low-income, Pascoe Vale represents middle-income, and Brunswick represents high-income.

3.1.1 Measured Roofs within Three Selected Postcodes in Moreland Using Nearmap™

We used zoning maps to identify three residential blocks within each selected postcode. Each dwelling was numbered from the top left corner of the block to the bottom right corner of each block to allow us to track each house when taking measurements for our later analysis.

[3] Nearmap ™ is a high-resolution and frequently updated aerial imagery program that contains an area measurement tool accurate to ± 15 cm

Only buildings which appeared to be residential (i.e. buildings that did not have large parking lots and looked similar to the surrounding dwellings) were measured.

From interviews with installers, we developed the proper methods to effectively use Nearmap™ to take measurements. We determined the amount of space on a roof that was available to support solar panels. These interviews occurred during our mapping process, which resulted in adjusting our methods. Originally, we measured the entire surface facing in each direction without taking into account any constraints, such as:

1) Shading, which could significantly disrupt the production of the cells
2) Obstacles such as antennas and chimneys, which solar panels cannot be installed over
3) The type of roof; some roof structures cannot support solar panel systems. Many tin roofs do not have suitable support for solar panel systems, and asbestos roofs can pose safety risks to installers.
4) Spacing around the solar panel systems, because solar panel systems cannot be easily supported if installed too close to a roof's edge.
5) The dimensions of an Australian standard 255 W solar panel, according to a sales employee of Braemac, which are approximately 1.7 metres by 1 metre.
6) Maintaining the aesthetics of a roof. This involves not mixing 'portrait' and 'landscape' orientations of solar panels on a single roof surface, and keeping them neatly ordered on a roof's surface.

We developed a revised method to adjust for the various constraints. Many of the measurements taken in Brunswick with the original method contained tin overhangs, which significantly skewed the gross and north-facing roof space, we retook all gross and north-facing measurements in Brunswick to correct these errors. We conducted this revised method fully on Fawkner first, and then returned to Brunswick and Pascoe Vale to adjust our initial measurements with a correction factor.

Houses were measured in increasing order of the numbers assigned to them in each block. Once a house had been selected for measurement, the entire area of the roof was measured by outlining the perimeter of the roof with the area measurement tool. The measurement was then recorded in a spread sheet next to the house's number, determined previously using the zoning maps. We determined which surfaces of the roof were facing North, East, and West; according to several PV installers, south-facing solar panels do not perform well and are rarely ever installed in this orientation, therefore they were excluded from our calculations. Flat roofs were all considered to be suitable for north-facing solar panels. We measured the width of a standard solar panel using the length measurement tool on Nearmap. The area measurement tool would then be used to create a box across the roof for the area of a single strip of solar panels with the previous length measurement as a guide. . The perpendicular height above the first row of solar panels needed to be at least 2 metres in order for there to be enough room for another row of panel. If there was enough room, additional rows were added. For each house, we determined three measurements: total North, East, and West available roof space. An example of measurements taken on a typical house can be seen in Figure 11. The lines beside each box are 1.7 metres in width.

Figure 11. Example of measurements on a typical rooftop in Moreland.

After the mapping exercise was completed for Fawkner, we returned to Pascoe Vale and Brunswick to apply our revised measurement method. Ten houses within each postcode were measured and compared to their original measured roof space in the form of a fraction of the original measurement. In doing so, we were able to apply a correction factor to all of our measurements, improving its accuracy. The correction factor for Brunswick was used to correct east and west measurements since the north-facing measurements were done with the more up-to-date method. The correction factor for Brunswick was 0.556 and Pascoe Vale was 0.618. When new technologies become more prevalent, such as building-integrated PV, the amount of available roof space will undoubtedly increase. With our improved total roof space calculations, we proceeded to calculate the carrying capacity for our chosen postcodes and the entirety of Moreland.

3.1.2 Calculated the Carrying Capacity within Three Sampled Postcodes and for entirety of Moreland

In order to perform accurate calculations, we created an Excel® spread sheet utilizing built-in functions and formulas. We performed two sets of calculations for each postcode individually and for Moreland as a whole: one set of calculations took into consideration the percentage of rented dwellings, number of heritage overlay properties and a 5kW system max while the other set did not have any constraints.

We created three columns to collect the North, East, and West measurements from Nearmap™ for each dwelling. Then we multiplied the correction factors for measurement errors by the measurements for Brunswick and Pascoe Vale. Next, the measurements were converted to kilowatts (kW) using. The conversion assumes a 255 W solar panel has an area of 1.7 m^2.

We then compared the kW values of East and West to determine which measurement was greater because typical inverters can only have two strings of PV systems attached to them, resulting in installation on a combination of North and either East or West roof orientations. Next, we summed the North column data with the greater of East or West to obtain the total system potential in kW. The average of the total system potential in kW yielded the respective postcode's average system size per house in kW. Multiplying this average by the number of dwellings in that postcode resulted in the postcode's unrestricted carrying capacity.

We followed the prior step a second time, excluding rented properties and dwellings in heritage overlays. According to the installers and MEFL employees, a typical residential PV system is less than 5 kW as well, so we limited each system measurement to 5 kW and used the average of these as the average system size per postcode.

We then summed the North orientation column, the comparison East/West capacities column, and the average system size per house, separately. In order to convert from kW to kilowatt-hours (kWh) we used values acquired through the MEFL staff for the peak sun hours (PSH) times the derating factor (DF). The derating factor accounts for loss of power due to constraints such as dirt accumulation and inverter efficiency. Because these numbers took into consideration only the North orientation, we had to adjust these values for East/West orientation. We did this through taking a weighting of the orientation to obtain an average overall peak sun hours times derating factor. For example, Brunswick has a North PSH x DF of 3.64, which we multiplied by 77.92, the sum of all North measurements, and divided by, 184.32, the total measurements. We then multiplied 3.02, the East PSH x DF by 118.41, the sum of the East/West measurements and divided by 184.32, the total measurements. Adding the results of the previous two steps, yields 3.26, the total average per year PSH x DF for Brunswick. This calculation resulted in the accurate conversion factor $(PSH \times DF)_{\text{Avg All Orientations}}$ which we used to translate the kW measurements into kilowatt-hours (kWh).

Then, we obtained weighting factors for the North and East/West peak sun hours using the ratios of average North and average East/West capacity to the overall average capacity. Table 4 shows the values used to convert PSH times DF for North to PSH times DF for East/West orientation.

As shown, the number of peak sun hours is different depending on the orientation, so the conversions of kW to kWh for North and East/West differ. We used 3.26, 3.31, and 3.32 as the PSH times DF values for Brunswick, Pascoe Vale, and Fawkner, respectively.

Next, we used the peak sun hours times derating factor to obtain new values in kWh. For example, Brunswick's system capacity of 2.85 kW was multiplied by 3.26, the peak sun hours times derating factor for Brunswick.

Conversion Ratios	
Total E/W Ratio	0.603
Total N Ratio	0.397
Conversion to kWh	
North Conversion	3.64
East Conversion	2.99
West	3.04
East/West Average	3.02
Weighting East/West	1.82
Weighting North	1.44
Peak Sun Hours x Derating	3.26

Table 4. Brunswick Conversion Ratios for peak sun hours times derating factor

To obtain the kWh per house per year we multiplied the kWh per house by 365 days per year. Then to obtain the full postcode capacity in GWh, we multiplied the kWh per house per year by the postcode's number of dwellings. We repeated the process for all three postcodes tested: Brunswick, Pascoe Vale, and Fawkner. Finally, we were able to scale up to all of Moreland based on the number of dwellings in each measured postcode as proportions of the total number of dwellings in these postcodes.

We performed two verification tests to check our calculations by finding the percentage of dwellings per postcode and multiplying that by either Brunswick, Pascoe Vale, or Fawkner system size. Bruce Thompson provided us with classifications of each postcode as being similar to Brunswick, Pascoe Vale, or Fawkner according to the ages of each postcode. Once we had all of the postcodes calculated, we summed the results together to obtain the system size for all of Moreland. We then compared this value with the original value. The calculations with and without restrictions had 11% and 2% error, respectively. Since the error values were less than 15%, we have high confidence that the numbers are valid.

3.2 Objective 2: Determined key market forces and technical constraints affecting the adoption of PV

We conducted interviews with six individuals from four PV installation companies to uncover unknown motivations and barriers in the solar PV market. Because the installers work directly with homeowners, we anticipated that their perspective would enlighten key information for further investigation.

3.2.1 Interview Instrument Development

We developed our interview questions through multiple drafts. We reviewed previous questions asked in literature and reworded questions to broad opening topics with specific follow-up questions, which resulted in a more valuable range of answers from the installers. We wanted to compare all of the installers' answers to the open-ended questions to determine if there were trends between socio-demographics, marketing strategies, and technical barriers.

3.2.2 Interview Sample and Recruitment

In order to understand the overall picture and scope of the solar PV market within Australia as a whole and make comparisons with the PV market in Moreland, we conducted six, semi-structured interviews with four different solar PV installation companies that worked both locally and nationally. To obtain our list of installers, we consulted with Bruce Thompson, the project manager of Positive Charge. He provided us with the names and contact information for the installers that we interviewed. We then sent an email to all of the interviewees, requesting an interview, and coordinated the interview logistics based on their availability. Refer to Table 5 for the company descriptions, interviewee names, and interview dates.

Installer Name	Company Description	Interview Date	Interviewee - Profession Area
Braemac	Founded in 1986, Braemac Energy supplies a wide range of solar products throughout Australia. In particular, they are consultants and installers of PV systems on homes, schools, businesses, and government buildings	8-Nov-13	Matthew Carmichael - Technical
		11-Nov-13	Astrid Murray - Client Rel.
Solar Gain	Founded in 1993 in Perth, Solar Gain is one of Australia's largest integrated solar energy businesses.	8-Nov-13	Chris Paine - Client Rel.
Solari Energy	Recently launched, Solari Energy is a subsidiary of Solar Inception Pty. that operates with nationwide and international solar outreach.	15-Nov-13	Paul Scerri - Group Sales Manager
		19-Nov-13	Leigh Hancock - Sales
Todae Solar	Founded in 2003, Todae Solar is an award-winning and experienced company, installing PV nationwide with locations in Sydney, Melbourne, Adelaide, Perth, and Canberra.	20-Nov-13	Sean Sweetser - Sales

Table 5. Summary of Installer Interviewees and Companies

3.2.3 Interview Implementation

The interviews were conversational with questions relevant to the interviewee's position within the company. Questions were categorised by socio-demographic, marketing, or technical classifications. This made the interview easier because we used questions directly from the category most appropriate to the interviewee's background and position within the company. The supporting documents for the PV installer interviews are given within Appendix 2.

3.2.4 Data Collection and Analysis

For both the in-person and phone interviews, we handwrote notes and recorded audio of the conversation in groups of two. One team member was the primary scribe for the meeting and the other was the primary interviewer. We used a digital audio recorder, if given permission from the interviewee. Each interviewee had the option to keep their personal information confidential and the ability to remain anonymous. We also asked interviewees their permission to use quotes only with their approval. The interviews lasted approximately 30 minutes and all notes were checked and compared with the audio recording, if obtained. We then compiled all of the interview notes and determined key drivers and constraints.

These interviews gave us insight to the installer's perspective on the solar PV market as a whole, which we used later for overall analysis. Obtaining multiple perspectives on the PV market across Australia helped us to gain an understanding of the motivations behind investing in residential PV systems.

3.3 Objective 3: Identify and survey households with PV installations to determine what factors influenced their decision to install a PV system and the barriers they overcame

We surveyed PV-homeowners within Moreland by two different approaches: door-to-door knocking and phone calls. We conducted the two different methods to ensure that we would have a sufficient sample size from the three different suburbs representative of the different income levels in Moreland.

3.3.1 Survey Instrument Development:

We developed our survey instruments through a series of stages. First, we reviewed surveys distributed by MEFL and Positive Charge to their members to identify appropriate topic areas for question structure, wording, and format.

We then developed a first draft of the PV household survey in a structured, question-by-question format. After review from our advisors and MEFL staff members, we determined that a semi-structured survey would suit our research better, as we would likely discover issues and concerns that we could not anticipate in advance. Hence, we developed broad primary questions, with follow-up questions to expand on information that may have come up in conversation. Questions such as "Could you tell me more about why you chose to install your solar panels?" were tailored to determine the consumer's primary motivations for installation and was followed up with discussion of barriers that were overcome throughout the process.

In order to adjust and determine the effectiveness of the set of questions, we scheduled pre-tests to conduct three door-to-door surveys of PV homeowners within Moreland, two in-person surveys of MEFL staff, and four phone interviews of MEFL's Annual General Meeting (AGM) / "Pub-Night" contacts. Our door-to-door methods were tested on members of *Zero*

Carbon Moreland [4], who were contacted via social media. Additionally, the MEFL AGM / "Pub Night" attendants were contacted by email to determine their preferred time for contact (refer to Appendix 3 and Appendix 4). Utilising the pre-tests allowed us to improve the quality of the questions and practice conducting surveys.

After completing our pre-test, we finalised our set of questions (refer to Appendix 5), and determined that the best method for note collection was to utilise a note-taking chart in order to compare and consolidate answers (refer to Appendix 6).

3.3.2 Survey Sample and Recruitment:

Door-to-Door Survey:

We utilised Nearmap™ in order to identify households with PV systems installed within each of the three selected postcodes. We chose primarily residential areas, by use of visual indicators such as building size, structure, and distance from heavily commercial properties (i.e. main roads and parking lots). We determined that the best areas to target were those with a high-density of PV installations within a reasonable walking distance between households. We aimed to target 12 to 17 dwellings, in hopes of surveying at least 4 homes. Additionally, we targeted households that were close to public transportation service stops. In doing so, we were able to access these dwellings more easily. After deciding on the ideal area for door-knocking, we mapped our travel path and marked the households with PV systems installed (refer to Appendix 7).

Phone Survey:

We sent an email to Positive Charge's contact list of 24 homeowners that installed a system in Moreland through the Positive Charge program in order to increase our response pool (refer to Appendix 8). Additionally, after sending our email to MEFL/ZCM members for non-PV homeowners (discussed in 3.4), we received responses from several members that had already installed PV systems, but were interested in contributing to our research. All respondents were contacted via email to coordinate a date and time for conducting the survey, at their convenience.

[4] *Zero Carbon Moreland* was a project conducted by MEFL, engaging the community to take positive local action for improved sustainability.

3.3.3 Survey Implementation:

Door-to-Door Survey:

After having mapped our target areas, our team split into groups of two to begin door-knocking at the dwellings. Through trial-and-error, we determined that the optimal time for door-knocking was between 5:45 PM and 6:45 PM, when people had arrived home from work but had not yet eaten dinner. If the homeowner answered their door, we clearly stated our intentions by use of our preamble (refer to Appendix 9). We stressed that we were students working on a research project for MEFL, not selling anything, and that their answers would remain entirely anonymous. Homeowners under the impression that we were salespeople immediately refused participation. In order to further incentivise participation, we offered participants entry into a drawing for two movie passes at the conclusion of the survey. The respondents listed their name and email address to be eligible for the tickets, but were assured that it would not be used in any identifying manner in our study.

If no one was available to speak at the selected household, we left a brief letter (refer to Appendix 10) in their letter-box or doorway. This described our project and offered two alternative methods for participating in our survey (i.e., online or by phone). Neither option was used by any homeowners, however. We encountered numerous dwellings with "No Door-Knocking" signs or that were inaccessible due to security gates or overgrown yards that we immediately excluded from our sample.

A portion of the survey included asking personal questions, pertaining to basic socio-demographics. We found that asking personal questions to the randomly selected sample was uncomfortable for both parties. To compensate, we developed a "Socio-Demographics Chart" (refer to Appendix 11) to be filled out by the homeowner at the completion of the survey. The socio-demographics were gathered to categorise the homeowners by age, education, parenthood, and total household income in order to analyse certain results for particular groups of people.

At the completion of our door-knocking exercise we had gathered a relatively small sample from each postcode (refer to Table 6). A house was marked as "Unavailable" if there was no one was available to speak, they had a "No Door Knocking" sign, or if they had a gate preventing us from entering.

Location	Targets	Surveyed	Rejected	Unavailable
Brunswick	28	5	2	21
Pascoe Vale	29	4	5	20
Fawkner	28	4	4	20
Total	85	13	11	61

Table 6. Responses from Door-to-Door Surveying

To increase our information pool, we pursued phone interviews of PV homeowners who responded to our previous emails.

Phone Survey:

After coordinating the best time for surveying with the previously contacted PV homeowners, we called nine respondents and administered our survey in a similar fashion as our door-to door method. The only variation in our surveying method was the collection of the socio-demographic information. It was easier to ask these questions outright, as these respondents were previously willing to aid in our study and were not chosen at random.

3.3.4 Data Entry and Analysis:

After collecting the postcodes of our phone survey participants, we were able to categorise their location to correspond, in terms of economic standing, with our three target postcodes. All data from both of our surveying methods was compiled into one spreadsheet for ease of interpretation. In doing so, we analysed our qualitative responses from the surveys and utilised the socio-demographics to define our sample. Our results accounted for a wide range of varying characteristics and responses, allowing for a greater understanding of the current PV households in Moreland.

3.4 Objective 4: Survey MEFL and Zero Carbon Moreland members within the local community to identify potential influencing factors for installing a PV system

We conducted an online survey of individuals in Moreland that do not own a PV system to determine what has been deterring them from purchasing a system and to identify potential factors that could be used to increase adoption.

3.4.1 Survey Instrument Development:

We assessed previous Positive Charge surveys to determine questions that had already been asked to its members. We reviewed Positive Charge’s survey sent out to individuals that expressed interest in solar PV and noted its question content and wording. Then, we reviewed the surveys sent out in the *Drivers of PV Households* and *Australian Householders' Interest in the Distributed Energy Market* (See Sections 2.3.3) to identify questions that we could ask in our survey in order to compare the results of these studies to our analysis of Moreland. We developed a new survey to allow us to determine the following:

1) Main reasons for not installing;
2) Preferred financial options;
3) Perception of initial cost;
4) Greatest incentive to installing a system; and
5) Most influential means of contact for information regarding PV

The survey was split into three different pages and had a total of 21 questions. The first page was designed to help us gain a better understanding of the categories listed above. The second page asked questions pertaining to the socio-demographics of the individual. These questions were used to determine any relationships within certain categorisations of people. These questions allowed us to determine drivers and barriers for the type of person more likely to adopt, as determined through the installer interviews and previous literature. The third page was optional and allowed the individual to fill out their name and email to be entered into a drawing for two movie passes, provided by MEFL. It also allowed the individual to provide a phone number if they wanted to be contacted by MEFL to receive more information about PV systems. The full list of questions can be found in Appendix 12.

The Community Engagement Coordinator and various other MEFL employees reviewed the survey. After it was reviewed internally, we pre-tested the survey on two lists of contacts. The first list contained 30 contacts for people that attended MEFL's Annual General Meeting on October 22nd, which we were in attendance for. The second list of contacts we used for the pre-test was MEFL's Pub Night contacts. This was a group of 21 contacts that were interested in being more involved with the organisation. The emails that were sent to these contacts are in Appendix 3 and Appendix 4. We received eight online survey results from this group and four phone calls to assist with Objective 3.

3.4.2 Survey Sample and Recruitment:

After completing the pre-test and reassessing our questions, we obtained two sets of contact lists from MEFL to send out our survey on a large scale. The first set of contacts was Zero Carbon Moreland (ZCM) subscribers and composed of 2,427 members. These people were individuals who participated in MEFL's project to promote sustainability in Moreland in recent years. The second list was 998 members who signed up to receive MEFL's e-Bulletin. We chose these two lists because they offered a potentially large sample size; we wanted to administer our survey to as many individuals within Moreland as possible, to increase the possible number of responses.

3.4.3 Survey Implementation & Data Analysis:

The email that was sent out to these contacts was designed through Mail Chimp, an emailing program for large mailing lists (refer to Appendix 13). MEFL's Community Engagement Coordinator advised us that emails sent out between 12-4 PM Monday through Thursday received higher response rates. We sent an email reminding these contacts to participate in the survey four days after sending out the survey initially. Table 7 summarizes the response rates of these contacts list.

Contact List	Subscribers	1st Email - Number of Opens	1st Email - Number of clicks to the link to the survey	Reminder Email – Number of Opens	Reminder Email – Number of clicks of the link to the survey
Zero Carbon Moreland	2,427	763 (31.7%)	229 (9.5%)	644 (26.9%)	91 (3.8%)
MEFL e-Bulletin	998	297 (30.1%)	82 (8.3%)	233 (23.8%)	33 (3.4%)

Table 7. Response Rates for Online Survey

A total of 335 people started the survey and 320 respondents completed the survey (9.3% of the email recipients).

We developed various profiles based on mutually exclusive demographic profiles, barriers they currently face, and other factors that may influence their decision to install. We compared the results to findings from the installer interviews and PV household surveys to determine the most effective recommendations for MEFL to pursue.

3.5 Objective 5: Provide recommendations and strategies to MEFL to promote future expansion in Moreland

Based on the research from our literature review and the results of the previous objectives, we provided recommendations and strategies to MEFL to help expand the solar PV market within the Moreland Municipality. Our recommendations addressed the main barriers that we determined have been having a significant impact on the Moreland area. We provided suggestions on how to overcome these barriers and additionally recommended methods of communication to address them and promote the overall PV uptake in Moreland.

Chapter 4: Findings

4.1 Carrying Capacity Calculations

The carrying capacity calculations suggest that the Moreland municipality would be able to offset 91% of its residential electricity usage if each dwelling installed the largest possible solar PV system their roof can fit. The average system size able to be put on a household in Moreland is 3.38 kW. These figures do not consider **restrictions, such as rented dwellings, heritage overlay, or a 5 kW system size maximum**. We determined that a system of this size would produce an average of 4100 kWh per year while the average electricity use per house per year is 4489 kWh, which was provided by MEFL. The carrying capacity of solar in Moreland was determined to be a total of 215.2 GWh produced per year while Moreland consumes roughly 236 GWh per year in residential dwellings, a difference of 20.8 GWh. Results by postcode and for Moreland without taking into account any restrictions are shown in Table 8.

Location	Average kW System per House	Total GWh produced per year	Average kWh Produced per House per Year	Average kWh Consumed per House per Year	Percentage of Electricity Produced to Consumed
Moreland	**3.38**	**215.2**	**4100**	**4489.5**	**91%**
Brunswick	2.85	31.5	3389	4270.5	79%
Pascoe Vale	4.08	28.9	4927	4489.5	110%
Fawkner	3.59	18.6	4356	4562.5	95%

Table 8. Carrying Capacity Results (No Restrictions) for Three Sample Postcodes and Entirety of Moreland

The average system size is the greatest for Pascoe Vale, followed by Fawkner and then Brunswick. Due to its potential larger average system size, Pascoe Vale would be able to produce 110% of the electricity it consumes in residential dwellings. Brunswick and Fawkner are not able to completely offset their electricity usage, but could produce 79% and 95%, respectively, of their total electricity usage in residential dwellings. The full results of this analysis are available in Appendix 14.

4.1.1 Realistic Calculation with Restrictions

There are roughly 16,138 dwellings in Moreland that are rented, accounting for 31% of the total number of residential dwellings. The tenants of these houses need to go through their landlords to install PV, so we considered these dwellings to be a current constraint for PV uptake. Additionally, there are also a total of 7,448 houses in Moreland that have a heritage overlay regulation, accounting for 14% of the total number of residential dwellings. These houses are not allowed to install PV on the part of their roof that faces the street, so approximately 25% of these roofs cannot have PV installed on them. Furthermore, with the reduced feed-in tariff, consumers are likely to size a system to match their consumption at peak hours. Also, two installers stated that they would not install a system on a residential dwelling greater than 5 kW, because then it would need to meet additional regulations. If we assume the maximum size of a system to be 5 kW, and also subtract the restrictions from rented and heritage overlay dwellings, the Moreland average system size is reduced to 3.20 kW and this results in a total capacity of 126.2 GWh. Refer to Table 9 for the full capacity results taking into account these constraints.

Location	**Average kW System per House**	**Total GWh produced per year**	**Average kWh Produced per House per Year**	**Average kWh Consumed per House per Year**	**Percentage of Electricity Produced to Consumed**
Moreland	**3.20**	**126.2**	**3875**	**4489.5**	**86%**
Brunswick	2.67	14.5	3182	4270.5	75%
Pascoe Vale	3.58	17.2	4330	4489.5	96%
Fawkner	3.47	13.1	4203	4562.5	92%

Table 9. Carrying Capacity Results (With Restrictions) for Three Sample Postcodes and Entirety of Moreland

Comparing the capacity results with restrictions to those without restrictions, there was a reduction of 5.3% of Moreland's average kW system per house and a reduction of 41.4% in the total GWh produced per year. An additional constraint that needs to be noted is total grid capacity. If PV installations do see a great uptake level, it might become important to understand the maximum capacity the grid can handle in the area of uptake.

With the opportunity to offset 86% of the electricity consumed in applicable dwellings (non-rented and non-heritage overlay with a 5 kW system size max) and a total of 91% of the electricity consumed in all residential dwellings, without restrictions, there is great potential for future adoption of PV within Moreland.

4.2 Installer Perspectives on Key Drivers and Barriers

Based on our installer interviews we identified three key factors that act as barriers to the adoption of PV systems, these include costs and financing, consumer knowledge, and split incentives between landlords and renters. We also identified three factors that tend to drive the PV adoption process that could be used in an effort to target future PV outreach and marketing efforts. Community engagement and referrals encourage people to install PV systems, and age appears to be a dominant variable affecting who installs. In particular, young families, retirees, and those approaching retirement appear to be the cohorts that are most likely to install PV in the near future (refer to Table 10).

Key Drivers	**Key Barriers**
Community Engagement	Price: Upfront Costs, Lack of Financing Awareness, Perception of Return on Investment, Green Loans
Age: Retirees & Young Families	Education of Consumers: Misinformation, Appropriate & Reliable from Reputable Source
Referrals: School, Family & Friends	Renters and Roof Ownership

Table 10. Key Drivers and Barriers from Installer Interviews.

4.2.1 Price and Financing Barrier

The price barrier includes upfront costs, return on investment (ROI), and lack of financial awareness. Four out of six installers indicated that the main reason why consumers were hesitant to install PV was because of initial cost. Of the six installers, five stated that return on investment was critical in the PV installation decision-making process. PV systems are advertised based on system costs and not system savings. One of the installers specifically mentioned that the average return on investment for residential consumers is roughly five years. This timeline can directly influence a homeowner’s decision because consumers are more inclined to invest if they will profit in a reasonable time period. If the savings and ROI can be conveyed in a way that is meaningful and tailored to each homeowner, then the initial cost of investment would seem much more feasible.

Of those four installers that emphasized initial cost as a barrier, all agreed that financing options needed to be expanded in order to assist homeowners of lower incomes to purchase a system. Financing options are available for homeowners but these options are not well advertised, increasing the issue of lack of information. One installer mentioned a common payment plan which has a high interest rate of 10%. Financial loans would be more desirable to homeowners if realistic rates are available. However, as it stands, financing is not marketed so that potential consumers understand the options. Financing options could be beneficial to lower social-economic backgrounds, according to another installer, because they generally do not have the upfront capital to invest in PV and it would ease the financial strain of electricity bills. Because homeowners are looking to save money on their power bills, it is important to have better advertisement of realistic financial plans in combination with educating potential consumers of their options.

4.2.2 Consumer Knowledge Barrier

The consumer knowledge barrier is composed of misinformation about solar PV systems and the difficulty of finding appropriate and reliable information from a reputable source. According to the interviews, potential consumers are misinformed of the feed-in tariff and how it affects the ROI. Some homeowners are under the impression that it is not worth investing because they believe that there is little or no ROI. Others are misinformed about feed-in tariffs and do not understand that with a low feed-in tariff, investing in a PV system that exceeds personal electricity usage is less profitable. Current PV homeowners are recommending large systems, because of their higher feed-in tariff scheme, to family and friends but this decreases the ROI substantially. One of the installers noticed that people want a third-party involved to take care of the decision-making, so that they do not have to learn and determine the most suitable system. Solar PV systems require technical decisions as well as a financial decision, and it is easy for people to become frustrated with the wide range of information out there. Through our findings, we confirmed that lack of information and misinformation are hindering PV uptake. To overcome this barrier, MEFL can provide reliable information through accurate and reliable sources.

4.2.3 Regulatory Barriers on Rented Dwellings

Rental properties comprise 31% of total residential dwellings in Moreland; therefore, there is great potential to install PV on these dwellings, as also supported by the installers. Half of the installers stated that finding a way to promote PV adoption to landlords who own these dwellings would significantly improve the market. Most landlords do not invest in PV systems because they do not believe it would be a profitable action for them. This may be due to them not being able to be publically recognised for improving the energy performance of their rental property because there is no mandatory disclosure of energy ratings for rental properties. Because of this, it is harder for them to charge extra for rent and still be able to rent out the dwelling, even though the tenant could save money on electricity bills in a more sustainable dwelling. An interesting idea that one of the installers presented is the idea of scheme that addresses the split incentive problem, where both tenants and landlords would benefit from a solar panel installation. Under the split-incentive scheme, tenants would pay for the system and installation, and landlords would give their tenants a discount on their rent for doing so.

Even though there are notable key barriers that the PV market needs to overcome in order to have future market success, there are also three key drivers we need to consider based on installer recommendations: target age groups, referral programs, and community engagement.

4.2.4 Target Age Groups: Retirees and Young Families

Four of the six installers agreed that the best two age groups to target are retirees and young families. Retirees have been identified by all of the installers interviewed as having the top share of solar power uptake and being the main targets for current and future PV installation. The installers believe that retirees tend to have more disposable income to invest in a solar system and are unlikely to have children living at home. Most retirees have paid off their mortgages resulting in less financial commitments. Their desire to settle down in the same dwelling for an extended period of time could also explain their inclination to have solar power installed. Since retirees are typically on fixed incomes, and electricity prices are predicted to rise in the future, they desire a sense of security for their future; PV can contribute towards this security.

Additionally, young families are another rising consumer group to target according to PV installers. Half of the installers noted that new families with young children are more likely to invest in PV systems than other age groups. New young families want to reduce their bills as much as possible, and investing in PV can help offset their costs as their children grow up. One installer directly stated that young families would be willing to take out a loan to support their PV investment while their children are still young and not using as much electricity. By reaching out to new young families, we can continue to promote PV in terms of future savings, which, from an installer's perspective is essential to expanding the PV market.

4.2.5 Driving the Market through Community Engagement and Referrals

Community engagement has been very successful in driving PV installations. PV systems are designed to suit a consumer's needs on a household level. Community events help promote awareness of the technology as well. People who have not considered solar PV might be more willing to learn about and invest in the technology if their neighbourhood is involved in a program on solar energy. Referral programs also help to further engage people's interest in solar PV technology on this same personal level.

One company we interviewed had great success with school referrals. When schools look to invest in a PV system, they send a referral letter home with students. If the parents then decide to install PV on their homes, they receive a discount from the installer and the school receives a donation. The idea is that the school would use profits made from the PV system to purchase school supplies and support school programs. The installers would then use the students to help advertise to their families the benefits of switching to solar systems through the referral discount. We believe that this is an interesting approach to widen the spectrum of PV homeowners because it relies directly on word-of mouth marketing and messaging. It does, however, rely on installer reliability. If expectations are not met, the school may be blamed for inadequate referrals.

Another company we spoke with mentioned that their marketing strategies rely solely on referrals of previous customers. Because people are more inclined to trust the advice of family and friends, and like to see testimonials that the investment is worthy, word of mouth can sway people's decisions to invest. One interviewee said that if a large family was content with their solar PV system, the rest of their family would be more likely to invest in systems as well. Referrals start the ripple effect: once one person invests, his/her friends and family invest and so on and so-forth. Honing in on the power of messaging and communication was a common trend between all of the conversations we had with PV installers.

In summation, the majority of installers were in agreement on the primary barriers and drivers to PV adoption and the particular age groups for improved uptake, thus allowing for a greater understanding of the local PV market.

4.3 Understanding the PV Homeowner Perspective: Motivations and Challenges behind Investment

In total we surveyed 22 homeowners, with 17 including socio-demographics. We surveyed 13 through our door-to-door method and 9 by phone. We analysed the PV homeowner survey results to assess the key drivers and barriers of previous PV installations in the local community.

4.3.1 Results Summary

This sample was composed of several different age groups and income levels, as shown in Figure 12 and Figure 13. The respondents were well educated; 13 of 17 responded that they had received at least a university degree. There were various PV system sizes represented in this sample, ranging from 0.5 kW to 5.2 kW; overall the most common system size was 2 kW.

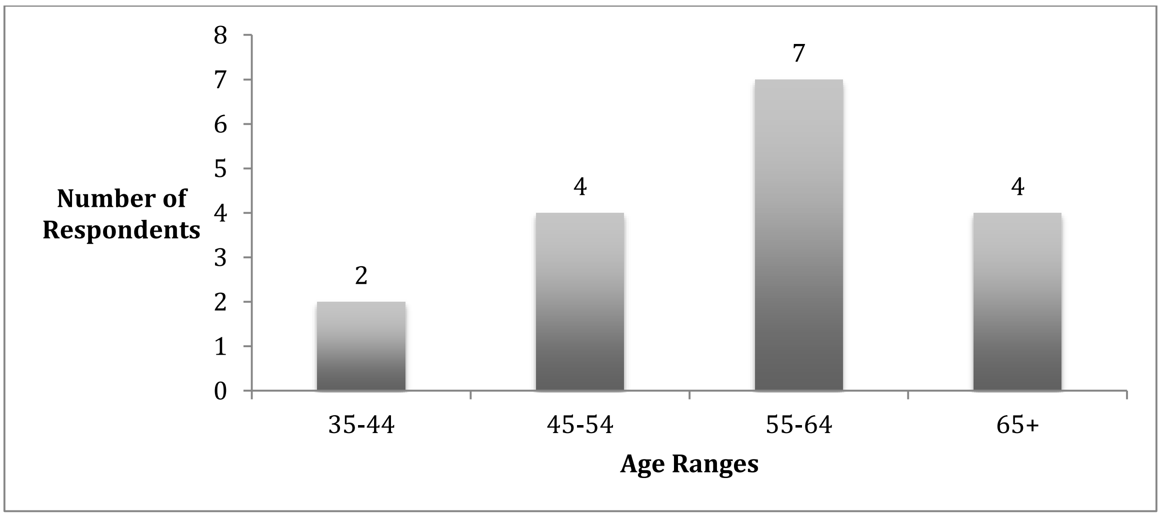


Figure 12. PV Homeowner Respondents Categorized by Age

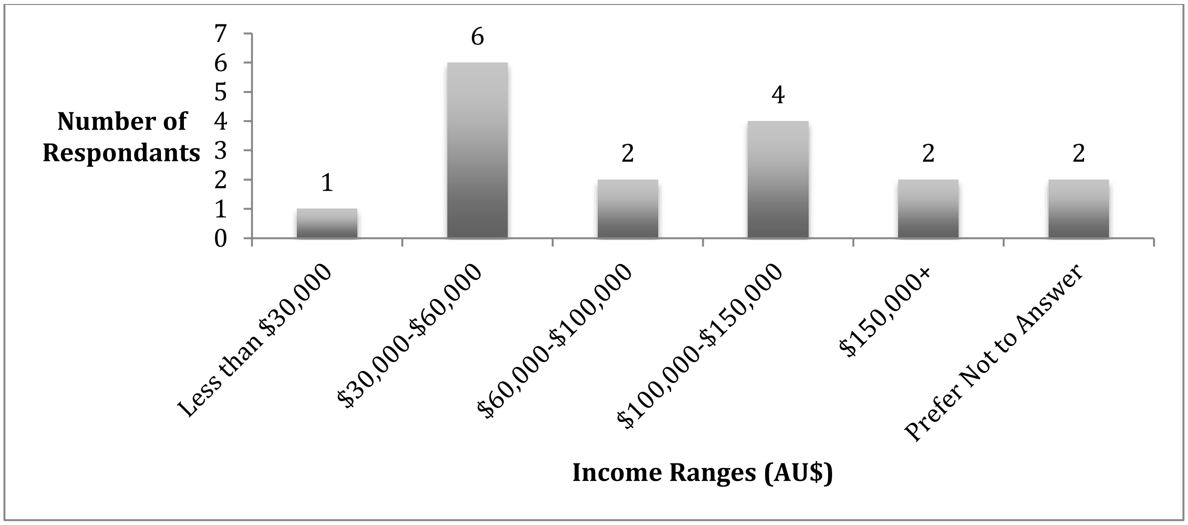


Figure 13. PV Homeowner Respondents Categorized by Income Bracket

Fifteen of the twenty-two individuals had their system installed one to three years ago during the large boom in the industry to take advantage of the high feed-in tariff rates. Twelve out of the twenty-two individuals had been living in their house for over ten years at the time of installation, and only two had been there for two years or less. The installation process, including grid connection, took anywhere between three and six weeks. Additionally, fourteen homeowners indicated that they had not experienced any quality or performance issues with their systems after installation, while the other homeowners indicated very minor issues (i.e. blown fuse, wiring issues, and faulty inverter). Once they were addressed, the issues were resolved very quickly with the assistance of the installation companies. The main difficulty with any problems was noticing that the system was having an issue; multiple respondents indicated they did not know their system was not working properly until they received their next electricity bills and noticed there was no production in electricity.

Overall, nearly all respondents reported environmental consciousness as one of their greatest motivations to install, followed by saving money on power bills. People who indicated that they had a $0.08/kWh FiT also noted that one of their primary drivers for installation was to become more self-sufficient in order to protect against the increased cost of electricity. The main reason why the overall respondents held back from installing initially was the financial barrier. The respondents primarily stated that the greatest satisfaction they received from owning a PV system was that their actions had a positive impact on the environment (refer to Figure 14). Various respondents indicated that the monetary benefits and having a positive impact on the environment were equally satisfactory so we counted those as responses for each category; hence the graphs in Figure 14 are not equal in number of responses.

Figure 14. Biggest Motivation/Greatest Satisfaction Responses from PV Homeownership

Two people directly said that they felt "guilt-free" about their energy usage after installing their PV system. The monetary benefits of saving money on energy bills placed second as a satisfaction. The majority of people who have installed PV have also taken various other pro-environmental actions, such as using water tanks, gardening, draught-proofing, and installing solar hot water. Half of our respondents are members of other environment groups, such as the Alternative Technology Association, GetUp, Greenpeace, and MEFL.

4.3.2 Challenges to Installation

The main barrier PV homeowners had to overcome was the financial barrier. Some low-income households (less than $60,000) were able to overcome this barrier without using financing options, presumably because they had other assets. We also found that most of these system owners were unaware of alternative payment options and would have considered utilising one of them if they had been informed. Due to the reduction of the feed-in tariff, it has become more cost-effective to size the PV system to match the user’s electricity needs and to not generate much excess electricity. Because of this, PV homeowners on the $0.08/kWh tariff reported that gaining independence from retailer energy prices was a major incentive to install, in addition to the environmental benefits. These households did not view the financial benefits as a significant reason to pursue the installation.

According to the *Drivers of Domestic PV Uptake* report discussed in our Literature Review (Section 2.3.3), households with people living there for 5+ years are less likely to install PV. This was not supported through our findings, since twelve out of the twenty-two individuals had been living in their dwellings for over ten years at the time of installation, and only two had been there for two years or less.

Contrary to the current study being performed by the APVA to assess if system quality is hindering market growth, our findings suggest that system quality has not been an issue for most of the individuals in our sample (Pulsford, 2012). Therefore, system quality may not be an actual issue, but the perception that this is an issue could be deterring potential consumers.

The greatest difficulty individuals faced with the installation process was organising the system connection with their energy retailer and distributor. According to these homeowners, their electricity providers made the process unclear, complex, and very drawn out. Several people stated that the system was installed within a day, but it took a few months until the system was finally connected to the grid and they could receive a tariff on the electricity the system generated.

4.3.3 Perspective of Installation on Multi-Unit Dwellings

As indicated by our installer findings, it is believed to be a much more onerous process for owners to install PV on multi-unit dwellings than on separate houses. Our findings suggest that the process does face additional barriers, but owners can overcome them in certain situations. The two owners of units that we interviewed were successfully able to install PV systems onto their roofs. They both lived in relatively small apartment complexes, consisting of 10 or fewer units. One of the interviewees lived in a two-storey dwelling and owned a unit on the first storey, while the other was in a single storey dwelling. The process these individuals faced differed from the standard installation process because they had to get majority approval from their Owners' Corporations, which consists of the owners of each unit. The roof is considered common property for these types of dwellings, and the vote had to go through a paper ballot distributed to each of the owners. Additionally, they needed provide background information on the costs and other potential risks to the roof by installing PV. For one of the individuals, the paper ballot was provided by the company that administrates the Owners' Corporation; however, the other individual had to pay $150 to purchase the paper ballot.

Members of the Owners' Corporation asked various questions to the prospective PV owners, which included the following:

- What will it look like?
- Is it going to negatively affect the appearance of a dwelling?
- If the roof needs to be replaced, are you going to pay for the removal/reinstallation of the panels?

The prospective PV owners needed to take full responsibility for any additional costs that could be caused by the panels. After they received majority approval, they were allotted roof space above their unit. The individual in the multi-storey dwelling was only given permission to use half of the roof space above her dwelling.

Overall the two individuals we spoke with stated that the installation process was very drawn out and took up to a year from when they first expressed interest to their Owners' Corporation to actually getting the panels installed. The main reason this process was drawn out was due to the difficulty of meeting with the entire Owners' Corporation and providing them with information on the process, costs, and risks. If this process was better regulated, it could be shortened greatly and contribute to a rise of individuals in similar dwellings proceeding with installing PV.

4.4 Critical Reasons why Non-PV homeowners have not invested

In order to understand the non-PV homeowner's perspective of PV and the barriers that have withheld their installation, we performed an overall analysis of our online survey responses, along with seven separate analyses of groups divided according to demographic categories. We were able to address our five separate research questions.

4.4.1 Analytical Strategy:

We began by analysing the overall results from our entire sample to gain a greater understanding of the overall perception of PV within Moreland. The number of responses between demographic categories varies due to respondents answering some questions and skipping others, but the total number of responses per question is between 316 and 326. Several questions in our online survey asked participants to rank their responses. In order to gain an understanding of the primary driving and hindering forces within the potential PV market, we only analysed responses that were ranked first. We then divided the respondents according to demographic characteristics: income (greater than $100,000 vs. less than $100,000 gross, total annual household income); mortgage (homeowners with a mortgage vs. homeowners without a mortgage); parenthood (parent/guardian vs. non-parent/guardian); homeownership (homeowner vs. renter); age (18-44 vs. 45+); length of homeownership (less than 5 years vs. more than 5 years) and education (university degree vs. no university degree). Two mutually exclusive groups were formed for each demographic characteristic.

We analysed their responses and determined if there was a relation between the frequency of responses and certain categories. To do so, their responses were tabulated and compared from those choosing a certain response versus those not (refer to Appendix 15). We then conducted a chi-square test for independence to test whether a response is statistically more likely to occur for one categorisation than the other. In most tests, there was no statistical significance. If the response was statistically significant (defined as $p<.05$), we report the odds ratio and its 95% confidence interval (CI). The smaller the value of p, the more statistically significant the result. An odds ratio is used to measure how more likely a response is within a group, versus another response. An odds ratio of 1 means that the response is no more likely in either group; a higher odds ratio indicates a greater relationship between the demographic variable and the response. The confidence interval indicates the likely lower and upper bounds of the true odds ratio. A smaller interval reflects greater statistical significance. Also, lower interval values that approach 1 indicate that it may not have a substantial comparison between the two characteristics. Our full tabulation of our online survey results can be found in Appendix 16.

4.4.2 Primary Reason for not Pursuing PV Installation:

With regard to discouraging factors for PV systems, 128 (42%) indicated initial cost of the system, 49 (16%) chose ‘do not plan to stay in dwelling for an extended period of time, and 32 (16%) chose the low feed-in tariff as the primary reason for not pursuing PV installation (refer to Figure 15.). In addition to our provided response, 64 (21%) indicated “other.” The majority of these responses included: “do not own roof” (i.e. renter), “roof is not suitable” (i.e. asbestos, orientation, structure, heritage overlay), and that the benefit from installing a system is low in comparison to other sustainability related actions. Additional responses to this question included “do not have enough information to make a decision,” “concerned with system quality,” and ‘no interest in solar technology,’ but their results were relatively small in comparison, accounting for 11% all together. We found that only 5% indicated that they did not have proper information to pursue installation, because installers indicated that the knowledge barrier is withholding expansion. This can be accounted for because we only analysed the highest ranked answer; lack of information may have been ranked high, but was less influential than initial cost.

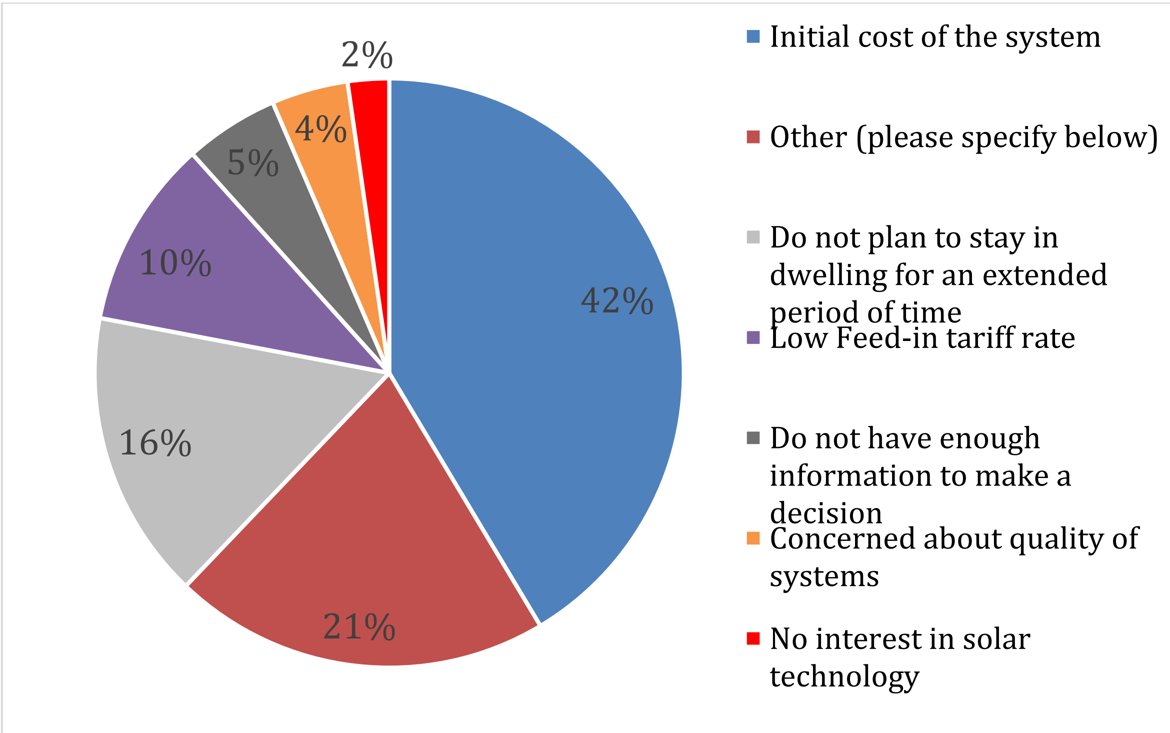


Figure 15. Factors Most Likely to Discourage Installation

We found statistically significant relationships between most discouraging factors for installation and parenthood and homeownership.

Respondents who are parents or guardians are 1.7 times more likely to rank initial cost as their primary reason for not installing, as compared to non-parents/guardians (95% CI: from 1.09 to 2.77) ($\chi^2(1, N = 300) = 5.42, p = .020$). Parent/guardians generally have different responsibilities and financial situation, as they are more likely to have additional costs than non-parents, as they support their children; because of this, spending a large sum of money on a PV system does not seem feasible in comparison to daily needs. In contrast, non-parent/guardians were 1.9 times more likely to rank "do not plan to stay in dwelling for an extended period of time" as their primary reason for not installing (95% CI: from 1.001 to 3.55) ($\chi^2(1, N = 300) = 3.93, p = .047$). Non-parent/guardians are less likely to have a reason to stay in their dwelling (i.e. children in a particular school) and are less inclined to invest in PV because they would not receive the full return on investment if they decided to out before breaking even.

While 16% of responses were "do not plan to stay in dwelling for an extended period of time," our data shows that respondents who rented their dwellings are 11.1 times more likely than homeowners to be deterred from installation because of this reason (95% CI: from 5.78 to 23.24) ($\chi^2(1, N = 305) = 61.35$, $p < 0.01$). This indicates that installing a solar PV system would not be an appealing option for a renter as the ROI will most likely outlast their stay in their rented dwelling, causing them to lose money.

4.4.3 Preferred Payment Option

When respondents were asked what their preferred payment option would be if they were to install a PV system, 120 (37%) responded "upfront, full payment," 81 (25%) did not have enough information to make a decision, 66 (20%) preferred a low financing option with a deposit, 40 (12%) chose "zero-down deposit low-interest financing option," and 16 (5%) would choose a leasing option (refer to Figure 16). While people are interested in paying for their system outright, it may not be economically feasible. This suggests that there may be insufficient information on alternative payment options. The availability of such information could help potential consumers overcome their concerns about financing for a PV system.

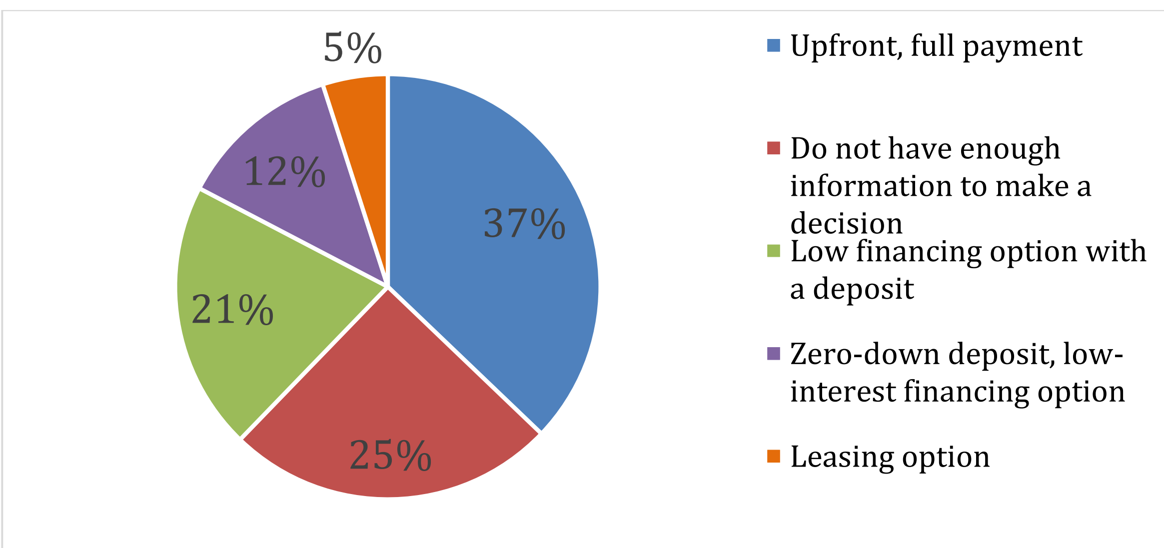


Figure 16. Preferred Payment Options

Our data shows statistically significant relationships between preferred payment option and mortgage, age, and education.

Homeowners who are currently not paying a mortgage are 2.2 times more likely to choose an upfront payment option (95% CI: from 1.26 to 3.67) ($\chi^2(1, N = 243) = 8.06, p = .005$). This is likely due to homeowners without a mortgage having assets that have already been paid off and being able to afford to make further upfront investments.

Respondents of age 45+ were 1.6 times more likely than respondents between 18 and 44 to prefer an upfront, full payment option (95% CI: from 1.09 to 2.74) ($\chi^2(1, N = 318) = 5.51, p = .019$). Older respondents are more likely to have sufficient funds after years of saving and would prefer not to pay over a period of time. Furthermore, those who are younger are more likely to be receptive to alternative payment options, as their funds may not be sufficient to support an upfront cost. However, for these homeowners to utilise different financial options, they must be fully aware of the availability of these options. Our previous indication from our overall group response supports this, in that a majority of people are not informed enough to make a decision on payment options.

While 12% of responses were "zero down, low-interest financing options," respondents without a university degree were 2.34 times more likely to choose this than those with a university degree (95% CI: from 1.42 to 6.12) ($\chi^2(1, N = 315) = 9.06, p = .003$). While they have chosen the option with the least upfront payment, it is likely to have the least amount of returns over time and they may be unaware of potential billing periods. This indicates that reliable information pertaining to payment options would aid in overcoming a potential consumer's perception of financial infeasibility.

4.4.4 Perception of Cost:

With regard to the respondents' perception of initial cost of a high-quality, three or four person-home PV system, 123 (38%) responded $5,000-$7,999, 118 (37%) said $2,000-$4,999, 58 (18%) indicated $8,000-$12,000, 13 (4%) responded more than $12,000, and 8 (3%) said less than $2,000 (refer to Figure 17). The price ranges that we allotted in the survey make deeper analysis nearly impossible. We were under the impression that the average system cost was approximately $3,200, but in actuality, it typically ranges from $4,000-$6,000 depending on the quality of the system, spanning over two answer choices. However, there were 71 respondents who believed the cost to be greater than $8,000, an overestimation, which supports the finding from installers about the lack of information and misinformation of PV. Consumers with this perception could potentially overcome the initial cost barrier if they were aware of the actual pricing. There was no statistically significant difference between perception of cost and any of our demographic categorisations.

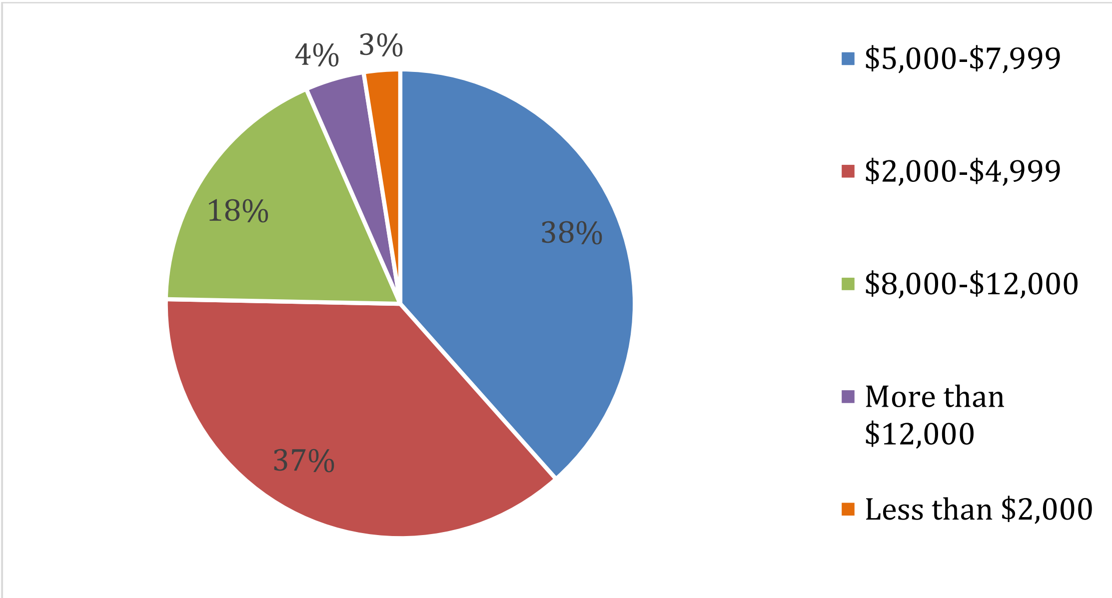


Figure 17. Perception of PV System Cost

4.4.5 Greatest Gain from Owning a PV System

In response to what our respondents hoped their greatest gain would be from installing a system, 187 (58%) said to reduce their personal greenhouse gas emission (GHGE) and 108 (34%) would be most satisfied by saving money on their power bill. Additionally, 8% responded to take advantage of the low system cost, increase dwelling value, or other, which is relatively small in comparison (refer to Figure 18). MEFL and Positive Charge can note from this that members of the community are primarily concerned with improving their GHGE in order to protect the environment, but the survey sample is likely biased toward residents that are already environmentally conscious because they are members of MEFL's e-Bulletin and their previous *Zero Carbon Moreland* project. There was no statistically significant difference between greatest gain of owning a PV system and any of our demographic categorisations.

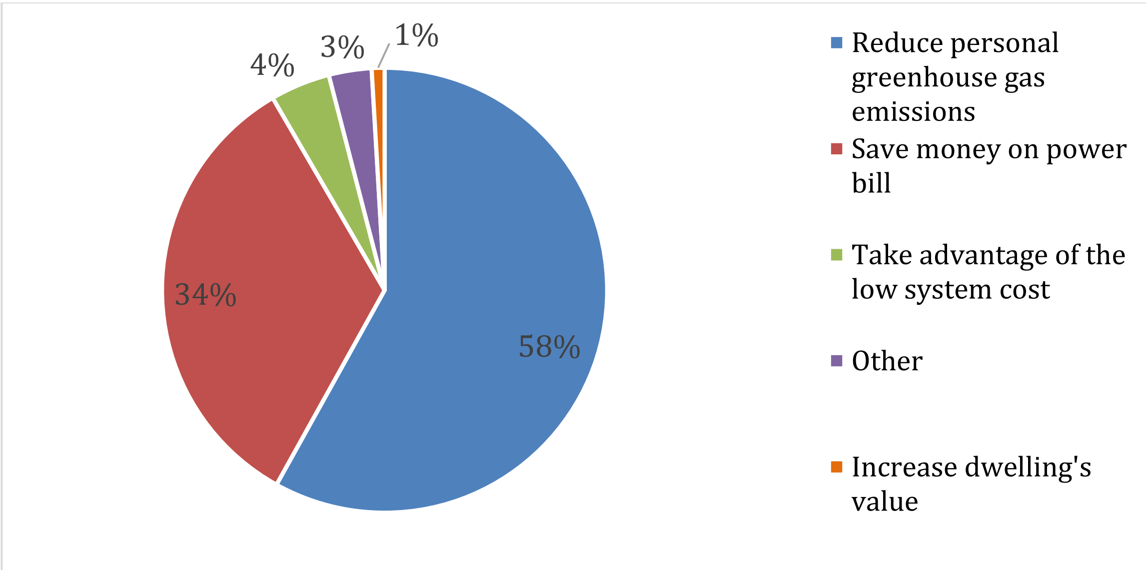


Figure 18. Greatest Gain from Owning a System

4.4.6 Preferred Source of Information

With regard to what information source would be the most influential in encouraging them to install PV, 143 (46%) ranked trusted not-for-profit (NFP) organisations as their preferred source, 86 (28%) said they preferred recommendations from family or friends, 48 (15%) chose case studies on the advantages/disadvantages of installing, and 31 (10%) indicated home visits from energy experts (refer to Figure 19). Other responses were social media, and contact from PV installers, but their results were small in comparison, accounting for 1% all together. MEFL and Positive Charge can note that members of the community will support their efforts as a not-for-profit organization, although the survey sample is likely biased toward residents that support MEFL's activities already.

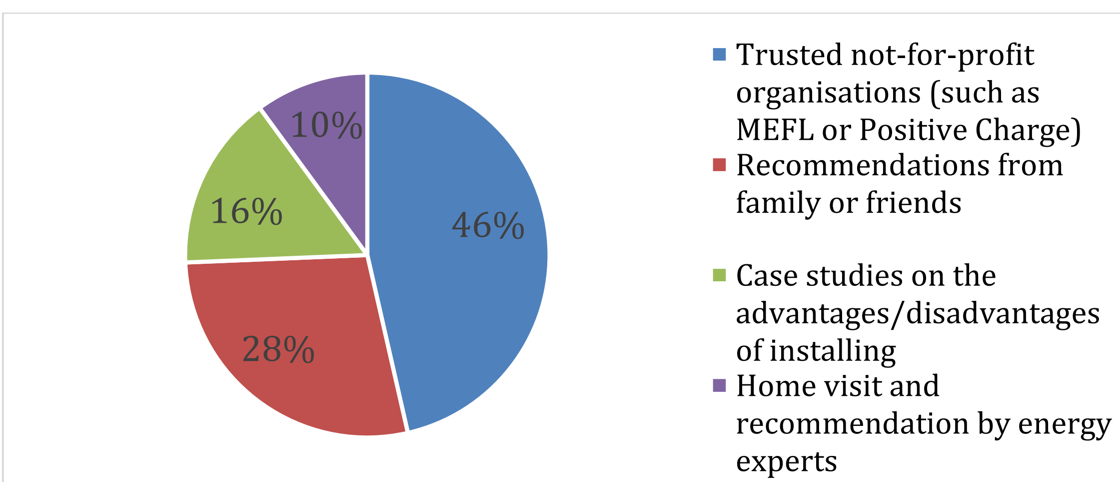


Figure 19. Most Preferred Information Sources on PV Installation

We found a statistically significant relationship between preferred information source and income, mortgage, and homeownership.

While 10% indicated home visits and recommendations by energy experts as their primary choice, this response was 2.7 times more likely to be the first choice for respondents with high incomes compared to those with lower incomes (95% CI: 1.22 to 6.12) ($\chi^2(1, N = 258) = 6.38, p = .012$). Households with higher income have more money to invest, but are also more conscious of where and how they invest their money. Their ability to invest depends on a range of financial responsibilities such as mortgages dependents. To overcome this barrier, Positive Charge needs to ensure high-income households of their credibility of information to bridge the informational gaps for all ranges of economic standing.

Respondents who currently own their home, but do not pay a mortgage are 2.0 times more likely to choose recommendations from family or friends than homeowners paying a mortgage (95% CI: from 1.13 to 3.61) ($\chi^2(1, N = 232) = 5.71, p = .017$). Homeowners without a mortgage are more likely to be older (86.5% of respondents without a mortgage are 45+). Older age groups are more likely to rely on word-of-mouth recommendations instead of utilising case studies or other information about PV that can be found on the Internet. These individuals already trust family and friends, indicating that public events promoting PV from neighbouring PV homeowners would be a viable way to increase their potential for PV adoption.

When comparing homeowners vs. renters, renters are 1.9 times more likely to rank case studies as their preferred information source (95% CI: from 1.02 to 3.83) ($\chi^2(1, N = 307) = 4.14, p = .042$). As indicated through our PV installer interviews and renter-installed PV owners, the process to install a PV system on a rented dwelling is a much different process than that for homeowners. If an agreement between the landlords and tenants could be formulated, both of these parties could profit from the installation of PV.

4.4.7 Comparisons to Previous Studies:

We compared our online survey results of non-PV homeowners, with our PV homeowner surveys and CSIRO's *Australian householders' interest in the distributed energy market* report, from October, 2013, in order to compare answers from non-PV owners to those of PV owners. Not all three surveys addressed the same questions and had slightly different answer choices, but we were able to draw connections between primary reasons for installation and payment preferences.

In contrast to CSIRO's report of 70% of responses, 47 % of our surveyed PV households and 34% of our online survey respondents indicated that their primary reason for installation is or would be to save money on their power bill. Our online survey results could be more swayed to have environmental reasons for installation because they are a potentially biased sample from MEFL members that are more environmentally conscious. This three-way comparison is shown in Figure 20.

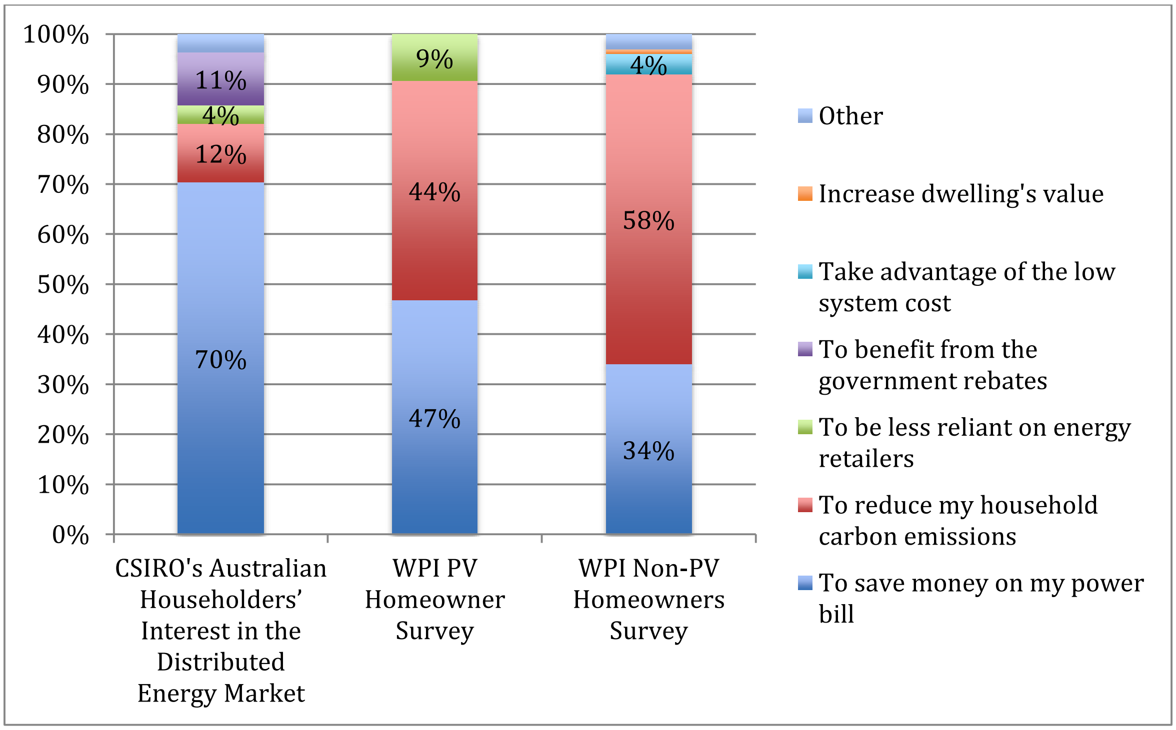


Figure 20. Comparison between Literature and Our Results

Supported by CSIRO's report, the majority of our online responses (37%) indicated that they would prefer to fully pay for their system upfront. Additionally, the second most preferred option was to utilise a form of financing (i.e. low financing option with a deposit, or a zero-down deposit, low financing option) with 32% of responses, collectively.

Chapter 5: Conclusions & Recommendations

Overall, the potential for PV capacity in this area is fairly high, as Moreland could potentially offset 91% of the electricity consumed in residential dwellings. However, we determined that there are various barriers for the PV market in the Moreland community that are currently withholding it from reaching its potential uptake. We found five main areas for improvement to increase uptake: regulations for landlords, educating owners of multi-unit dwellings, overcoming the financial and knowledge barrier, and promoting uptake through community engagement. We have addressed each of these conditions and proposed solutions to overcome them in order to stimulate the market and help Moreland reduce its overall greenhouse gas emissions.

5.1 Regulatory Barrier on Rented Dwellings

From our findings, we conclude that there is a large potential capacity for PV uptake in dwellings in Moreland that are rented. Rented dwellings make up 31% of all dwellings in Moreland, and thus have a large share of its overall electricity usage. Renters are significantly more likely than homeowners to say the primary reason for not installing a system is that they "do not plan to stay in the dwelling for an extended period of time," so it is not profitable for them to pay for a PV system. Therefore, it is not a reasonable idea to target renters for the adoption of PV systems on the dwellings they inhabit. Instead, it would be much more feasible to target the landlords of the dwellings, since they have the opportunity to profit from the PV system.

Currently, there is no mandatory disclosure of energy ratings for rental properties. This is preventing landlords from being publically acknowledged for improving the energy performance of their rental property their dwelling. It becomes harder for them to increase the cost of rent because of this, even though the tenant could benefit financially by savings on their electricity bills.

Recommendation #1.

It is important that MEFL supports and helps to **create a regulation to have a mandatory disclosure of energy ratings for rental properties** to ensure that renters understand there is an opportunity to save money on electricity bills on buildings with PV installed.

If this can be accomplished, we recommend MEFL to **educate landlords on how they can benefit economically from installing a PV system** on their dwelling. If the landlord purchases a system, they could charge an individual more for their rent by justifying that the tenant will be making up the money through savings in their energy bills.

5.2 Multi-Unit Dwellings

Single storey and multi-storey unit dwellings face different barriers than fully detached dwellings. People in this situation may not even know it is possible to install solar on their roof due to a lack of information on the installation process for unit-type dwellings. First, the owner must determine if there is enough roof space for the system. For multi-storey dwellings, the roof is evenly split up to each of the units directly under it. The owner must provide the Owners' Corporation with background information on the process and potential risks; following this, they must get majority approval from the Owners' Corporation through a paper ballot. Additionally, they have to accept responsibility for any damages done to the roof by the system, or pay to remove the system if necessary.

The overall process can take substantially longer than if a homeowner installed on a fully detached dwelling, due to the difficulty of ensuring an entire Owners' Corporation of its benefits and informing them of the process and risks.

Recommendation #2. We recommend that MEFL **educates Owners' Corporations** of multi-unit dwellings to aid in providing awareness of the process and feasibility of installing solar.

We suggest that MEFL primarily focuses on **apartment dwellings that are at most 3 storeys**, because there is likely to be less roof space for the taller apartment blocks. It also becomes increasingly more difficult and expensive to install on higher rooftops, as the installer must utilise alternative methods for installation.

We suggest that MEFL focuses on apartment-type dwellings that are **smaller in terms of the number of total units**. This improves the level of ease for the interested owner to inform the whole Owners' Corporation and get majority approval.

5.3 Financial Barrier

Through our survey of non-PV households and installer interviews, we determined that the initial cost of a system is one of the main barriers preventing individuals from installing solar PV; 41% of our non-PV household survey respondents ranked initial cost as their greatest reason for not installing. There is a misconception of the initial cost of PV systems, as 22% of respondents in this survey greatly overestimated the price of a solar power system on an average family's dwellings. This overestimation could contribute to the potential consumer's perception of the return on investment of PV being longer than it actually is, as mentioned in the installer interviews. Additionally, 25% of respondents do not have enough information about payment options and thus need to be made more aware of alternatives to paying the large upfront capital.

Recommendation #3. We recommend MEFL to **educate individuals on the various payment options available for solar PV**.

We suggest that MEFL further emphasizes the education of **communities with higher percentages of people with mortgages**, because people with mortgages are significantly more likely than people without mortgages to not have enough information on the various financial options. These individuals also have additional overhead costs, so they may be more inclined to take advantage of a financial option if they were made aware of them. Approximately 30% of Moreland residents with a private dwelling have a mortgage.

We suggest that MEFL **educates communities on the financial options in areas with more schools**, since parents are significantly more likely than non-parents to have initial cost as the greatest reason discouraging them from installing solar PV. Overall, around 60% of Moreland households consists of parents.

5.4 Consumer Knowledge Barrier

One installer believed that most homeowners prefer to have all of their decisions about installing PV done for them, including: sizing, financing, and determining the ROI. Through our online survey, we determined that the majority of individuals ranked not-for-profit organisations as the most influential at encouraging them to install PV. Organisations such as Positive Charge have the potential to influence an individual's decision to purchase PV for two reasons: they are more trusted than other means of communication, such as solar installation companies and social media; and they provide the individual with information they need to purchase PV, or provide them with trusted contact for further assistance.

Recommendation #4: We recommend that MEFL creates an **interactive webpage showing potential savings** a homeowner can make through purchasing PV.

This tool could also be used to **determine an appropriate sized system** that can be determined by various variables, such as the number of individuals in the house, average energy consumption, standard times they are home, and number of high-energy appliances. We believe that the majority of the potential PV homeowners would respond well to a user-friendly online tool to help calculate future savings if an investment in PV is made.

The calculation page would also **incorporate financing options, incentives, and current cost of electricity,** in order to improve financial awareness. This allows the user to determine what system size and financing plan would be most feasible for their situation. By providing the savings a PV system has to offer, as well as noting upfront costs, to future PV homeowners, this webpage could help make initial investments for PV easier to understand.

5.5 Community Engagement

The installers indicated that the ideal customers for PV uptake are either retirees or young families. They indicated retirees, because generally they do not have many additional financial liabilities so they can be more receptive to the idea of investing their money in PV.

The majority of respondents who currently own their home and do not pay a mortgage fall into the older age group. These individuals are also significantly more likely than individuals paying a mortgage, who are generally younger, to choose recommendations from family or friends as their most influential source of information to purchase PV.

Installers suggested young families because they are likely concerned about rising electricity prices in the future, especially due to the significant increase over the past few years. With PV systems, young families will ease the financial stress of high electricity bills, especially with the additional energy used by their children.

Recommendation #5: We recommend that MEFL promotes PV adoption to **older individuals who do not have a mortgage through word-of-mouth recommendations and marketing**.

Since these individuals are older, they **may be less tech-savvy** than younger members of the community. Because of this, they are more likely to stick to word-of-mouth recommendations instead of utilising case studies or other information about PV that can be found on the Internet. These individuals already trust family and friends, indicating that **community events where PV homeowners provide personal testimonials about uptake to**

their neighbours and friends would be a viable way to increase the potential for PV adoption to older individuals who are not paying a mortgage.

Recommendation #6: We recommend that MEFL hosts family-friendly community events to promote PV uptake to younger families.

One of the installers specifically mentioned that a great way to reach young families is through **school fundraisers**. These fundraisers help raise money to put PV on schools while also offering **incentives to the homeowners of the children attending these schools**. By promoting solar PV to young families, **children will also be exposed to pro-environmental behaviours**, which could be beneficial to the future PV market as the children grow into independent adults and future homeowners.

5.6 Limitations of Our Study, Potential Uses of the Recommendations, and Areas for Future Expansion

5.6.1 Limitations of Our Study:

We recognize that our study has various limitations, which are explained as follows:

1. Our project only determined the carrying capacity of three postcodes in Moreland. It might be useful to measure a few more postcodes to determine to see if the estimated total capacity in Moreland was reasonably scaled or if further measurements need to be considered for an accurate calculation.
2. The online survey that was sent out to non-PV households had various limitations for the demographic comparisons due to the small count in particular categories. Some of the noted results that are statistically significant have a wide-ranging confidence interval, indicating some uncertainty in that area caused by the low counts. Examples of demographics where low counts were evident are parenthood for initial cost as reason not to install, and age for upfront payment options. If another similar survey were conducted, it would be useful to analyse whether our statistically significant findings are reproduced.
3. If substantial PV uptake occurred in the Moreland area, it would become important to determine the potential grid capacity, as this is likely a limiting factor if the grid can withstand the energy produced.

5.6.2 Use of Our Recommendations:

We created our recommendations for use by MEFL and organisations looking to promote solar PV uptake within municipalities similar to Moreland. If our recommendations are considered, we are hoping to see the following improvements to the Moreland PV market:

- More landlords installing PV systems on rented residential buildings and a regulation on mandatory disclosure of energy ratings on rented dwellings;
- Greater awareness and uptake of solar PV on multi-unit dwellings;
- Improved understanding of financing options when making the initial investment in residential solar PV; and
- An overall improved community awareness of the potential to offset residential consumption by roughly 90% using residential solar PV systems within Moreland.

5.6.3 Areas for Future Expansion:

To expand our project, further research could be conducted to determine the consumers' perception of the ROI for PV and whether this is a substantial factor discouraging consumers from adopting PV. These findings would provide a better understanding as to whether current advertising schemes are reflecting the ROI in a positive light.

Areas of future research could also look at the real estate market to see if the installation of PV systems is having a substantial effect on the costs and sales of houses. Additionally, it would be important to determine the main reasons why some builders have been installing PV systems on new residential dwellings, while others have not.

Finally, a future study could be conducted to see if the recommendations outlined within this report have significantly improved the solar PV market within Moreland. While our results suggest that there is a high potential for uptake in Moreland, this future study could solidify our recommendations and facilitate communities around the globe who are also looking to improve the uptake of residential solar PV.

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Appendix 1 Sponsor Description

The Moreland Energy Foundation Ltd (MEFL) was founded in December 2000 by the Moreland City Council to promote local energy sustainability. The Council created this not-for-profit foundation in response to growing concerns about the electricity production and consumption following restructuring of the Victorian electrical industry. Its funds came from the sales of local electricity assets after Victorian electricity was privatised and the council-owned Brunswick Electricity Supply Department was sold in the mid 1990's (MEFL, 2013).

Until relatively recently, MEFL was unique among local government groups in Victoria, with its emphasis on and expertise in sustainable energy. As the leading foundation within Victoria, they have played a prominent role in the Northern Alliance for Greenhouse Action (NAGA) and serve as an example for nascent groups with a similar passion for sustainable living, such as the Yarra Energy Foundation. Overall, MEFL is on the leading edge of technology within the region, promoting further expansion as others follow their lead.

Over the past thirteen years, MEFL has worked with households, businesses, and community groups in Moreland City to achieve its primary goal of "implementing [a] sustainable energy supply and reducing energy use." MEFL is dedicated to upholding the following five core values: innovation, honesty, respect, resilience, and teamwork. By integrating their core values, MEFL has declared their mission to "undertake community engagement, do research, consult, provide professional development and advocate on energy efficiency, renewable energy and related policy and planning issues" (MEFL, 2013). Their expertise and dedication to promotion of green energy has made MEFL a leader within the field of reducing carbon emission.

Building on the successes of the past years, MEFL has established a five year strategic plan to be completed by 2015 to make Moreland "an active, inspired community tackling climate change with sustainable energy solutions," (MEFL, 2013). MEFL offers an extensive set of programs within the community to minimize excessive energy waste, reduce energy bills with practical and sustainable ideas, and develop low carbon alternatives. They offer "advice, training, consultancy services, cheap and easy energy-saving tips, and consultation with government to discuss options to make it easier for people to reduce energy use," (MEFL, 2013).

In recent years, MEFL's efforts have become more evident throughout the community as they worked on numerous improvement projects. These include partnership with Sustainability Victoria to improve existing Victorian homes' energy efficiency by:

- Replacing halogen down lights;
- Installing wall insulation;
- Draught-proofing buildings; and,
- Implementing regular energy efficiency testing.

MEFL relies primarily on government support for its funding. They receive their base funding from the Council, and also collect substantial funding in the form of numerous federal, state and local government grants. In 2012, they operated with a budget of $2.7 million, which was primarily used for their Zero Carbon Moreland program. MEFL also receives funds through membership for service activity and has attracted over $610,000 in dues. Members have the ability to work with staff to “advocate for sustainable outcomes at a policy level and in [their] own community” (MEFL, 2013). Table 11 describes the various membership options and their prices.

Membership type	**1 year**	**3 years**
Individual	$30	$80
Concession	$15	$40
Family/Household	$50	$140
Business/Community Organisation	$60	$170

Table 11. Membership Options (MEFL, 2013)

From 2008-2012, MEFL received considerable funding through the Moreland Solar City Project, which began through a solar city grant provided by the federal government. The Australian Government’s Solar Cities program was designed to “trial new sustainable models for electricity supply and use,” and Moreland was selected as one of seven Solar Cities for this program (MEFL, 2012b). Moreland Solar City consisted of four projects streams, including:

- Zero Carbon Moreland (reducing existing energy use of residents, community groups and businesses);

- Zero Carbon Moreland Concession Assist (helping low-income households become more energy efficient);
- Moreland Energy Partnerships (transforming the way Moreland generates energy into more of a focus on renewable energy); and,
- Sustainable Urban Planning (working with commercial developers to produce effective tools to incorporate sustainability into new precincts).

Through this $10 million project, MEFL assisted over 1,000 low income households with the help of 4,000 volunteers and businesses.

MEFL partners with numerous local organizations to achieve its goals. For example, MEFL is collaborating with Climate Action Moreland on a community funded solar project to build a medium scale solar photovoltaic (PV) array. Climate Action Moreland also stages protests and rallies to show that there is a large support within the community to pressure political leaders into taking action against climate change. The recent interest in a sustainable future has led to the development of a new MEFL initiative, Positive Charge. The primary goal of Positive Charge is to combat rising energy costs by making energy saving easier for local residents and businesses. Through this initiative, energy conservation experts conduct research and provide information to the public to promote conservation. Additionally, Positive Charge sells energy efficient products, such as PV panels, insulation, LED lights, and electric bicycles. Through this and similar efforts, MEFL hopes to raise awareness and encourage more people to adopt energy saving strategies and promote greater environmental sustainability (Positive Charge, 2013a).

MEFL has twenty-five full-time, part-time, and casual employees, as well as fifty volunteers and eight interns and is governed by a Board of Directors consisting of ten members drawn from the organization and local community (Figure 21) (*Moreland Energy Foundation LTD*, 2013). The Board includes the Chief Executive Officer, Paul Murfitt, Secretary, Ian Thomas, and Chair, Monique Conheady. In addition there are four general members, a community representative member, and two nominees from the Moreland City Council. There are three subcommittees under the board which are composed of elected members with particular skills and an interest in MEFL's work (Moreland Energy Foundation)**.** The Community and Stakeholder Engagement Committee promote the communication and cooperation of the Moreland community stakeholders with MEFL. The Performance Assessment Committee oversees the CEO's work and helps to appoint a new one in the event of a vacancy. The Business Sustainability and Risk Committee, on which Chair Monique Conheady serves, has the responsibility of overseeing risk management strategies and modifying them when necessary, advising the board when business development opportunities are available, and also monitoring several of MEFL's projects. Figure 22 shows how the board oversees the activities of MEFL through its subcommittees. Reports on the organization's activities and progress are published annually in their yearly review (MEFL, 2012c).

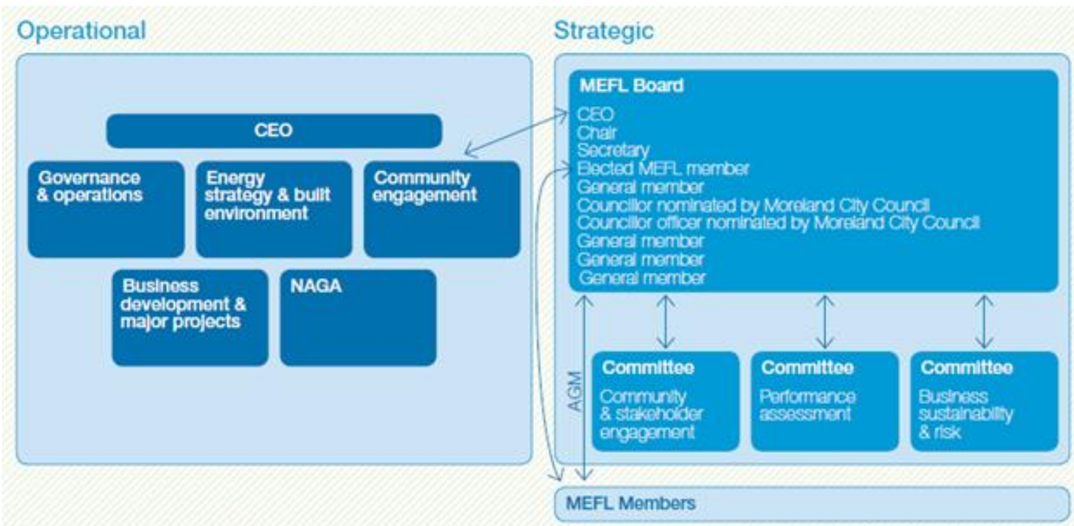

Figure 21. MEFL Hierarchy of Organisational Bodies (MEFL, 2013).

MEFL has programs in many parts of Australia, but 90% of its funds are spent in Victoria and 56% focus on Moreland in particular. MEFL runs operations in the city of Moreland, which is located north of Melbourne and includes the suburbs shown in Figure 22. MEFL works in all of the suburban areas within Moreland to reduce greenhouse gas emissions and promote sustainability.

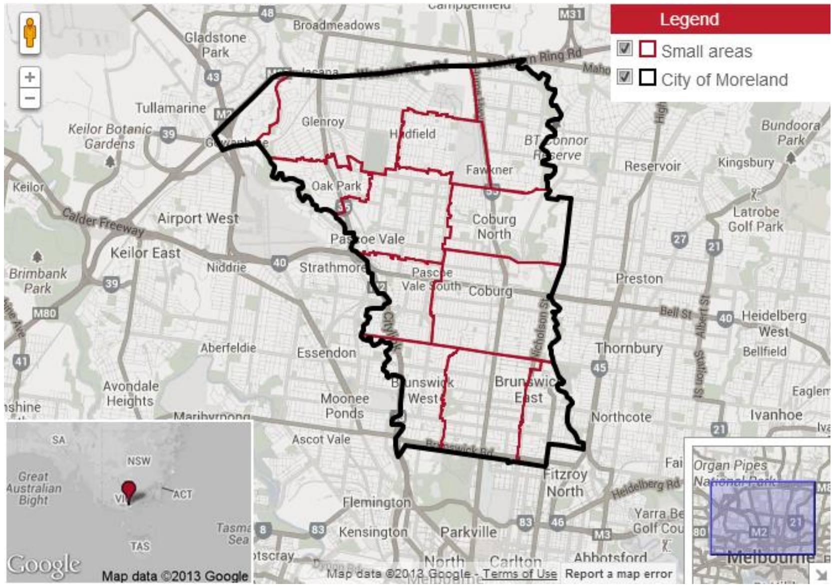

Figure 22. Map of Moreland and surrounding areas ("City of Moreland profile - Moreland City Council, Victoria, Australia," 2013)

Moreland is primarily a residential area with a population of 147,244 and 63,370 total dwellings, in 2011. Moreland is a racially-mixed area with 34% of residents born overseas, primarily from Italy, India, Greece, United Kingdom, Lebanon, and China. Forty-eight percent of individuals in Moreland have an income of less than $600 per week and 36% of dwelling types are in medium or high-density surroundings. These two statistics suggest that there are significant areas of poverty in the Moreland area (Moreland, 2013).The median personal income for the rest of Melbourne is $698 per week (Australian, 2011).

Appendix 2 Installer Interview Supporting Documents

Request for Correspondence

Subject: Interview with WPI Team from MEFL

Dear <insert interviewee name>,

I am writing to you on behalf of my project team. All four of us are third year students studying engineering at Worcester Polytechnic Institute in Worcester, MA, USA. We are here in Melbourne working with the Moreland Energy Foundation on a project to expand the solar PV market into the next million homes. Our supervisor, Bruce Thompson at MEFL referred us to you, thinking you would be a great contact for a brief interview. We hope that you will be able to help us by answering a few questions about the local solar PV market and how to utilize technology and software, such as Nearmap, to obtain estimates for usable roof-space for solar PV installation.

We have prepared a list of questions for our brief interview and are hoping to set up a day and time within the next week that works best for your schedule. You can contact me directly at eamiller@wpi.edu to set up the interview. The group is very enthusiastic to speak with you, either via phone or in person. Thanks for your time; we look forward to corresponding with you soon.

Sincerely,
Liz Miller

Worcester Polytechnic Institute (WPI)
B.S. Robotics Engineering 2015

Installer Interview Preamble

Thank you for taking the time to speak with us today. Our main objective in today's interview is to gain a better understanding of the factors affecting homeowners' decisions to install solar PV systems. Would you mind if we record our conversation today, or would you prefer that we just take notes? Okay, let's get started with the interview.

Installer Interview Questions

Below is a list of all of the installer interview questions that we used. Note that not all of these questions were asked to each interviewee. Depending on the conversation, we would ask the main questions (designated by numbers) and the sub-questions (designated by bullet points) would help prompt and move the conversation along. We classified each of these questions based on whether they were relevant to sales, client relations or technical interviewees. Refer to Table 12 for a list of the questions pertaining to each classification.

1. Can you tell me more about what you do, about your job title and primary responsibility?
    - Do you work more on the technical side, the sales, or client relations side of the company?
    - In what capacity do you interact with homeowners directly?
    - Do you have a PV system installed? Why/Why not? What was your motivation behind installing or not installing?

2. Have you thought about constraints of mapping out roof spaces (i.e. shading, useable roof size)?
    - What is the typical size of a solar system installed residentially?
    - Are there any regulations for installing PV on apartment roofs? Who owns the roof?

3. Roughly, how many installations do you have per year? How many of these (%) are residential vs. commercial/industrial?

4. Out of all of the last year of quotes that you did, approximately what percentage did you actually go through the installation process with?
    - What factors stop you from proceeding with a quote?

- What factors do you think influence a homeowner from stopping the installation process?

5. Within Moreland, is there a target area that you are pitching more towards?
    - Where in Moreland have you had the most residential systems installed within the past 5 years? What drivers do you think contributes to this pattern of uptake?
    - What are your drivers for a specific area?
    - Where are some of the “hot areas” for sales?

6. How would you categorize the typical customer for a residential PV system?
    - What kinds of suburbs: middle class, high-end do you find have typical installations?
    - What kinds of people are purchasing these systems: young families, middle-aged, or empty nesters?

7. What factors do homeowners consider when they are choosing a system?
    - Is it mainly due to cost, energy consumption or roof space, or some other factor?
    - What kinds of information do customers ask for when purchasing PV systems (i.e. incentives, saving money, energy, environmental)?

8. How long is the full process from quoting to homeowners’ independently generating energy from their system?
    - Does the timeline or process effect a homeowner’s decision to purchase?

9. What is your company doing in order to attract new customers?
    - (What is the most effective way to attract new customers?)

10. What do you think are the critical factors that need to change in order for solar power to be more widely adopted?
    - What do you think about government policies towards solar PV installation?
    - How do you think the solar PV market has changed over the past 5 years?

Interviewee Job Title	Sales Team	Client Relations	Technical
Category	Socio-demographical	Marketing	Technical
Most Applicable Question Numbers	1. 3. 4. 5. 8. 9. 10.	1. 6. 7. 8. 9.	1. 2. 8. 10.

Table 12. Installer Interview Questions Sorted by Most Applicable Question to Respective Interviewee and Category

Installer Interview Closing

Some of your quotes from our interview may be valuable for our report. Is it okay if we quote you? We will plan to run all quotes by you and you can sign them off before they are used within the report. A copy of our report can also be made available to you once completed, if you would like to receive one. Thanks again for your time. Would we be able to follow up with you in the future?

Appendix 3 Email to MEFL AGM Contacts

Dear <insert name here>,

We are the group of students from Worcester Polytechnic Institute in the USA who met you at MEFL's AGM on October 29th. Paul Murfitt briefly introduced us and talked about our project to increase the use of solar power systems within Moreland. We would greatly appreciate your help as we begin surveying and interviewing people around the area. Your assistance can help us test and further develop these two methods.

Do you own a solar power system?

If yes, would you be willing to talk with us on the phone for about 10 minutes at a time convenient to you? Please let us know by email what would be a convenient time and number to call.

If no, could you please take 5-10 minutes to fill out the anonymous survey at the following link: https://www.surveymonkey.com/s/WPIStudentSurveyMEFL

Your responses will be very valuable for our research and MEFL's future efforts. If you would like to know more about our project, feel free to contact us by email or phone at 9385 8585.

Sincerely,
Tanishq, Alex, Liz, and Nick

Appendix 4 Email to “Pub Night” Contacts

Dear <insert name here>,

We are a group of students from Worcester Polytechnic Institute in the USA and are currently working on a project at the Moreland Energy Foundation to increase the use of solar power systems within Moreland. You are being contacted because you have attended one of MEFL’s Pub Nights in the past. We would greatly appreciate your help as we begin surveying and interviewing people around the area. Your assistance can help us test and further develop these two methods.

Do you own a solar power system?

If yes, would you be willing to talk with us on the phone for about 10 minutes at a time convenient to you? Please let us know by email what would be a convenient time and number to call.

If no, could you please take 5-10 minutes to fill out the anonymous survey at the following link: https://www.surveymonkey.com/s/WPIStudentSurveyMEFL

Your responses will be very valuable for our research and MEFL’s future efforts. If you would like to know more about our project, feel free to contact us by email or phone at 9385 8585.

Sincerely,
Tanishq, Alex, Liz, and Nick

Appendix 5 PV Homeowner Questions

1. May we ask you a few questions pertaining to your solar power system?
    a. What size solar panels and inverter did you have installed? Why?
    b. Approximately, when did you have your solar panels installed?
    c. At the time of installation, how long had you owned your home for?
    d. How long did the installation process take?
    e. Did you pay for the system upfront or did you utilise a financing/leasing option? Did you receive any incentives? What FiT scheme do you receive?
    f. Have you experienced any performance or quality issues with your system?
    g. Have you ever considered increasing the capacity of your system?
2. Can you tell me more about why you chose to install your solar panels?
    a. What was your biggest motivation for installation?
    b. Were there any barriers that you overcame before or during the installation process? Or anything holding you back?
    c. Have you noticed a change in your electricity bill since the installation? How much have you been saving on your electricity bill?
    d. What is the greatest satisfaction from owning your system? Have you recommended solar panels to family or friends? How?
3. Has installing your solar power system made you more environmentally conscious?
    a. Have you taken any "green" actions after the installation to improve your level of sustainability? How has your electricity usage changed after installation?
    b. Are you a member of any "green" groups? When did you become involved?
4. Socio-demographic information sheet:

    Lastly, we would like to answer a few personal questions that will help in our analysis, if you would not mind filling out this brief sheet. All information gathered will remain anonymous. Feel free to omit any questions you prefer not to answer.

In closing:

Thank you for taking the time to talk with us today. Your answers will be very helpful in our study. We greatly appreciate your time and participation in our study.

Appendix 6 PV Homeowner Data Collection Sheet

	Location	
	Dwelling Type	
1.	**Questions about their PV**	
	Size of solar panels and inverter	
	Installation date	
	Length of homeownership	
	Length of installation	
	Paid upfront or Financing	
	FiT Scheme / Incentives	
	Performance/Quality Issues	
	Increasing Capacity	
2.	**Why installed?**	
	Biggest Motivation	
	Barriers during installation	
	Change in electricity bill/Savings/comparison	
	Greatest Satisfaction/recommendations	
3.	**Environmentally Conscious**	
	Green actions/Electricity usage	
	Green Groups	

Appendix 7 Map of PV Households for Door-to-Door Surveying

Figure 23. Nearmap image of Pascoe Value Homes with Solar Panels Installed

Appendix 8 Email to Positive Charge Members with PV systems

Dear <insert homeowner name>,

We are contacting you because you recently purchased a solar power system through the Positive Charge initiative, coordinated by the Moreland Energy Foundation (MEFL). We are a group of third year undergraduate students from Worcester Polytechnic Institute (WPI) in the United States. As part of our studies, we are doing a research project with MEFL, investigating ways to improve the uptake of solar power systems in the Moreland area. Can you help us with our project by participating in a brief phone survey? This should take only 10 minutes of your time. Please be assured that this survey is for research purposes only, and has ethics approval from WPI.

If you are able to help, could you please reply to this email, and include your phone number and the best times for us to call you.

As a token of our appreciation, upon completion, you will be entered into a drawing for two movie passes!

If you have any questions about our research, please feel free to contact Bruce Thompson from MEFL on bruce@mefl.com.au (9385 8585), or our academic supervisors, Dr Andrea Bunting (abunting@wpi.edu) or Dr Dominic Golding (golding@wpi.edu)

We look forward to hearing from you.

Kind regards
Alex MacGrogan, Liz Miller, Tanishq Bhalla, Nick Tosi

Appendix 9 PV Homeowner Preamble

Hello! We are students from a university in the United States. We would like start off by saying that we are not selling anything, but are working in partnership with the Moreland Energy Foundation to assess the future of solar power systems in Moreland. We noticed that you have solar panels installed on your roof and would greatly appreciate a few minutes of your time to partake in a brief survey that will be used to develop recommendations for MEFL to improve local uptake of solar power systems. If you choose to participate, as a token of our appreciation, you will be entered into a drawing for two movie passes. Are you currently available for discussion? If not, we can contact you later for an over-the-phone (9385 8585) survey, if that suits you better. All information will be kept entirely anonymous and you may omit any questions if you so choose. May we begin?

Appendix 10 Letter to Absentee Homeowners

Dear Homeowner,

We are a group of students from Worcester Polytechnic Institute (WPI), in the United States. We would like to start by saying that **we are not** trying to sell anything! We are currently working in accordance with the Moreland Energy Foundation Ltd. (MEFL) in order to improve solar power system uptake within Moreland and have noticed that you have a solar power system installed. We have developed a brief set of questions to assess information from homeowners that will be valuable to our study. If you would be willing to partake in the study, we would greatly appreciate your time. Per your request, we can either conduct a phone interview. If you are willing to be a part of our study, we can be contacted either by email (wpi@mefl.com.au) or by phone (9385 8585) to coordinate the best time to talk. If you would prefer an online survey, the link is: **https://www.surveymonkey.com/s/PVStudentSurvey**.

Your time and participation is greatly appreciated and we look forward to hearing from you in the near future.

Sincerely,

The WPI Team (Tanishq Bhalla, Alex MacGrogan, Liz Miller, and Nick Tosi)

Appendix 11 Socio-Demographics Chart

WPI Student Survey

Which age group do you fall into?

☐ 18-24 ☐ 35-44 ☐ 55-64

☐ 25-34 ☐ 45-54 ☐ 65+

☐ Prefer not to answer

What is your highest level of education?

☐ Some high school ☐ High school diploma

☐ Some college ☐ Bachelor's degree

☐ Post-grad. degree ☐ TAFE

☐ Prefer not to answer

How many adults (18+) live in your home?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

☐ Prefer not to answer

Are you a parent/guardian?

☐ Yes ☐ No

☐ Prefer not to answer

If yes, how many children (under the age of 18) live in your home?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more

☐ Prefer not to answer

What is your approximate gross household yearly income?

☐ Less than $30,000 ☐ $30,000-$59,999

☐ $60,000-$99,999 ☐ 100,000-$150,000

☐ More than $150,000 ☐ Prefer not to answer

To be entered into the drawing for two movie passes:

Name:

Email:

Appendix 12 Online Survey of Households without Solar Power Systems

Survey of Households without Solar Power Systems

On completion of the survey, you will be entered into a drawing for two movie passes! All answers to questions will remain anonymous and will not appear in any reports. The survey should take no longer than 5 minutes to complete. We greatly appreciate your participation.

1. Do you own your dwelling?

- ◯ Yes; I have paid it off in full
- ◯ Yes; I am currently paying a mortgage
- ◯ No; I rent my dwelling

2. Have you ever considered installing a solar power system on your home?

- ◯ Yes, I am considering installation
- ◯ Yes, but my roof is not suitable for installation
- ◯ Yes, but I do not own my dwelling
- ◯ No
- ◯ Other (please specify)

3. Please rank the following reasons that have discouraged you from installing a system (1 being the most influential and 7 being the least influential). If other, please fill in the box below.

▢	Initial cost of the system	☐ N/A
▢	Low Feed-in tariff rate	☐ N/A
▢	Do not plan to stay in dwelling for an extended period of time	☐ N/A
▢	Concerned about quality of systems	☐ N/A
▢	Do not have enough information to make a decision	☐ N/A
▢	No interest in solar technology	☐ N/A
▢	Other (please specify below)	☐ N/A

4. Other (from question 3):

5. What would be your preferred payment option, if you were to install a solar power system?

- ◯ Upfront, full payment
- ◯ Zero-down deposit, low-interest financing option
- ◯ Low financing option with a deposit
- ◯ Leasing option
- ◯ Do not have enough information to make a decision

Survey of Households without Solar Power Systems

6. Please explain why you chose the option indicated in Question 5

7. How expensive do you believe it would be to install a high-quality solar power system on an average (3 or 4 people) family's dwelling?

	Less than $2,000	$2,000-$4,999	$5,000-$7,999	$8,000-$12,000	More than $12,000
Cost of installation:	○	○	○	○	○

8. If you were to install a solar power system, what would you hope to be the greatest gain from owning the system? Please rank the following (1 being the most important and 5 being the least important). If other, please fill in the box below.

☐	Take advantage of the low system cost	☐ N/A
☐	Save money on power bill	☐ N/A
☐	Reduce personal greenhouse gas emissions	☐ N/A
☐	Increase dwelling's value	☐ N/A
☐	Other	☐ N/A

9. Other (from question 8):

10. Please rank how important the following would be at encouraging you to install a solar power system (1 being the most influential and 6 being the least influential).

☐	Recommendations from family or friends	☐ N/A
☐	Trusted not-for-profit organisations (such as MEFL or Positive Charge)	☐ N/A
☐	Case studies on the advantages/disadvantages of installing	☐ N/A
☐	Contact from solar installation companies	☐ N/A
☐	Home visit and recommendation by energy experts	☐ N/A
☐	Social media	☐ N/A

The development of surrounding properties can have an impact on the efficiency of existing and future solar PV by overshadowing solar panels, however multi-storey apartments assist in reducing urban sprawl and reducing transport related energy consumption through locating housing near existing transport and services. In trying to balancing these objectives;

11. How important is it to protect the individual's right to solar panels from overshadowing from neighbouring properties?

	1 (Not important)	2	3	4	5	6	7 (Very important)
Rating	○	○	○	○	○	○	○

Survey of Households without Solar Power Systems

12. How important is it to protect the individual's right to develop their property and the associated benefits of restricting urban sprawl?

	1 (Not important)	2	3	4	5	6	7 (Very important)
Rating	○	○	○	○	○	○	○

Survey of Households without Solar Power Systems

Finally, we would like to ask a few personal questions that will help in our analysis. Feel free to omit any questions that you prefer not to answer.

13. What is your age?

	18-24	25-34	35-44	45-54	55-64	65+	Prefer not to answer
Age:	○	○	○	○	○	○	○

14. How many years have you lived in your home?

	Less than 1	1-3	3-5	5-10	More than 10
Years:	○	○	○	○	○

15. How many adults live in your home (18 years of age or older)?

	1	2	3	4	5 or more	Prefer not to answer
Adults:	○	○	○	○	○	○

16. Are you a parent/guardian?

○ Yes

○ No

17. How many children live in your home (under the age of 18)?

	0	1	2	3	4	5 or more	Prefer not to answer
Children:	○	○	○	○	○	○	○

18. What is the highest level of education you completed?

	Some high school	High school diploma	Some university	Bachelor's degree	Post-graduate degree	TAFE	Prefer not to answer
Education:	○	○	○	○	○	○	○

19. What is your approximate gross household yearly income?

	Less than $30,000	$30,000-$59,999	$60,000-$99,999	$100,000-$150,000	More than $150,000	Prefer not to answer
Income:	○	○	○	○	○	○

Survey of Households without Solar Power Systems

Movie Pass Entry

20. Thank you for your participation in our survey! You will be entered into a drawing for two movie passes in appreciation of your time. Please enter your name and email below to be entered in the drawing. This will remain confidential and will not be used in identifying your answers in any way.

Name:

Email:

Additional information about installing a solar power system is available from MEFL's staff members and from their website: http://www.mefl.com.au/

21. If you would like to be contacted by a MEFL staff member to learn more about solar power systems, please enter your phone number below. Neither your name nor phone number will be used to identify any of your previous answers in this survey.

Phone:

Appendix 13 Email to MEFL/ZCM Subscribers for Non-PV Household Survey

Moreland
Energy
Foundation

Dear << Test First Name >>,

We are a group of students from Worcester Polytechnic Institute in the United States and are currently working on a research project at the Moreland Energy Foundation. Our primary goal is to have a positive impact on the Moreland area by reducing greenhouse gas emissions through the increased use of solar power systems. We would greatly appreciate your help by taking 5 minutes to fill out our anonymous online survey. Please only fill out this survey if you **DO NOT** own a solar power system. Please click here to fill out the survey.

As a token of our appreciation, on completion, you will be entered into a drawing for two movie passes!

If you have any questions about our research, please feel free to contact Bruce Thompson from MEFL at bruce@mefl.com.au (9385 8585), or our academic supervisors, Dr. Andrea Bunting (abunting@wpi.edu) or Dr. Dominic Golding (golding@wpi.edu).

Your response will be very valuable to our research and MEFL's future efforts. Thank you for your participation!

Sincerely,
Nick Tosi, Tanishq Bhalla, Liz Miller, and Alex MacGrogan

Appendix 14 Mapping Calculations

Brunswick Results	
kW per House North	1.13
kW per House East	1.48
kW per House West	1.55
Without Restrictions	
Avg. kW per House	**2.85**
post Code kW	26462.40
kWh per House per Day	9.28
kWh per House per Year	**3388.94**
Total postcode MWh per Day	86348.37
Total postcode GWh per Year	**31.52**
With Restrictions	
Avg. kW per House	**2.67**
post Code kW	12159.70
kWh per House per Day	8.72
kWh per House per Year	**3181.55**
Total postcode MWh per Day	39677.82
Total postcode GWh per Year	**14.48**

Table 13. Brunswick Carrying Capacity Calculation Results

Pascoe Vale Results	
kW per House North	2.09
kW per House East	1.71
kW per House West	1.75
Without Restrictions	
Avg. kW per House	**4.08**
post Code kW	23924.38
kWh per House per Day	13.50
kWh per House per Year	**4927.43**
Total postcode MWh per Day	79162.85
Total postcode GWh per Year	**28.89**
With Restrictions	
Avg. kW per House	**3.58**
post Code kW	14260.34
kWh per House per Day	11.86
kWh per House per Year	**4329.51**
Total postcode MWh per Day	47185.72
Total postcode GWh per Year	**17.22**

Table 14. Pascoe Vale Carrying Capacity Calculation Results

Fawkner Results	
kW per House North	1.76
kW per House East	1.52
kW per House West	1.26
Without Restrictions	
Avg. kW per House	**3.59**
post Code kW	15328.84
kWh per House per Day	11.93
kWh per House per Year	**4356.03**
Total postcode MWh per Day	50911.83
Total postcode GWh per Year	**18.58**
With Restrictions	
Avg. kW per House	**3.47**
post Code kW	10789.72
kWh per House per Day	11.52
kWh per House per Year	**4203.13**
Total postcode MWh per Day	35835.98
Total postcode GWh per Year	**13.08**

Table 15. Fawkner Carrying Capacity Calculation Results

Moreland Census Data	
Total Population	52484
Applicable Dwellings	32577
Percentage to total Moreland Dwellings	
Brunswick	0.4786
Pascoe Vale	0.3018
Fawkner	0.2196
Applicable Dwellings Percentage to Applicable Moreland Dwellings	
Brunswick	0.391
Pascoe Vale	0.342
Fawkner	0.267

Table 16. Moreland Census Data Used to Weight Data from Each Postcode

Moreland Results Without Restrictions	
kW per House North	1.56
kW per House East	1.5590
kW per House West	1.5475
Moreland MW North	81.7
Moreland MW East	81.825
Moreland MW West	81.217
Avg. kW per House	**3.38**
Moreland MW Capacity	177.51
kWh per House per Day	11.23
kWh per House per Year	**4100.13**
Total Moreland GWh per Day	0.59
Total Moreland GWh per Year	**215.19**
With Restrictions	
kW per House North	1.63
kW per House East	1.5700
kW per House West	1.5412
Moreland MW North	53.0
Moreland MW East	51.146
Moreland MW West	50.208
Avg. kW per House	**3.20**
Moreland MW Capacity	104.12
kWh per House per Day	10.62
kWh per House per Year	**3874.64**
Total Moreland MWh per Day	0.35
Total Moreland GWh per Year	**126.22**

Table 17. Moreland Full Carrying Capacity Results

	Dwellings	% Non-Rented	Heritage Overlay Homes	Applicable Dwellings	Verification #1: Postcode Groups kW *WITHOUT RESTRICTIONS*	Verification #2: Postcode Groups kW *WITH RESTRICTIONS*
Gowanbrae	965.00	0.748	34.24	687	0.075	0.075
Brunswick East	3585.00	0.549	127.19	1840	0.194	0.161
Oak Park	2152.00	0.777	76.35	1595	0.167	0.176
Pascoe Vale South	337.00	0.805	11.96	259	0.026	0.298
Brunswick*	9300.00	0.525	329.94	4552	0.504	0.373
Coburg	9116.00	0.696	323.41	6021	0.624	0.641
Coburg North	2408.00	0.709	85.43	1621	0.165	0.173
Brunswick West	5564.00	0.546	197.40	2840	0.302	0.234
Pascoe Vale*	5864.00	0.714	208.04	3978	0.456	0.438
Hadfield	1915.00	0.777	67.94	1420	0.149	0.156
Glenroy	7012.00	0.699	248.77	4652	0.480	0.495
Fawkner*	4266.00	0.765	151.35	3112	0.292	0.331
Total	**52484**	**69.25%**	**1862**	**32577**	**3.43**	**3.55**
*Measured Postcodes				**Error**	**2%**	**11%**

Table 18. Moreland Dwellings Breakdown by Postcode and Results of Verification Tests 1 and 2

Appendix 15 Example Demographic Tabulation

Main Reason for not Installing	High Income	Low Income
Initial Cost	37	62
Other Responses	69	88

Table 19. Tabulation of Main Reason for not Installing vs. Income Comparison

Appendix 16 Tabulated Online Survey Results

		Ownership		Parenthood		Income		Education		Mortgage		Length of Homeownership		Age	
Main Reason for Not Installing	Full Survey	Owners	Renters	Parents	Non-Parents	High Income	Low Income	University Degree	No University Degree	Mortgage	No Mortgage	New Homeowners	Long-time Homeowners	18-44	45+
Initial cost of the system	128	114	12	77	48	37	31	98	25	77	37	20	75	56	70
Other (please specify below)	64	43	20	28	34	25	16	55	8	23	20	10	24	34	30
Do not plan to stay in dwelling for an extended period of time	49	15	33	19	28	12	14	42	6	11	4	3	10	31	16
Low Feed-in tariff rate	32	27	5	18	13	15	7	23	8	15	12	6	16	17	14
Do not have enough information to make a decision	16	15	1	9	6	8	2	15	1	12	3	4	10	9	7
Concerned about quality of systems	13	12	1	6	7	7	3	9	4	8	4	1	10	5	8
No interest in solar technology	7	5	2	4	3	2	4	4	3	2	3	1	4	3	4

		Ownership		Parenthood		Income		Education		Mortgage		Length of Homeownership		Age	
Preferred Payment Options	Full Survey	Owners	Renters	Parents	Non-Parents	High Income	Low Income	University Degree	No University Degree	Mortgage	No Mortgage	New Homeowners	Long-time Homeowners	18-44	45+
Upfront, full payment	120	96	23	63	52	37	25	95	20	50	46	17	64	50	68
Do not have enough information to make a decision	81	60	21	47	33	25	20	66	14	44	16	14	38	44	36
Low financing option with a deposit	66	47	18	37	28	24	18	58	8	31	16	12	27	36	29
Zero-down deposit, low-interest financing option	40	31	8	18	21	14	15	25	14	21	10	3	21	21	18
Leasing option	16	9	7	7	8	6	5	13	2	7	2	3	4	11	5

		Ownership		Parenthood		Income		Education		Mortgage		Length of Homeownership		Age	
Perception of Initial Cost	Full Survey	Owners	Renters	Parents	Non-Parents	High Income	Low Income	University Degree	No University Degree	Mortgage	No Mortgage	New Homeowners	Long-time Homeowners	18-44	45+
$5,000-$7,999	123	94	29	64	54	48	28	101	18	59	35	17	62	57	64
$2,000-$4,999	118	86	30	67	48	34	33	93	23	58	28	20	51	66	52
$8,000-$12,000	58	44	13	28	30	20	14	47	11	27	17	12	27	34	23
More than $12,000	13	11	4	9	5	4	4	9	2	5	2	0	4	2	6
Less than $2,000	8	4	2	3	4	0	4	6	4	2	6	0	10	2	11

		Ownership		Parenthood		Income		Education		Mortgage		Length of Homeownership		Age	
Greatest Gain From Having a System	Full Survey	Owners	Renters	Parents	Non-Parents	High Income	Low Income	University Degree	No University Degree	Mortgage	No Mortgage	New Homeowners	Long-time Homeowners	18-44	45+
Reduce personal greenhouse gas emissions	187	134	52	100	82	68	52	158	28	87	47	33	78	110	77
Save money on power bill	108	83	24	54	52	33	24	83	23	54	29	16	55	49	58
Take advantage of the low system cost	14	10	2	8	4	1	4	8	2	4	6	0	7	2	9
Other	10	10	0	6	4	3	2	7	2	5	5	0	10	1	8
Increase dwelling's value	3	3	0	2	1	1	1	1	2	2	1	0	2	0	3

		Ownership		Parenthood		Income		Education		Mortgage		Length of Homeownership		Age	
Preferred Information Source	Full Survey	Owners	Renters	Parents	Non-Parents	High Income	Low Income	University Degree	No University Degree	Mortgage	No Mortgage	New Homeowners	Long-time Homeowners	18-44	45+
Trusted not-for-profit organisations (such as MEFL or Positive Charge)	143	110	33	85	55	42	46	111	29	72	38	17	76	69	72
Recommendations from family or friends	86	66	17	40	41	25	17	72	10	33	33	14	36	44	39
Case studies on the advantages/disadvantages of installing	48	30	17	28	19	15	13	37	11	20	10	5	21	21	27
Home visit and recommendation by energy experts	31	23	8	12	19	17	4	27	4	16	7	8	13	20	11
Social media	2	2	0	1	1	1	1	1	1	2	0	0	2	1	1
Contact from solar installation companies	1	1	0	1	0	0	0	0	1	1	0	0	1	0	1