Barriers Preventing an Equitable Uptake of Sustainable Energy Innovations in New Zealand

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Katerina Angjeli
Thomas Burns
Emma DeMartino
Oliver Reera

BARRIERS PREVENTING AN EQUITABLE UPTAKE OF SUSTAINABLE RESIDENTIAL ENERGY INNOVATIONS IN NEW ZEALAND

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Submitted By:
Katerina Angjeli
Thomas Burns
Emma DeMartino
Oliver Reera

Submitted To:
Dr. Jono Barnard
Ara Ake: Research and Insights Manager
Dr. Cristiano Marantes
Ara Ake: Chief Executive

Project Advisors:
Professor Michael Elmes
Professor Ingrid Shockey

Abstract

Despite its commitment to reducing carbon emissions, New Zealand exhibits low adoption rates of electric vehicles and residential solar systems. Recognizing a need for future policies to address this, our study aimed to delineate the barriers preventing an equitable uptake of residential energy innovations. We conducted a comprehensive survey and interviews across Greater Wellington. Based on our findings, we propose several strategic interventions including public awareness campaigns and strategic incentives to address the low rates of adoption.

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- Project sponsor Jono Barnard for his valuable insight and feedback throughout the duration of our project.
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Authorship

Katerina Angjeli

Electrical and Computer Engineering Student, Worcester Polytechnic Institute

Thomas Burns

Civil Engineering Student, Worcester Polytechnic Institute

Emma DeMartino

Biomedical Engineering Student, Worcester Polytechnic Institute

Oliver Reera

Computer Science Student, Worcester Polytechnic Institute

Equal Contributions:

All authors contributed equally to conceptualization, research methodology, data analysis, writing, and final review, showcasing a collective effort in the completion of this project.

Meet the Team

Katerina Angjeli

Hey! My name is Katerina, and I am an electrical and computer engineering student from Albania and Greece. When I have time outside of working and studying, I enjoy mountain biking, Krav Maga and camping. Traveling to new places and meeting cool strangers is an important part of my life so, spending the last term before I graduate in New Zealand with this incredible group of people has been, to say the least, an invaluable experience to me. Aotearoa gradually made a warm place in my heart, and I can't wait to come back someday!

Thomas Burns

Hello! My name is Tommy Burns, and I am a Civil Engineering student from Morris Plains, New Jersey. I am also an outfielder on the baseball team, and a member of the Sigma Phi Epsilon Fraternity. I loved being able to meet and work with our sponsors on a unique project in New Zealand. Sustainability was not something I had studied much before, so I am glad I was able to learn about different energy practices and their effects on climate change. Not only was our project interesting, but it is relevant to the current and future landscape of our world. Traveling to New Zealand was an unbelievable experience, and I am definitely going back one day!

Emma DeMartino

Hi! I am a student majoring in Biomedical Engineering from Bolton, Massachusetts. I spend most of my free time at WPI performing with the Philharmonic, or Medwin Quartet as a cellist. I feel extremely thankful for all of the skills I have developed and for the experience I had here in New Zealand. Getting to interact with a culture and environment so different from what I am used to, as well as collaborating with such wonderful people, was such a meaningful experience. New Zealand is a gorgeous place, and I will definitely return someday!

Oliver Reera

Hello! I am a computer science student from Rockland, Massachusetts, and part of the class of 2024. I hope to go into the field of software development. This was my very first research project, and I am glad I had the chance to work on such an interesting and meaningful project. I also have come to appreciate New Zealand's culture and natural beauty and I would definitely visit again.

This project is original to the project's authors and study participants and was not generated or assisted using ChatGPT or other AI tools.

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Executive Summary

Scientists believe that anthropogenic climate change has increased the intensity of heavy storm events by roughly 30 percent and increased the likelihood of one of these events occurring in the Pacific regions by 4 times (Cardwell, 2023). Following a series of severe climate events in early 2023 (including cyclones, extreme wind and rainfall), New Zealand experienced catastrophic damage to the electricity network, which took days to restore in certain areas. A more sustainable grid could potentially future-proof or, at the very least, mitigate some of the adverse effects that weather-related events impose on New Zealand communities, thereby enhancing their long-term resilience. Despite New Zealand's commitment to becoming carbon neutral by 2050, the nation exhibits low consumer adoption of sustainable residential energy innovations, such as residential solar panels for electricity generation and electric vehicles.

Ara Ake is Aotearoa New Zealand's future energy center, with a mission to accelerate the country's transition to an equitable, secure, and decarbonized energy future. Our team is working in collaboration with Ara Ake to understand the disparities and barriers preventing individuals and communities from accessing affordable, reliable, and sustainable energy in New Zealand's capital, Wellington. To achieve this goal, we identified the following objectives:

1. Understand the baseline of local public awareness of energy innovations.
2. Identify the specific barriers that have either limited adoption or have been overcome.
3. Rank and prioritize the barriers by significance.

Our team chose to concentrate on electric vehicles (EVs) and residential solar panels, employing a mixed-methods approach in our study. Initially, we gathered quantitative data through questionnaire responses and then identified a subset of participants willing to participate in extended interviews.

Surveys were primarily carried out by going door to door, although a portion of respondents were contacted through online platforms including Reddit and Facebook. Our team surveyed 250 participants and conducted 13 interviews for the qualitative section. Among these 13 interviews was an expert in the solar energy industry and an expert in energy equity and policy.

To fulfill our primary objective, we investigated public awareness levels concerning electric vehicles and residential solar panels. Our analysis highlighted a disparity in awareness, with solar

panels trailing behind EVs. Among solar panel non-adopters, 84.5% felt moderately informed or less about residential solar technology. This percentage decreased to 70.6% among non-adopters of EVs, indicating a relatively higher understanding. Interestingly, 80.5% of EV adopters reported a high level of understanding, while only 52.4% of solar panel adopters expressed a similar depth of comprehension regarding the technologies they had adopted.

These findings highlight a lack of basic understanding among the public, which is necessary to make a well-informed decision about purchasing these technologies. Despite the awareness levels surrounding electric vehicles being higher than solar panels, we found through our qualitative survey and interview results that a significant amount of people still had misconceptions about EVs.

Another significant finding was an indication of an inequitable uptake of household energy innovations, as seen in ***Figure A***. Survey respondents in higher income brackets were more likely to be adopters of household energy innovations than survey respondents in lower income brackets. This suggests the possibility that electric vehicles and household solar panel uptake is not equitable across income brackets.

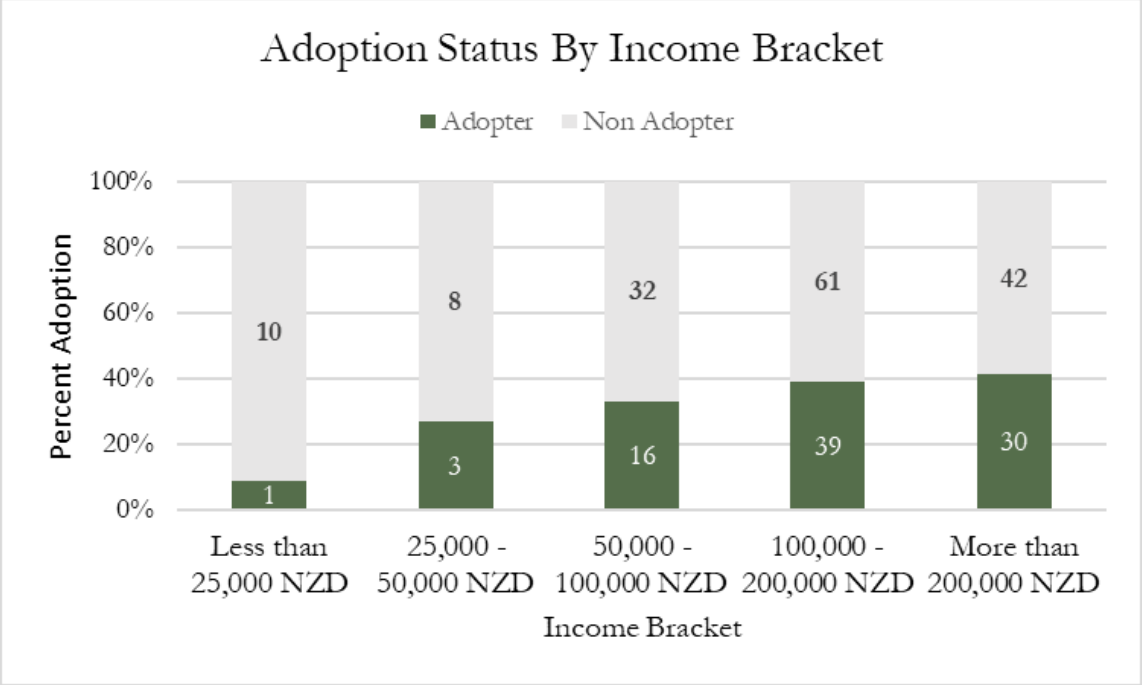


Figure A. A graph of the breakdown of adoption status by income bracket (n = 242).
Note, the average household income in the Wellington region is 142,000 NZD (Household Income, n.d.).

To achieve our second and third objectives, both survey respondents and interview participants were asked to identify common barriers preventing the uptake of residential solar panels

and electric vehicles, before being asked to then rank these barriers by their significance in preventing adoption.

Table A and ***Table B*** present the 3 most frequently identified barriers, along with a ranking of the 3 most significant/impactful barriers, by both non-adopters and adopters of solar and electric vehicles respectively. It is important to highlight that just because a barrier was commonly chosen, it does not necessarily imply it was considered as the most crucial factor in impeding an equitable uptake of these technologies.

Solar Non-Adopter	Solar Adopter
3 Most frequently Identified Barriers 1. High initial cost 2. Maintenance costs 3. Lack of information **3 Highest ranked barriers (by significance)** 1. High initial cost 2. Maintenance costs 3. Lack of information	**3 Most frequently identified barriers** 1. High initial cost 2. Structural roof integrity 3. Shading and obstructions **3 Highest ranked barriers (by significance)** 1. High initial cost 2. Lack of information 3. Shading and obstructions

Table A. Top 3 most identified and ranked barriers for solar panel adopters and non-adopters.

EV Non-Adopter	EV Adopter
3 Most frequently identified barriers **1.** High initial cost **2.** Limited charging infrastructure **3.** Range anxiety **3 Highest ranked barriers (by significance)** 1. High Initial Cost 2. Concerns about EV battery life 3. Preference towards ICE vehicles	**3 Most frequently identified barriers** **1.** Battery degradation over time **2.** Limited driving range **3.** High initial cost **3 Highest ranked barriers (by significance)** 1. High Initial Cost 2. Limited driving range 3. Battery degradation over time

Table B. Top 3 most identified and ranked barriers for electric vehicle adopters and non-adopters.

Our team formulated the following recommendations aimed at achieving a future with more equitable and increased rates of adoption.

Recommendations on Solar Panel Technology

1. Conduct a public awareness campaign/s regarding household solar panel technology. The purpose of these campaigns should be to provide people with a centralized information source to enable well-informed decisions about solar panel technology. Awareness campaigns, potentially run by Ara Ake, could provide insight into different aspects of the technology (including installation costs, maintenance costs, financial options already available and additional benefits associated with installing the technology). Providing information that is more digestible for the average person will likely simplify the process for the public.
2. Since High Initial Cost was determined as the most significant barrier, we recommend that future policies should include incentives to increase the uptake of residential solar. From our interviews, we identified rebates and feed-in tariffs as the most appealing types of incentives for non-adopters. Rebates were preferred to alleviate the high upfront cost from potential customers, making solar panels a more attractive purchase. Feed-in tariffs with a guaranteed period were also preferred by most non-adopters interviewed due to the accelerated payback of the investment. Low interest loans were not preferred among non-adopter interviewees.

Recommendations on Electric Vehicle Technology

1. For electric vehicles, we recommend more specialized awareness campaigns compared to those for solar. Our research indicated that while a lot of EV non-adopters feel knowledgeable about the technology, there were certain misconceptions regarding range anxiety and battery degradation that became apparent during interviews.
2. Improving the availability, or perception, of fast and reliable public charging infrastructure should also be prioritized. With range anxiety and charging infrastructure being significant concerns for non-adopters, improving the infrastructure should lessen this concern, and encourage more people to consider adopting an electric vehicle. We also recommend showcasing the nationwide charging infrastructure by organizing a social media campaign featuring a cross-country journey in an electric vehicle. This initiative would highlight the feasibility of long-distance travel using EVs.
3. Despite government incentives currently being offered for electric vehicles in New Zealand, 'High initial cost' was consistently a top barrier among all respondents. We suggest that future policies could include varying incentives by income level. This was due to an uneven income-to-incentive ratio amount survey participants. Those in lower income brackets sought higher incentive amounts compared to those in higher-income brackets. We believe varied incentives will be effective in leveling the playing field across income brackets and thus equitably increasing the uptake of electric vehicles across Aotearoa.

1 Introduction

Climate change has real and tangible consequences. It already poses a significant disruption for global communities and global energy policy and will continue to be a challenge in the future. Extreme weather conditions are dramatically affecting Aotearoa New Zealand and its infrastructure. In January of this year, the country experienced the most rainfall and flooding it had seen in over 170 years, with more than 45% of the yearly precipitation occurring in just one month. Extensive flood damage was reported to infrastructure across the nation (Rowley, 2023). As a result, New Zealand faces new coordinated community climate adaptation decisions and a need to provide citizens with the knowledge and tools in its transformation towards a renewable energy future.

Extreme weather events that damage roads and homes often also physically damage the electrical grid, causing widespread power outages that can take several days and even weeks to restore. This kind of damage disproportionately affects vulnerable communities that often lack the resources needed to swiftly recover. For example, during Cyclone Gabrielle in February 2023, residents living closer to large urban areas saw their energy restored promptly, whereas some rural areas experienced what was characterized as "catastrophic damage to the electricity network" that took days to restore (Magrin, 2023). Furthermore, some of these areas are geographically more prone to natural disasters, but the delays can also indicate a less capable infrastructure. With an increase in the adoption of more sustainable household energy products, such as solar roofs, residents can control their energy security and resilience.

New Zealand is actively taking measures to ensure a more sustainable and resilient energy future for its residents by investing time and resources into meeting the goals set forth by the World Energy Council's "energy trilemma" (WEC Energy Trilemma Index Tool, n.d.). The Energy Trilemma was initially introduced as a rationale for how countries can monitor and assess their energy usage. It uses three key dimensions to measure success: energy security, sustainability, and

affordability. New Zealand has become a top performing country by abiding by the trilemma and ultimately ranking eighth globally in the World Energy Council's index in 2022 (WEC Energy Trilemma Index Tool, n.d.). The country is committed to fulfilling the goals outlined by the World Energy Council while embracing innovative solutions and accelerating the transition to a clean, efficient energy future.

Ara Ake is Aotearoa New Zealand's future energy center, with a mission to promote the country's transition to an equitable, secure, and decarbonized energy future. The organization promotes the adoption of innovative/ sustainable energy solutions and has made great strides with its goals. For example, the organization, in collaboration with solarZero, purchased and sourced approximately 30MW of electricity from residential solar batteries earlier this year. An amount of energy that could support roughly 30,000 homes was given back to the electric grid to be used for electricity shortages throughout the winter ("11,000 Residential Solar", n.d.). Efforts like these to accelerate decarbonization and enhance energy security can make a significant difference in climate change resilience, especially if sustainable infrastructure is widely developed across the community. Therefore, understanding how and why energy innovation is NOT adopted is critical to making these choices affordable and equitable for all.

Our team will work in collaboration with Ara Ake to understand the disparities and barriers preventing individuals and communities from access to affordable, reliable, and sustainable energy innovations across Aotearoa New Zealand. To meet this goal, we have identified 3 objectives. The first is to understand the baseline of local public awareness of energy innovations and incentives. The second objective will identify the barriers that have either limited adoption or have been overcome. The third objective will rank and prioritize the barriers by significance and type. Understanding limiting factors in the adoption of sustainable technologies, such as solar panels and electric vehicles, is paramount for Ara Ake's commitment to supporting the development and widespread adoption of sustainable energy technologies. We hope this insight will enable Ara Ake to tailor their strategies and foster relevant collaborations accordingly.

2 Literature Review

In the following section, we discuss the energy trilemma in greater detail. We identify key stakeholders in this effort, and how this project might affect residents in Aotearoa New Zealand. Finally, we look at how recent research in sustainable energy innovation both locally and globally could inform our project.

2.1 Renewable Energy in Aotearoa New Zealand

Energy drives the economy and impacts everything from infrastructure design to utility planning, transportation, manufacturing, security, and much more. However, choices can be made in delivery and source. The weight of global demand and the damage caused by burning fossil fuels have accelerated the need for more renewable options. Climate change has further intensified this sense of urgency. For example, the 2023 storms in Auckland ranked January as its wettest month in history, exceeding the previous record with an astonishing 119 millimeters (about 4.69 in) of rainfall (see ***Figure 1***) (National Institute of Water and Atmospheric Research [NIWA], 2023).

Figure 1. A house in West Auckland collapsed after a slip

Note. Reprinted with Permission. Photo: Tom Taylor (Radio New Zealand [RNZ], 2023)

Scientists have concluded that human-caused climate change has increased the intensity of heavy rain events by roughly 30 percent and increased the likelihood of one of these events occurring in the Pacific regions by 4 times (Cardwell, 2023). A more sustainable grid can future-proof or at least offset some of the dangerous outcomes of weather-related events in communities.

One way to understand the country's energy footprint and identify potential areas of improvement is through the Energy Trilemma framework as defined by the World Energy Council (WEC). The energy trilemma is an interpretive framework that breaks down three factors: energy equity, energy security, and energy sustainability. Aotearoa New Zealand performs relatively well, with an energy trilemma score of 80.3 out of 100, placing them 8th in the world in 2022 (World Energy Council, 2023). Despite this strong score, the work of reducing emissions is still a significant and challenging target.

To that end, Aotearoa New Zealand has established a range of objectives aimed at diminishing emissions. The country aims to attain net-zero carbon emissions by 2050 through a concerted effort to lower car emissions and increase the deployment of electric vehicles (Energy

Efficiency and Conservation Authority, 2023), among other objectives. The government set a benchmark to have battery electric vehicles (BEVs) account for 35% of new vehicle registrations by 2035, as compared to the current 3% (International Trade Administration [ITA], 2021). The country has made progress towards this goal, exemplified by a recent investment of $1.7 million in a project focused on testing the use of electric vehicles within the police force (Lyth, 2023). In fact, one of the intended outcomes of this initiative was to enhance the public's awareness of electric automobiles through added visibility. Further efforts have been made in public transportation, with 13% of public buses in Wellington now operating with zero-emissions (How Much of New Zealand's, 2022), and several major taxi companies electrifying their fleets (Taxi Rides That Don't Cost the Earth, 2022).

Institutional policies that affect taxis or police vehicles can force uptake. However, one of the biggest challenges in building a more sustainable future is understanding the barriers that impede the general public's voluntary adoption of sustainable energy technologies such as BEVs or residential solar panels. New Zealand has been working to stimulate public engagement in electric vehicles in recent years and in 2021 and 2022, EV registrations doubled (Ministry of Transport, 2023). Similarly, the solar power landscape is evolving in New Zealand. Solar capacity has risen by 180 MW since 2018 (Rodriguez, 2023). However, a better grasp of the challenges that citizens face in adopting these energies will accelerate this energy transformation.

2.2 Partners and stakeholders in renewable energy

Ara Ake is a government-funded organization that focuses on developing sustainable energy in New Zealand. Their primary goal is to "reduce the time, cost and risk associated with the development and commercialization of energy innovation in Aotearoa by fostering a new energy ecosystem and leveraging national and global knowledge, as New Zealand transitions to a low emissions future" (Ara Ake, n.d.). By working toward this goal, Ara Ake's mission is to contribute to the protection of the environment and a safer, more efficient economy. They also assist other organizations in developing, commercializing, and entering the market with innovative energy products (Ara Ake, n.d.).

Among their areas of interest, Wellington is New Zealand's capital city and second largest urban area, and the most populated national capital in Oceania (NW Encyclopedia, 2023). It is home to one of the country's most influential seaports, handling tons of cargo imports and exports

annually (NW Encyclopedia, 2023). The city hosts key governmental agencies, several universities, a large share of international tourism, and serves as a busy commercial and cultural hub for the area. The greater Wellington area includes over 8 territorial authorities comprised of large urban areas, suburban areas, and rural communities that stretch alongside the island's southeastern corner (NW Encyclopedia, 2023). Wellington is known for its abrupt terraces, and consequently, many of the residential homes within Wellington rise high above the city's center (NW Encyclopedia, 2023). These steep mountainous hills in the Wellington region combined with seismic code ratings can cause challenges for the installation or new construction of technology in the residential areas, as shown in ***Figure 2*** and ***Figure 3***.

Figure 2. *Wellington New Zealand Homes*

Note. by Robert Calvert (Unsplash.com free uncopyrighted images)

Figure 3. Wellington Harbor
Note. by Pat Ho (Unsplash.com free uncopyrighted images)

The city includes a diverse multicultural community including Māori and European-descended, or Pākehā, residents (Terruhn, p. 2). Within these neighborhoods, there are points of inequity and disparities in income, infrastructure, and resources. A 2018-2019 study from the Ministry of Social Development Wellington found that material hardship rates for Māori were much higher than those of Pākehā at 23% and 10% respectively (2022 Child Poverty Report - Overview and Selected Findings, 2022). While New Zealand has achieved some recent success overall, experiencing a 2% reduction in the child population living in poverty, with 16 percent of the children living below the poverty line, which is below the 2021 target of 18 percent there are still concerns about how these barriers might impact decisions around the energy transition (Fewer Kiwi Children Living in Poverty but Disparity between Māori and Pākehā Remains, 2022). Significant policy reforms may be necessary to reduce disparities before communities can contemplate transitioning to more sustainable energy practices.

2.3 Current Energy Landscape

We know that renewable energy plays a major role in New Zealand's energy landscape due to its popularity in electricity generation. In 2022, more than half of all electricity was generated through hydroelectric power alone, with additional support from geothermal, wind, and other renewable power sources (Electricity Statistics | Ministry of Business, Innovation & Employment, 2022). But while electricity generation might be doing well in terms of renewable sources, the same cannot be said for all aspects of New Zealand's energy landscape. According to the country's Energy Efficiency Conservation Authority (EECA, 2023), about 70% of its total energy consumption still comes from fossil fuels. This is further illustrated in ***Figure 4***, where about 40% of New Zealand's emissions are shown to originate from the energy sector (EECA, 2023).

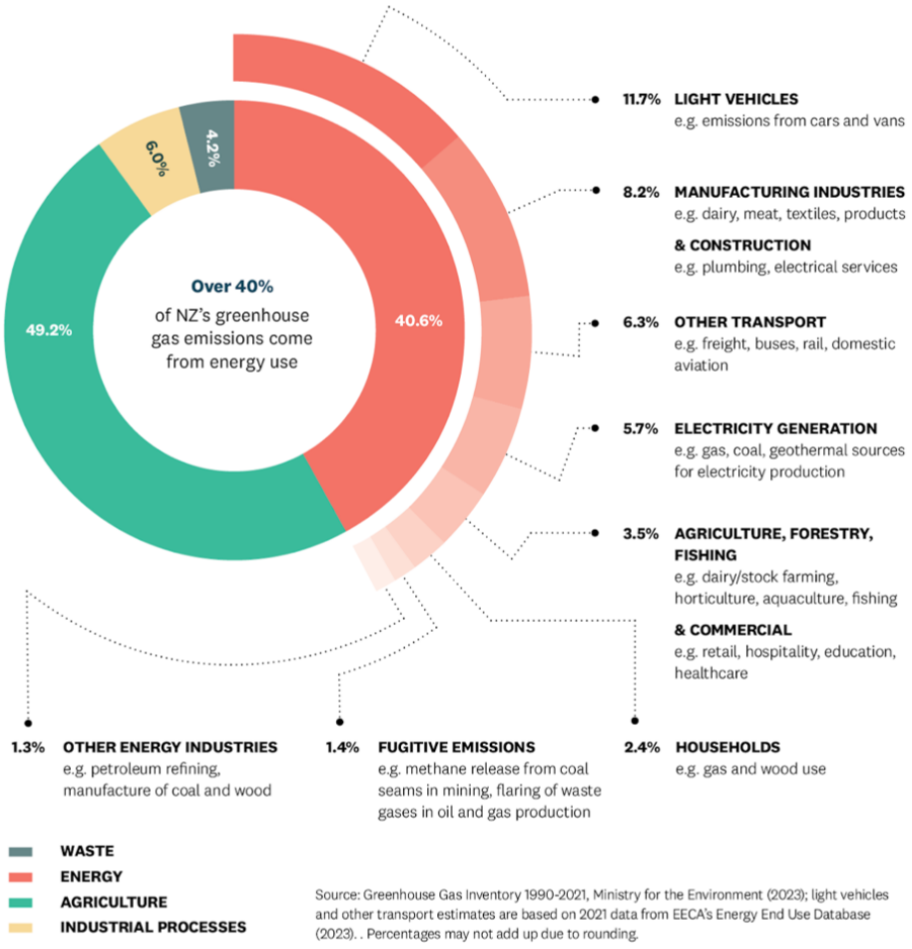


Figure 3. Breakdown of New Zealand's greenhouse gas emissions
Note. EECA: (n.d.). New Zealand's energy-related emissions. EECA. Retrieved September 24, 2023, from https://www.eeca.govt.nz/insights/energys-role-in-climate-change/new-zealands-energy-related-emissions/

New Zealand's journey towards equal access to sustainable energy practices is far from complete. However, in the following sections, we delve into how electric vehicles and solar energy could help make progress toward that goal.

2.3.1 Electric Vehicles

Over the past few years, New Zealand has seen a steady uptake in electric vehicle (EV) purchases, with 24,000 plug-in hybrids and 60,000 fully electric vehicles registered across the country (Ministry of Transport, 2023). However, there is still a long way to go with petrol and diesel vehicles still dominating the fleet at a 72% majority as seen in ***Figure 5***.

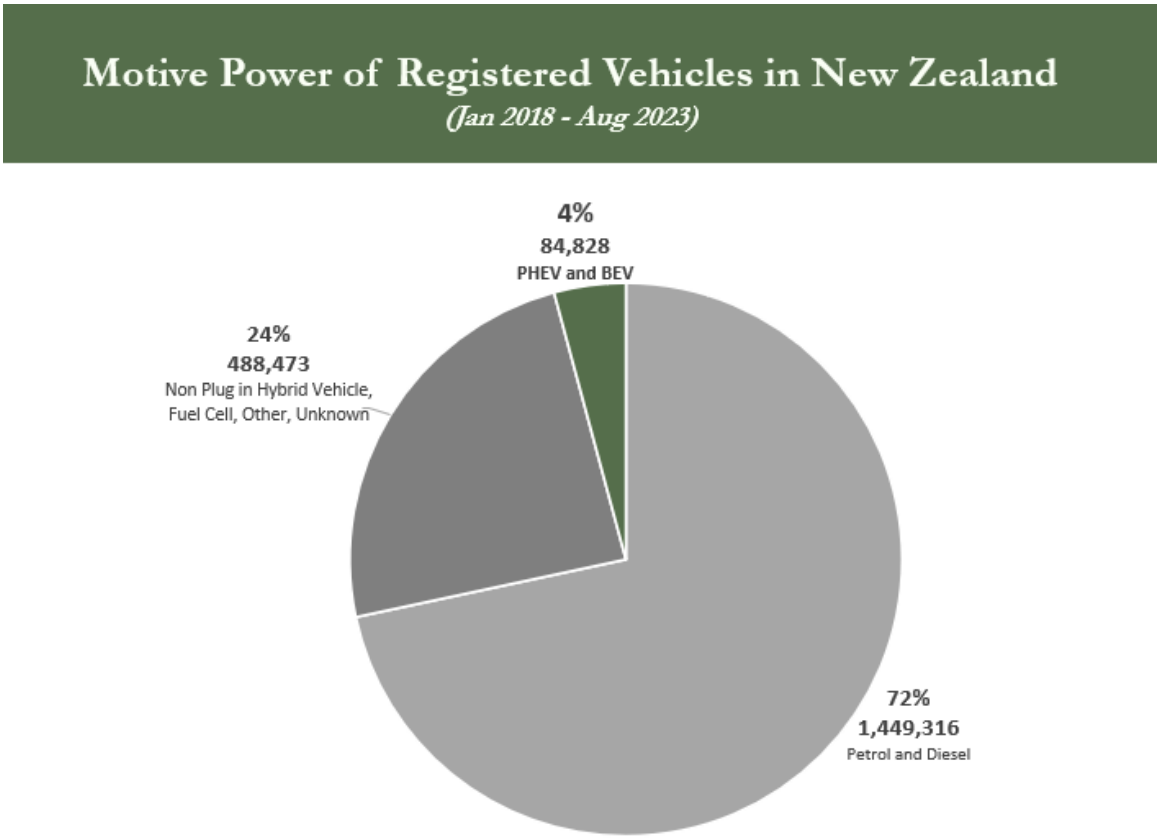


Figure 4. Motive power of registered vehicles in New Zealand from January 2018 to August 2023
Note. Adapted from "Motor vehicle registrations – dashboard and open data" by Waka Kotahi NZ Transport Agency, https://www.nzta.govt.nz/vehicles/how-the-motor-vehicle-register-affects-you/motor-vehicle-registrations-dashboard-and-open-data/

The New Zealand government has been committed to reducing emissions produced by the 72% majority in the transportation sector. In 2019 the Climate Change Response Amendment Act was introduced targeting "emissions of all greenhouse gases [to] reach net zero by 2050" ("Te huringa o te āhuarangi", n.d.). The major contributor to greenhouse gas emissions in the transport sector is light vehicles, such as passenger cars. In 2021, these vehicles contributed 63.9% to New Zealand's domestic greenhouse gas emissions in the transport sector as seen in ***Figure 6*** (*NZ's Interactive Emissions Tracker*, 2021). While ensuring public transport services are reliable and plentiful across the country is a must in reducing the need for private transportation, the other impactful way to achieve this goal is by encouraging a transition to low-emission vehicles for both private and heavy transport vehicles. However, a few concerns arise when consumers consider this shift, a notable one is the phenomenon of 'range anxiety.' This apprehension revolves around what people perceive to be a limit in the driving range of many EVs compared to traditional internal combustion engine (ICE) vehicles and is usually paired with a concern about the availability of charging infrastructure, which New Zealand lacks compared to other countries. New Zealand reported a metric of nearly 100 electric light-duty vehicles per public EV charging point, which is more than twice as much as the next country (Global EV Outlook 2023 – Analysis, 2023).

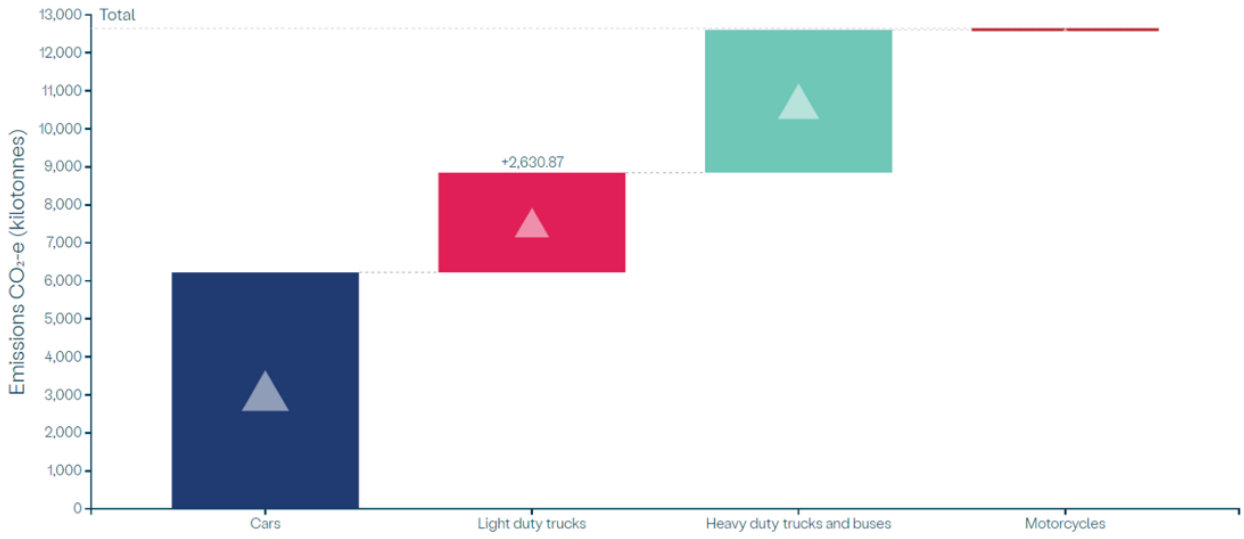


Figure 5. Domestic greenhouse gas emissions from transport in 2021
Note. Reprinted from New Zealand's Interactive Emissions Tracker Ministry for the Environment. (2021). Retrieved November 7, 2023, from https://emissionstracker.environment.govt.nz/

The EV Database (2023) reports that EVs currently support an average range of 348 km (about 216 miles) with the shortest coming in at 95km (59 miles) and the longest range being 685 km (426 miles). As battery research continues, the average range EVs support is expected to increase significantly, however, even current BEVs on the market can support the average commutes of New Zealand residents by almost 15-fold. According to the Ministry of Transport, locals in New Zealand commute an average of 22km (about 13.67 mi) a day making most of the country well-suited for EV technology ("Te Kaupapa Waka", n.d.). Addressing concerns about the ability of EVs to travel long distances is crucial to fostering wider EV adoption and alleviating anxieties associated with this shift in transport.

The previous Labour government provided various incentives to encourage the adoption of EVs including offering rebates to interested customers. Rebates are offered for purchases of zero to low-emission vehicles and fees can be distributed for high-emission ones. ***Figure 7***, shows that with the purchase of vehicles in the BEV category, residents can receive up to a maximum of $7,000 for new vehicles and $3,000 for used ones.

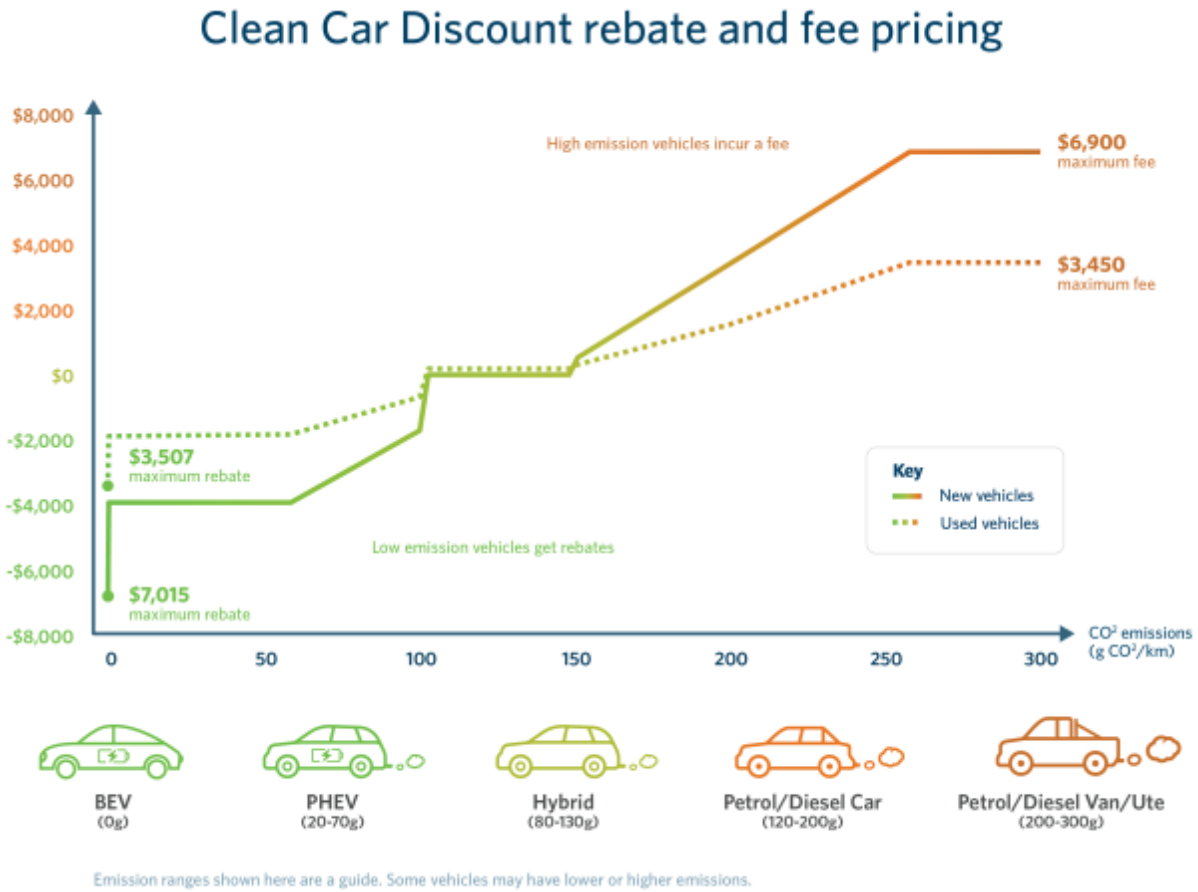


Figure 6. Clean car discount rebate and fee pricing

Note. [Chart] Reprinted from Clean Car Discount overview Waka Kotahi NZ Transport Agency. (n.d.). Retrieved September 23, 2023, from https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-discount/overview/

However, if a resident opts to purchase a petrol or diesel vehicle, they may be subject to a maximum fee of $6,900 if that vehicle is new. The effectiveness of rebates as an incentivizing measure has been recognized by research from the MIT Center for Energy and Environment Policy Research which found that "incentives offered as direct purchase rebates generate increased levels of new BEV registrations at a rate of approximately 8 percent per thousand dollars of incentive offered" (Clinton & Steinberg, 2019). By providing financial relief and reducing the upfront costs associated with EV purchases, rebates increase the accessibility and affordability to a more extensive demographic.

Private companies across the country are also committed to helping the government reach the goals it has set forth. This past year, Uber announced a subsidy program in Aotearoa that enables 750 drivers with EVs to be "eligible for a 50% service fee discount up to $5,000 per year for two years" to encourage Uber drivers to consider adopting EV technologies and contribute to a net-zero transition in transport ("Uber Newsroom", 2023). In addition to this program, Uber has added the 'Uber Green' feature into their app to allow Kiwis to select low-emission rides. Various energy companies are also offering discounts and payment options to EV owners for charging. Octopus Energy, which operates through the Charge Net network, offers $200 credits or free charging cables for users, while other companies offer discounts on home charger installations (EVDB, 2023).

While the country is still dominated by a fossil fuel fleet, it is committed to transitioning to a more sustainable and zero-emission future. The incentives provided have already proven effective as shown by a steady increase in EV adopters over the past few years, with a change in government and policy, it is unclear if that upward trend will continue in the years to come.

2.3.2 Residential Solar

Even with New Zealand's prominent role in the sphere of renewable energy sources, solar panels or photovoltaic (PV) technologies only comprised a mere 0.2% of total electricity generation in 2019 (Shillito, 2019). Despite the slow adoption, PV systems, especially in residential communities, hold significant potential to reshape the trajectory of electrical energy sources. An increase in residential solar panel adoption has the potential to decrease grid dependency, allowing

homeowners to generate their electricity independently throughout the year and during power outage events.

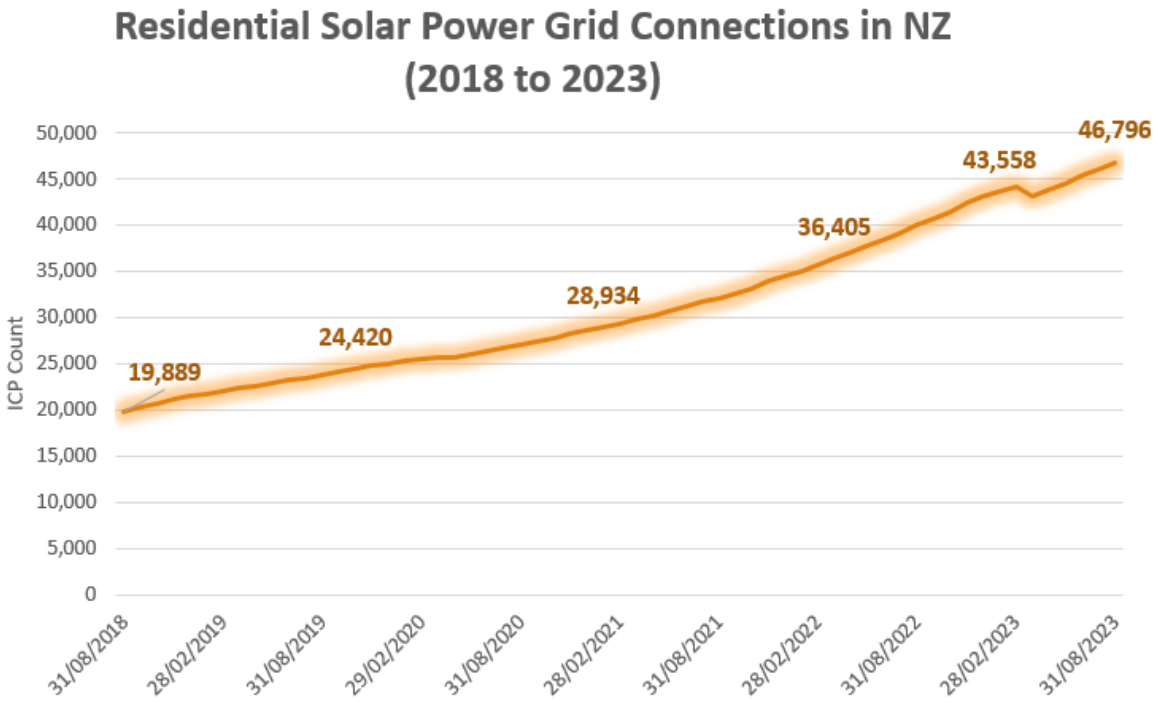


Figure 7. Residential solar power grid connections in New Zealand between 2018 and 2023
Note. Adapted from "Installed Distributed Generation Trends" by *Electricity Authority,*
https://www.emi.ea.govt.nz/Retail/Reports/GUEHMT?DateFrom=20180901&DateTo=20230831&MarketSegment=Res&FuelType=solar&Show=ICP_Count&_rsdr=L60M&_si=v%7C3

Over the past five years, New Zealand has seen a steady increase of solar roof connections from residential properties to the national grid as highlighted in ***Figure 8***. In fact, the number of connections has doubled since 2018, which reflects a growing awareness for homeowners looking to reduce their carbon footprint. However, even with this encouraging surge in solar power adoption, the overall percentage of residential solar installations to residential properties remains below 3% as seen in ***Figure 9***.

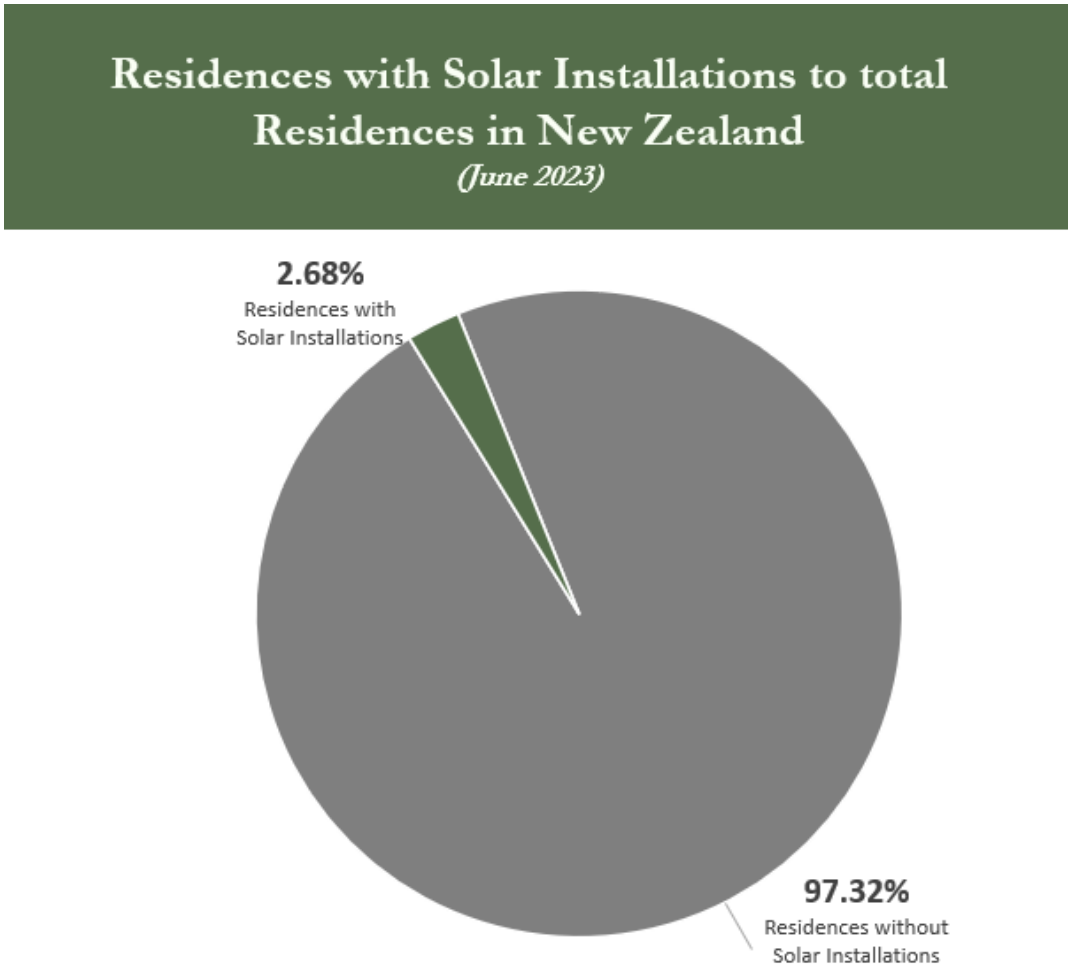


Figure 8. Percentage of solar installations in residences across New Zealand as of June 2023
Note. Adapted from data from "Installed Distributed Generation Trends" by Electricity Authority and "Estimated number of private dwellings in New Zealand" by Figure.NZ

In an interview Luke Nutting, the CEO of the solar power company, Lightforce, discussed how historically the "barrier to entry [for residential solar installations] was pretty high, the average system being $10,000 to $20,000 and [having] a payback of 15 years, [meaning] there was no real driver for anyone to go and do it" (Carroll, 2021). In the past decade, however, there has been a shift to make solar more affordable for the average consumer. ***Figure 10*** trends the price of an average solar power system in New Zealand over the past 15 years.

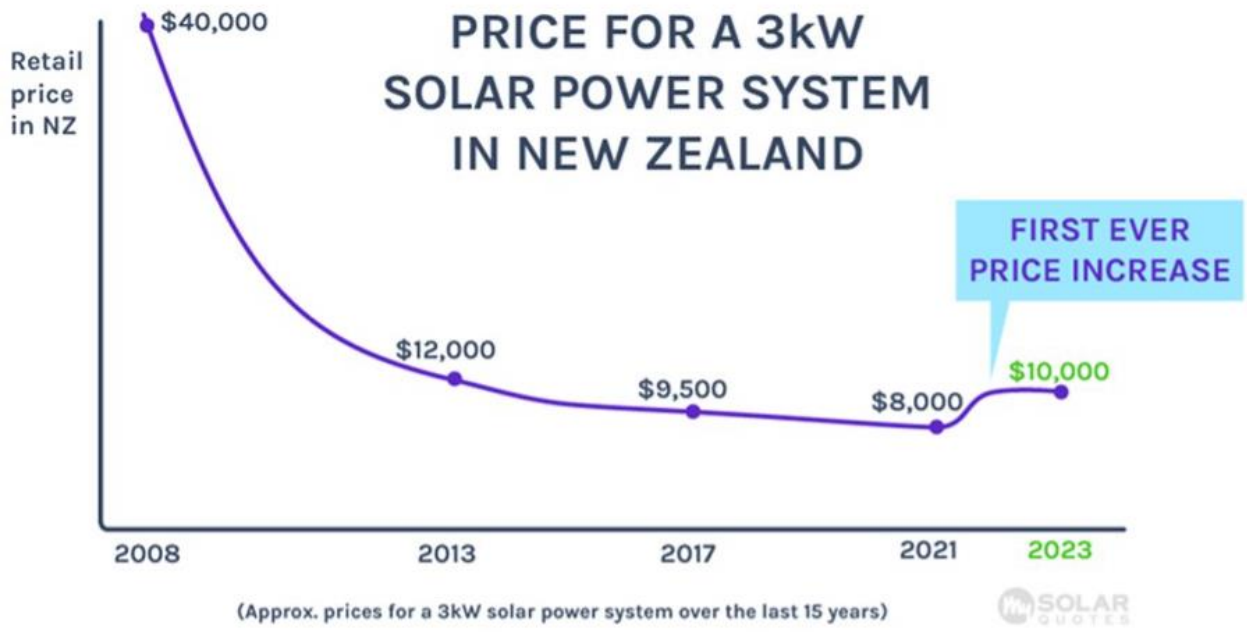


Figure 9. Price for a 3kW solar power system in New Zealand from 2008 to 2023
Note. Reprinted with permission from *The Price of a Solar Power System* by MySolarQoutes, https://www.mysolarquotes.co.nz/about-solar-power/residential/how-much-does-a-solar-power-system-cost/

Despite an overall decline in costs, a minor uptick in expenses over the past two years suggests that there remains potential for further improvement. Currently, solar installation companies offer systems ranging from 1.5kW to 10kW capacity which range from $7,000 to a staggering $24,500 (*The Price of a Solar Power System*, 2023). This price further increases when power demand, installation conditions, and additional devices are factored in. For example, a battery storage system which is needed to make use of power harnessed throughout the day during the nighttime, or in the event of a power outage, can range anywhere from $6,000 to $18,000 in cost for 5kW to 15kW systems respectively (*The Price of a Solar Power System*, 2023). Currently there are no rebates offered to residents interested in adopting residential solar systems, so the barrier to entry for the technology remains relatively high.

The Green Party announced a policy to provide $6,000 in grants to cover the installation cost of solar panels and is making "$30,000 [available] through interest free loans to cover the cost of additional zero carbon home upgrades" (*Clean Power Payment*, n.d.). The Green Party is also hoping to "scale up solar [to] 30,000 [Kāinga Ora homes] in the next three years" if elected to office

(*Clean Power Payment*, n.d.). Similarly, the Labour Party is promising to offer $4,000 in rebates to assist in residential solar panel and battery system installations, and to provide "1000 Kāinga Ora homes a year [with] solar panels, reducing tenants power bills" (LabourVoices, 2023). Both proposed bills/ policies also include additional incentives for residents beyond rebates, which could make the adoption of residential solar installations even more appealing.

Currently customers can opt into Feed-in-Tariff (FiT), a cash-back incentive that increases the interest in residential consumption of renewable technology (Shillito, 2019). FiTs offer consumers who generate their electrical energy payments based on the amount of kilowatt hours used and the type of technology the resident uses. Net and gross FiTs will also pay residents for any unused energy, which is then put back into the grid for every unit generated (Shillito, 2019). Usually, FiTs are fixed at an above market rate which makes the program appealing to prospective owners; however, New Zealand does not currently offer FiTs.

An increase in the transition to residential solar energy installations is undoubtedly on the horizon, but it remains at an early stage due to high upfront costs and lack of rebate or grant incentives. As the elections are finalized, the future of residential clean energy policies will become apparent and could encourage a higher yield of residential solar energy adoption.

2.4 Comparative Case Studies in Global Development

To support this project, we present two case studies that illustrate the experience of other countries managing energy perspectives and challenges regarding the use of sustainable energy technologies and incentives to promote adoption in those regions.

Case 1. Electrical Vehicle Adoption: Studies from Europe and the US

A comparative case study of European countries and the United States was performed by Broadbent in accordance with Geography Compass to understand the barriers countries face when incentivizing consumers to adopt electrical vehicles. According to Broadbent, many potential customers are willing to make the change from gasoline/diesel-powered vehicles to EVs; however, technical, financial, and institutional barriers constrain them from purchasing an EV (Broadbent, 2017). Previous research compiled by Broadbent shows the many concerns affecting an EV transition including access to charging stations, duration of charge time, cost of the vehicles, cost of

charging, and range efficiency (Broadbent, 2017). From these barriers, two were ultimately more influential than the rest: the cost of the vehicle and charging station availability.

High interest in EV adoption does not resolve a lack of advocacy in European countries and the United States, as price remains an influential barrier in numerous communities. Another condition to consider is whether a consumer's cost preferences for EVs is based on their willingness to pay for an EV or their capability to pay for an EV. For example, the case study highlights that while most Americans are willing to pay for an EV, they did not purchase one since they perceived the cost of the product to be up to a few thousand dollars higher than its' true cost (Broadbent, 2017).

The perception of limited charging infrastructure availability is another factor that determined how likely a consumer was to purchase an EV. Participants in a global survey stated that if convenient recharging stations were more readily available, the purchase of an EV would be more attractive, regardless of the vehicle's range or whether they are provided with excessive subsidies when purchasing the vehicle (Broadbent, 2017). Another study in the UK discovered the same result. British drivers were more concerned about recharging availability in their local areas than they were about the price of the EV (Broadbent, 2017). Widespread availability of charging stations would be a compelling motivator for interested customers to purchase an EV.

Incentives for purchasing an EV can play a substantial role in some countries; in others, they have not contributed to increasing adoption rates. Broadbent compiled modeling done by Harrison and Thiel, and found that in Europe, purchase rebates alone did not lead to an increase in EV market success. However, the case study found that there was a positive correlation between financial incentives and charging infrastructure with the purchase of EVs (Broadbent, 2017). Although financial incentives play a considerable role in the market for EVs, other factors, such as charging infrastructure, access, and knowledge about products need to be considered as well.

Overall, implementing only one measure toward an EV transition is insufficient to promote a drastic increase in adoption rates. If multiple steps are taken at once, such as offering rebates on EVs and focusing on establishing better charging infrastructure, it could be more indicative of higher adoption rates (Broadbent, 2017). Providing the public with information on incentives and charging availability assists in addressing factors contributing to market loss and provides information that will circulate through client communication, improving purchase rates (Broadbent, 2017). For New Zealand and other countries struggling to implement effective policies towards EV

uptake, Broadbent and others predict that if a good mix of government policies is taken, it could heighten the transition to renewable technologies.

Case 2. Battery Electrical Vehicle (BEV) Uptake across Nordic Countries

The Norwegian EV Association and Nordic Energy Research conducted a survey in 2021 to better understand prospective EV consumer behaviors and concerns regarding the purchase of a BEV. This included a sample size of 4,850 participants distributed across Norway, Sweden, Denmark, Finland, and Iceland, the breakdown of which is presented in Table 1.

Country	Norway	Sweden	Denmark	Finland	Iceland
Participant sample size	1000	1000	1000	1013	837

Table 1. Sample size of participants surveyed on EVs from Nordic Energy Research
Note. *Adapted from* Nordic EV Barometer 2021. *(2021, April). Retrieved September 23, 2023, from https://www.nordicenergy.org/wordpress/wp-content/uploads/2021/05/Nordic-EV-barometer-2021-ENG-1*

The study also explores barriers reported by consumers between 2019 and 2021 when asked why they have not purchased a BEV. Over those three years, the top documented barriers to purchasing BEVs remained consistent as shown in ***Figure 11***.

Barriers for not buying a BEV – Nordic

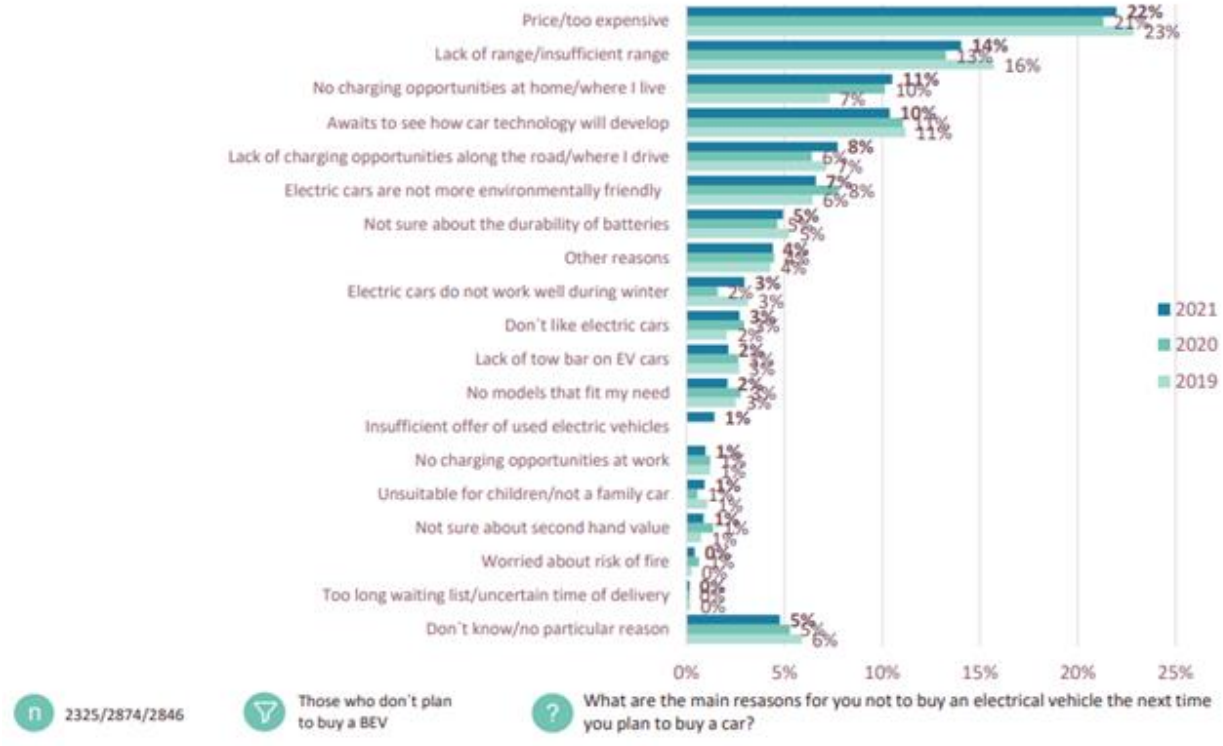


Figure 10. Barriers for not buying a battery electric vehicle

Note. Reprinted with corrections (changed Barrieres to Barriers) from Nordic EV Barometer 2021 (2021, April). Retrieved September 23, 2023, from https://www.nordicenergy.org/wordpress/wpcontent/uploads/2021/05/Nordic-EV-barometer-2021-ENG-1

Firstly, the issue of price continues to be a significant hurdle for many prospective buyers across the countries surveyed due to these vehicles being perceived as more expensive compared to their higher-emitting vehicle counterparts. Secondly, consumers appeared apprehensive about the driving range of BEVs, feeling that they were not suitable for long ranges. Finally, the survey also identified limited charging opportunities at home as a concern which surprisingly has had a 3% increase over the past three years the survey was conducted. While this research has not been extensively conducted in New Zealand yet, the results from the Nordic Energy Research are indicative of similar sentiments across the world. ***Figures 12 - 15*** provide an insight into two nations and the current EV charging infrastructure each has, to support an increase in BEVs.

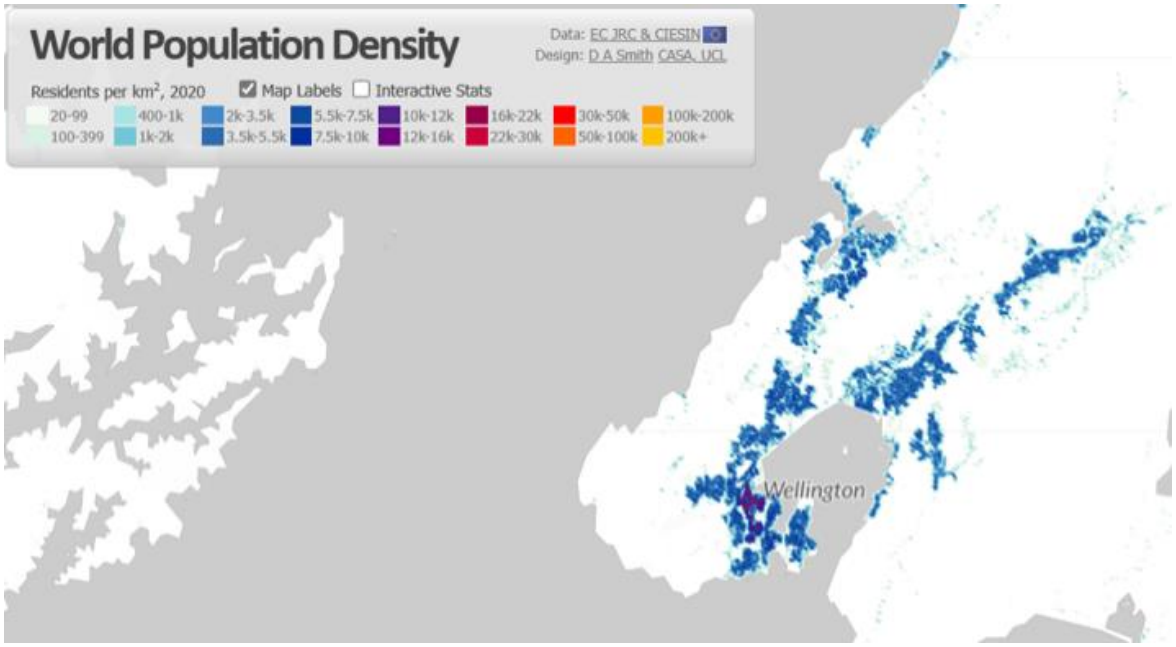


Figure 11. Population density in Wellington
Note. Mapping Population Density Across the Globe. (n.d.). Retrieved September 24, 2023, from http://luminocity3d.org/WorldPopDen/

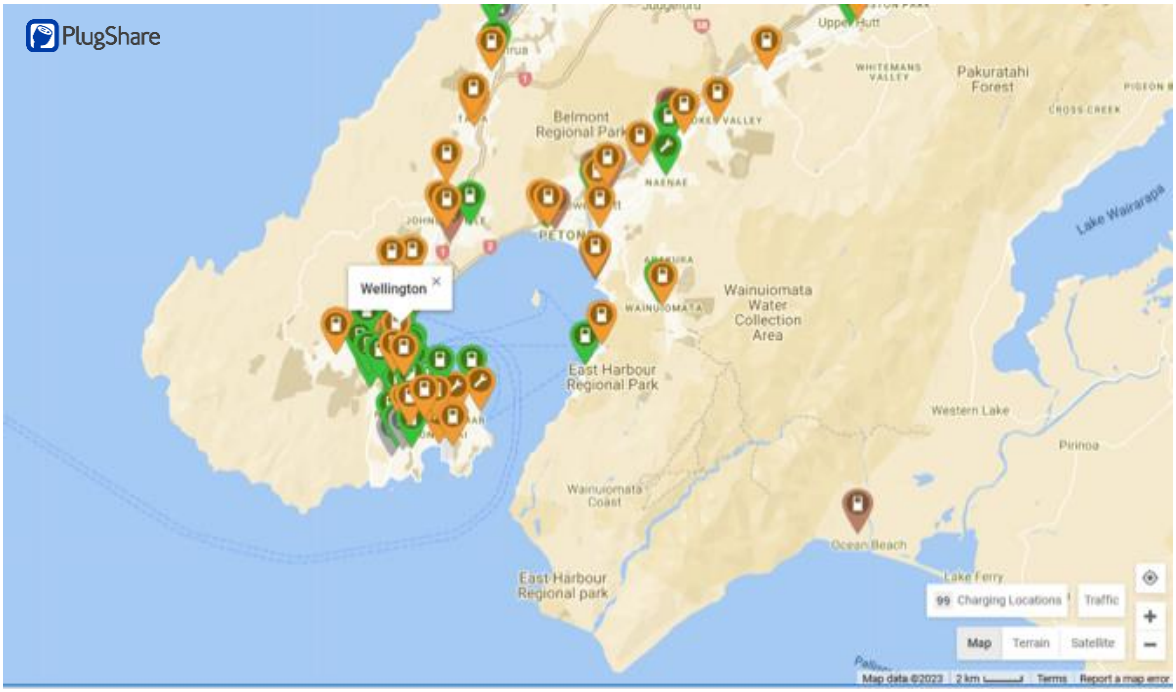


Figure 12. Map of EV charging stations in and near Wellington
Note. Reprinted with permission from PlugShare EV Charging Station Map Find a place to charge. (n.d.). Retrieved September 24, 2023, from https://www.plugshare.com/

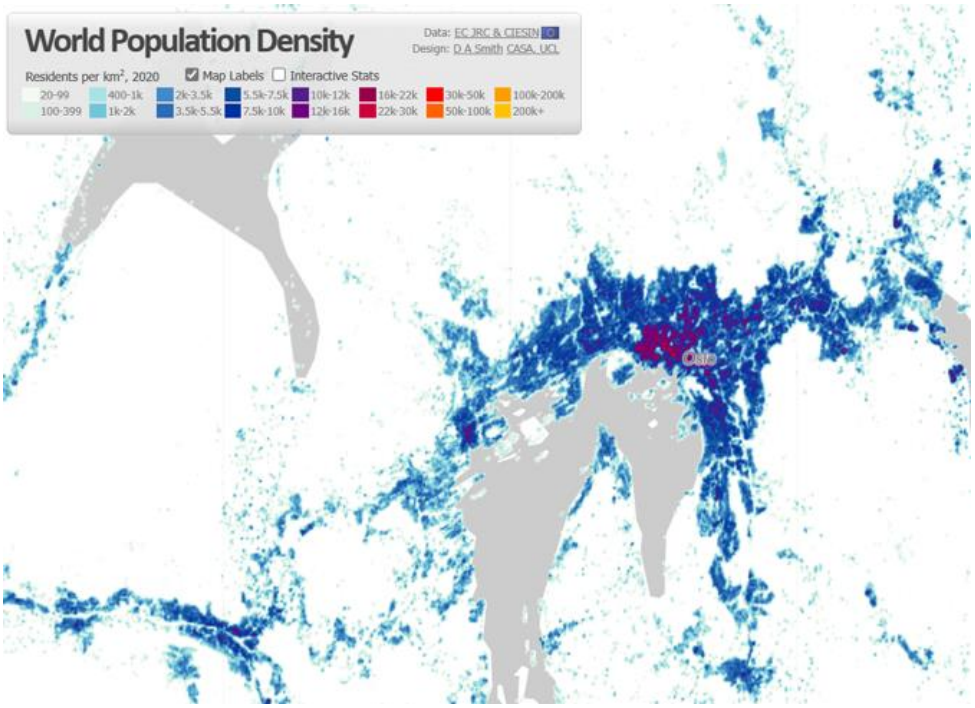


Figure 13. Population density of Oslo

Note. Mapping Population Density Across the Globe. (n.d.). Retrieved September 24, 2023, from http://luminocity3d.org/WorldPopDen/

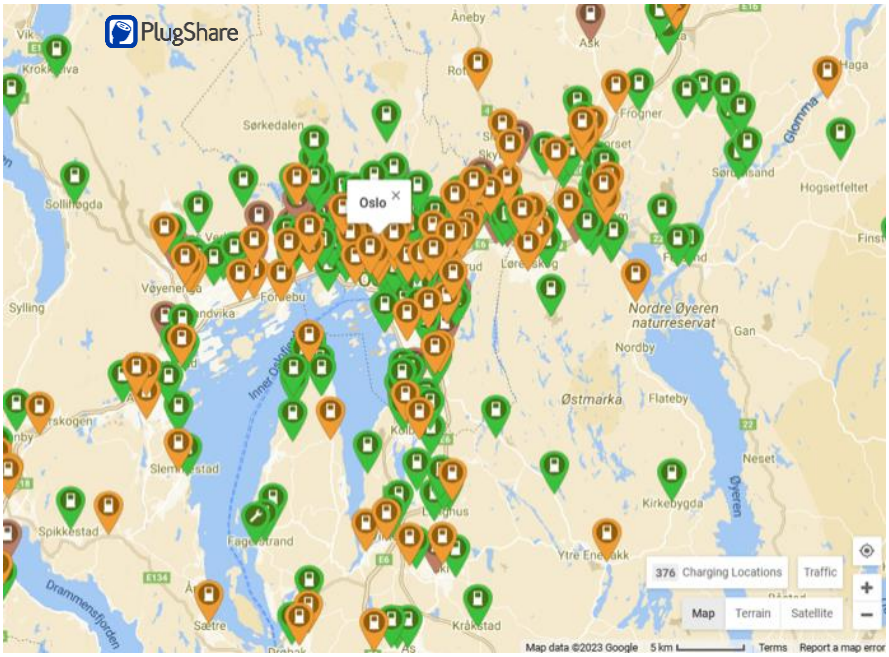


Figure 14. Map of EV charging stations in and near Oslo

Note. Reprinted with Permission from PlugShare EV Charging Station Map Find a place to charge. (n.d.). Retrieved September 24, 2023, from https://www.plugshare.com/

Figure 12 and ***Figure 14*** show the population density in the capitals of New Zealand and Norway, respectively. Alongside these figures are maps of EV charging stations across both cities (***Figures 13 & 15***), with each pin representing between 1-5 charging stations (the orange pins represent fast chargers, while the green ones represent normal chargers, for more information refer to the PlugShare Map Icon page). Oslo, Norway displays a greater amount of EV charging stations per capita than Wellington, New Zealand, showing that the former is better equipped to support a larger fleet of EVs. These maps could be an indication of people across Wellington sharing similar concerns on buying an EV to those in Norway, Sweden, Denmark, Finland, and Iceland, specifically as it pertains to 'range anxiety' and availability of charging stations. Norway, which is dubbed as 'the EV capital of the world' provides around 25,000 charging stations across the country, yet two of the top three barriers to BEV adoption included concerns about range and charging infrastructure *(Norway the EV capital of the world,* n.d.).

Case 3. Preferences and Impacts of Financial Incentives for Residential Rooftop Solar System Installation in Australia

In 2019, "Australia [had] one of the highest rates of residential solar adoption in the world with 20% of households having solar panels." The research in this case study aimed to understand the preferences and impacts financial incentives have on residential solar PV system installations among Australian citizens. Survey participants were presented with distinct sets of questions based on their adoption status, entering a choice experiment. For instance, individuals who had not adopted solar were presented with various solar PV system options, with variations in system cost, upfront subsidies, Feed in Tariffs (FiT), guaranteed FiT periods and the availability of interest free loans.

The results indicated that a person's intention "to adopt solar PV [was] not affected by the possibility of receiving an interest free loan nor receiving a rebate of AUD 2,000" (Zander, 2019). Installation costs had the largest influence on the choice of a photovoltaic system, followed by FiT period guarantees. When a FiT was guaranteed for 10 years the percentage of people who would opt for a solar PV system increased by 20%, a guaranteed FiT period of 5 years provided an increase of 14% (Zander, 2019). This implies that customers, over a 10 or 5-year duration, would have the opportunity to sell surplus power they generate back to the grid at a stable rate, unaffected by market fluctuations. At the time, most states in Australia offered a FiT period of 10 years, which

could be an indication of the high adoption rates across the country. In the study there was also a direct correlation with "younger respondents and those with higher incomes [being] more likely to adopt PV systems" (Zander, 2019). Another interesting finding was that "low interest loans had no appeal, and rebates only little," in maximizing PV adoption, they speculated this could have been "because they did not represent an opportunity to raise revenue and continue to receive financial benefits from solar PV" in the long run (Zander, 2019).

In 2017, when this survey was distributed, two primary strategies were actively employed in Australia to enhance the financial appeal of PV installations for residential households. These included an initial rebate on the purchase of a PV system and the implementation of FiT policies, which varied by state. In New Zealand on the other hand, there are no rebates or FiTs offered as incentives for increasing the installation rate of PV systems (Hoare, 2022). The paper also discussed the financial uncertainties associated with Feed in Tariffs. Unlike rebates, which can be easily budgeted for due to their fixed value, FiTs pose challenges in modeling and have resulted in "larger than expected increases in [costs]" over time (Zander, 2019).

This case study provides valuable insights into trends and adoption incentives across diverse demographics. It sheds light on the preferred incentives for individuals contemplating the adoption of a solar PV system. The uniqueness of residential solar PV technology lies in its ability to offer households long-term financial advantages. Thus, understanding whether individuals prioritize immediate or long-term payback more can offer valuable insights into the results our team will expect to see through surveying Wellington residents.

2.5 Summary

Aotearoa New Zealand has a complex relationship with energy, with numerous aspects that collectively can result in a detrimental environmental footprint on a global scale. The country is grappling with elevated emissions from fluctuating uptakes of fossil fuels for energy generation, as it endeavors to curtail both pollution and reliance on non-renewable energy sources. Although some of New Zealand has embraced sustainable technologies like electric vehicles (EVs) and solar photovoltaic (PV) systems, the adoption rate could significantly benefit from the implementation of supportive incentives and policies. Despite performing very well on a global scale in terms of sustainability, the country still possesses untapped potential for substantial improvement, positioning itself to enhance its environmental standing even further.

3 Our Approach

The goal of this project was to better understand the barriers to an equitable uptake of household energy innovations in Wellington. In achieving this goal, we had identified three objectives:

- ❑ Understand the baseline of local public awareness of energy innovations.
- ❑ Identify the specific barriers that have either limited adoption or have been overcome.
- ❑ Rank and prioritize the barriers by significance.

Participants in this study included mostly Greater Wellington residents who fell into the category of adopters and non-adopters of household energy innovations, along with energy experts and other stakeholders on the topic. To have a representative distribution across demographics, we gathered participants through several means such as convenience sampling in high-traffic areas, knocking on doors, and posting to forums and online communities such as Facebook groups and Reddit. High-traffic areas included, for example, Countdown supermarkets, a populated grocery shopping area, or the Te Papa Museum courtyard and waterfront for central Wellington, especially its frequent hours during the weekly farmer's market. Sampling sites for more of the greater Wellington area included, but were not limited to, the North City Mall in Porirua, Queensgate in Lower Hutt, the Upper Hutt Mall, the Coastlands Shopping Center in Paraparaumu, etc. This helped us get a more consistent stretch of demographics in our data collection overall. We also included a few incentives for participating in this research study. Everyone who completed our survey was given the chance to enter a raffle to win a 200 NZD voucher to Countdown supermarket. Furthermore, every interviewee received a similar 40 NZD voucher either by mail or hand delivery.

The team took a mixed-methods research approach. Initially, we collected quantitative data for all the objectives through survey responses and then identified a smaller subset of participants open to an extended interview. Please reference Appendix C to access the survey questions administered to participants. The team sampled survey takers from stratified samples in the extended interviews to ensure diverse experiences and responses. These stratified samples were based on the demographics of the survey takers, such as their adoption status, ethnicity, age, location of residence, and income level as shown in the results section. When these categories were compared, for example, their adoption status in correspondence with their income level, we discovered survey respondents with low-income levels who fully adopted solar and electric vehicle technologies.

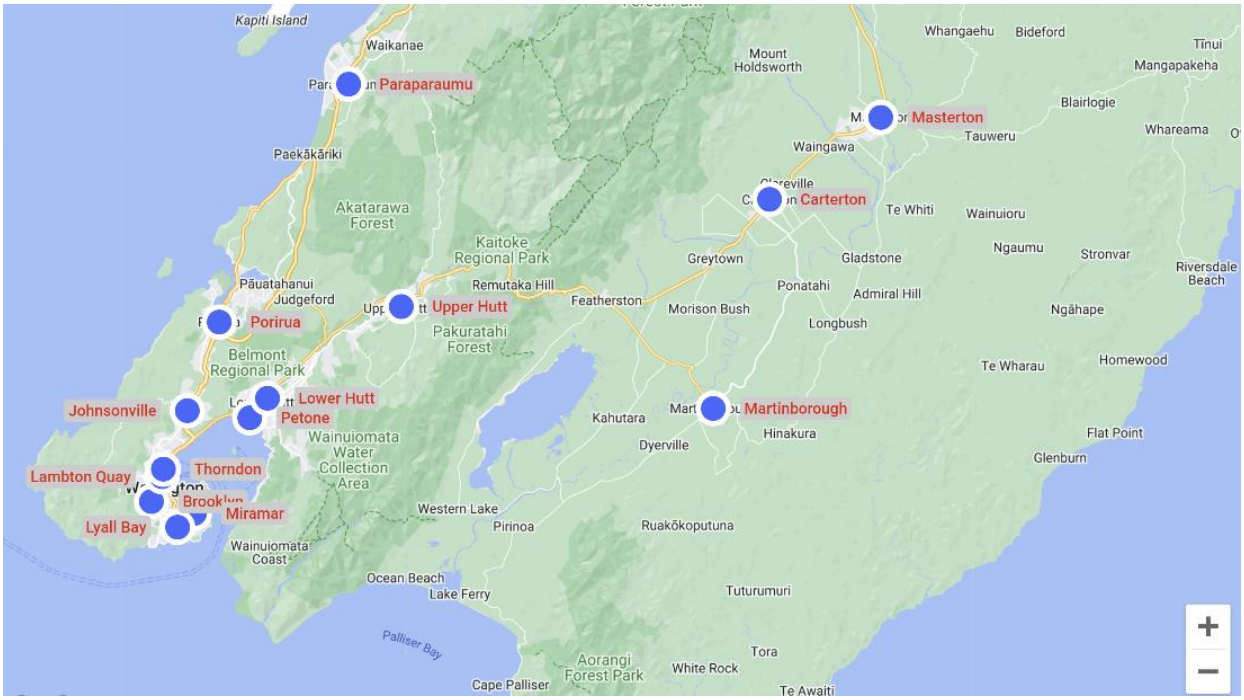


Figure 15. Map of surveying locations in the Wellington Region (Atlist)

The population of the Wellington Region in 2023 is around 421,624 (World Population Review, 2023). Our group targeted a survey sample size of 136 participants split into two groups: 68 adopters of household energy innovations and 68 non-adopters of household energy innovations. This gave us a confidence level of 90% and a margin of error of 10% for each data group (Qualtrics, 2023). To understand how this was achieved, the Margin of Error (MOE) needed to be calculated to

inspect that it was possible to correctly reflect the region of Wellington with a participant level of n = 136. The Margin of Error indicates where the actual population likely lies in a data set. The MOE was calculated using the Standard Error (SE) multiplied by the critical value (z) as seen in (1).

$$MoE = z * \frac{\sigma}{\sqrt{n}} \quad (1)$$

The standard error was calculated as seen in (2), where p, the proportion of the population that we estimated, or 50% p = 0.5, and n, the sample size or n = 136.

$$SE = \frac{\sigma}{\sqrt{n}} = \frac{\sqrt{p(1-p)}}{\sqrt{n}} = \sqrt{\frac{p(1-p)}{n}} \quad (2)$$

Therefore, using (2), the MOE was calculated to be approximately 0.072 when the critical value of a 90% confidence interval is 1.645, and the SE was calculated using p = 0.5 and n = 136. Since the MOE fell in between the correct range for a confidence interval using a 90% confidence level, it reflected that there is a 90% probability that our results will be accurate for the Wellington Region. A confidence level of 90% and a margin of error of 10% were determined as an acceptable representation of Wellington.

Moreover, to calculate any relevant correlation coefficients in the results section, the Pearson correlation coefficient formula was used as shown in (3).

$$r_{xy} = \frac{\sum(xi-\overline{x})(yi-\overline{y})}{\sqrt{(\sum(xi-\overline{x})^2)(\sum(yi-\overline{y})^2)}} \quad (3)$$

We were able to measure the linear correlation between two sets of data using the ratio between the variance and the standard deviation of the two variables (*Correlation Coefficient*, n.d.). The Pearson correlation coefficient only measures linear correlations and ignores any other type of relationship or correlation. Also, the result always represents a value between -1 and 1, where 1 indicates a strong positive relationship, -1 indicates a strong negative relationship and 0 would indicate no relationship at all.

3.1 Baseline public awareness of energy innovations

To measure baseline awareness, two sections of questions were added to the survey to gauge the public's awareness of electric vehicles and residential solar systems, including the costs associated

with adopting them. The first section contained questions on the perceived costs associated with residential solar systems and included questions such as "What do you think the average cost is to purchase and install a residential solar energy system in New Zealand?", which we then compared to the average cost to do so in New Zealand, which we found to be about 20,000 NZD (*The Price of a Solar Power System*, n.d.). The other section contained questions about the awareness of electric vehicle purchases and the perception of the technology's environmental impact. We distributed the survey using convenience sampling in and around the Greater Wellington region to gauge public knowledge and awareness of sustainable energy technologies.

Interviews with two New Zealand energy experts were also conducted to gain deeper insight into public awareness of sustainable technologies. The experts identified possible challenges associated with low adoption rates and offered insight into strategies that better inform the public. This background understanding was relevant when analyzing survey responses and provided context on public outreach and education. By gauging the survey taker's awareness of the technologies, the team received insight into whether baseline awareness is one of the barriers to adoption.

3.2 Identifying specific barriers that have either limited adoption or have been overcome

The second objective was to identify barriers that non-adopters reported impeded them from adopting household energy products or what barriers adopters had to overcome. A study by the Pew Research Center found compelling evidence that forced-choice questions yield more accurate results than select-all-that-apply lists (Mitchell, 2019). The team considered that research when preparing the survey and decided to use rank order scaling, multiple-choice/forced response, and Likert scale survey questions. Some examples of questions used include: “On a scale of 1 to 5, how often do you experience range anxiety?” and “Rank the following barriers in terms of how likely they are to prevent individuals from solar panel adoption, with 1 as the most significant.” By including these types of questions in the surveys, both quantitative and qualitative data were collected. In interviews, the team delved deeper into factors hindering the interviewee from adopting sustainable technologies. Questions that could snowball into other conversations were asked, for example, “From your perspective, what do you consider to be the top three obstacles that might hinder you or others from purchasing a solar panel system?”

Using a survey, the team could effectively reach a more significant and diverse pool of respondents. Because energy innovations often have a high upfront cost, it was essential to see how respondents from different income levels felt about these technologies. Therefore, a distribution of household income that properly represents Wellington was determined as a critical demographic factor to consider. This was accomplished by including a question in the survey of the following household income categories: less than $50,000, $50,000 to $100,000, $100,000 to $150,000, and greater than $150,000.

For outreach, social media presented a valuable opportunity to identify communities and forums of household energy innovation adopters, such as Facebook groups and forums of electric vehicle owners. The survey platform used was Qualtrics, which offered several key features that allowed us to conduct our research. One beneficial feature was the ability to branch the survey based on responses to specific questions dynamically. At the start of our survey, we asked which energy innovations the participant had adopted from electric vehicles and solar panel systems. The participants were then given different questions depending on their answers. A flowchart of our survey is illustrated and located in Appendix A. At the end of the survey was a question asking if participants were willing to be contacted for potential interviews, and if so, they were asked to provide their contact information.

To increase the number of survey respondents, the team provided the participants with information regarding a chance to win a grocery voucher. We handed out small flyers containing a code to reach the survey online and a description of what the respondents could win if they filled it out. Providing vouchers increased our outreach in the Wellington region and enabled us to exceed our participant goal of a minimum of 68 adopters and 68 non-adopters. We were able to collect responses from 98 adopters and 172 non-adopters as will be highlighted in the results section.

The team conducted 17 face-to-face and online interviews to obtain more detailed qualitative information as is discussed in the results. However, due to time constraints, only 13 of these interviews were used in data analysis. While surveys helped identify trends and barriers, conducting interviews was an effective way to understand and explore them in more depth (Ward, 2014). A semi-standardized interview format, with open-ended questions and prompts on insight into the barriers reported, was used. The semi-standardized interview method also allowed the interviewees to speak more freely about their opinions on barriers that prevent an equitable uptake of sustainable energy innovations beyond the more structured topics (Berg & Lune, 2017). These interviews

involved survey participants encompassing all four adoption status categories: those who have adopted electric vehicles (EV adopters), those who have adopted residential solar panels (solar adopters), those who have adopted both technologies (EV and solar adopters), and those who have adopted neither (non-adopters).

To assist in discerning the prominent barriers mentioned in every interview, the team used a qualitative data analysis approach known as coding. The coding process was split into two separate parts: first, collection, and second, analysis. For collection, a pre-recorded transcript of each interview was deciphered and read through to collect the data. Interviewee quotes that were directed toward one of the project's three objectives or that piqued interest were marked within the transcript and were gathered and organized into a document. This resulted in the development of 5 major categories in which every quote was sorted into for both EV and Solar. (See ***Figure 16*** for a visual)

These categories were as follows:

1. Barriers: Problems participants may face or have overcome in adopting either technology.
2. Personal Awareness: The interviewee's level of information regarding either technology.
3. Public Awareness: The interviewee's perception of information provided to the public about either technology or overall public awareness of either technology in general.
4. Policy: Their opinion on current and future policies regarding each technology and recommendations they may have for future policies.
5. Concern: Quotes mainly supplied by professional interviews that piqued the team's interest.

The previous main categories served as hypernyms for other specific subcategories where quotes were further organized. The Barriers category was further separated based on specific barriers that were mentioned in interviews. These included:

- NZ Already Being Renewable-Based: Interviewees mentioning New Zealand having an already large presence of renewable based energy generation.
- High Cost: Mention of the overall cost and its effects towards their adoption.
- Charging Infrastructure/Charging Anxiety: Interviewee's current opinions of the charging infrastructure overall, and if they personally have anxiety about electric vehicle battery longevity.
- Homeownership Status: The interviewee's homeownership status and how that determines their view on either technology.

- Maintenance: Which was each interviewee's perspective of how much management goes into owning either technology besides the upfront cost.

Policy developed as a category due to the high frequency of quotes we received from multiple interviews on current policies and future policies. There were three subcategories that were developed for the Policy category. These included:

- Incentives to Purchase: Incentives or paybacks that either assisted in gaining interest in a technology or discouraged potential clients.
- Recommendations: Ideas that some interviewees had on current or future government policies.
- Current Policy Controversy: Current policies that interviewees mentioned have both positive and negative effects in an equitable uptake.

Awareness was separated into personal and public awareness, however, personal awareness was further separated into two more subcategories:

- Personal Information: How interviewees found information on either technology or personal opinions regarding how they received that information.
- Geopolitical Concern: Information that interviewees discovered that caused issues with their adoption due to geopolitical effects.

Once all the barriers had been discerned in the qualitative and quantitative data, the team identified the most significant ones by addressing the third objective.

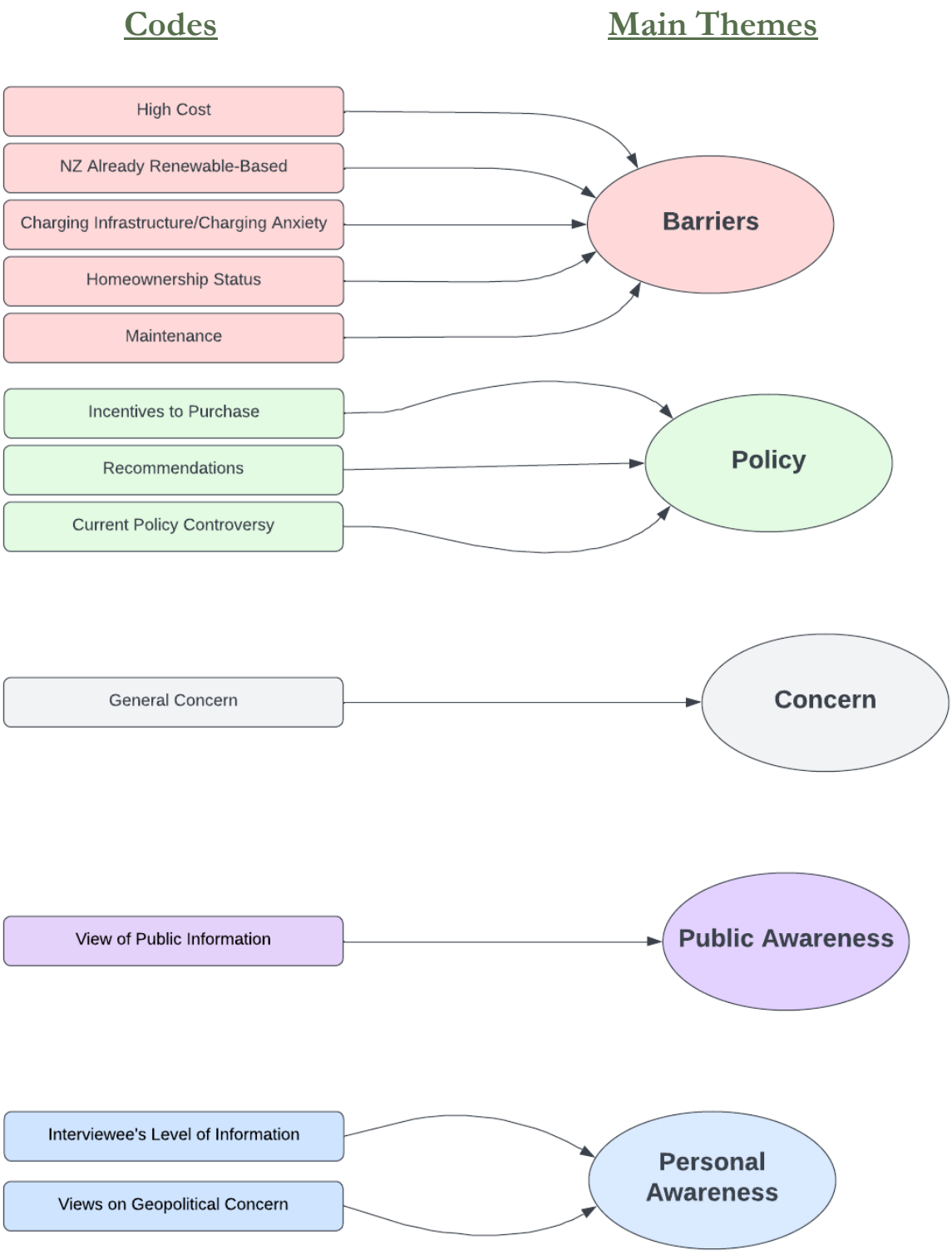


Figure 16. Flow Chart visualizing the subcategories that fit into each category for our qualitative data analysis.

3.3 Rank each barrier by significance and type

The third objective was to rank and prioritize the factors and barriers impeding the adoption of sustainable energy innovations. Data for objectives 1 and 2 were analyzed and characterized to form a basis for our findings. For analysis, our team checked each survey respondent's results and ensured they complied when responding to each question. For example, if participants did not reorganize their options or left numerical questions blank in survey answers for the rank order questions, their response was considered incomplete. Their answers to the questions or the entire survey were removed to gauge a more accurate representation, as we wanted complete and well-thought-out responses. After removing outliers from the survey responses, our team identified plausible correlations between demographics and survey responses, then ranked barriers and assessed awareness based on respondents' answers.

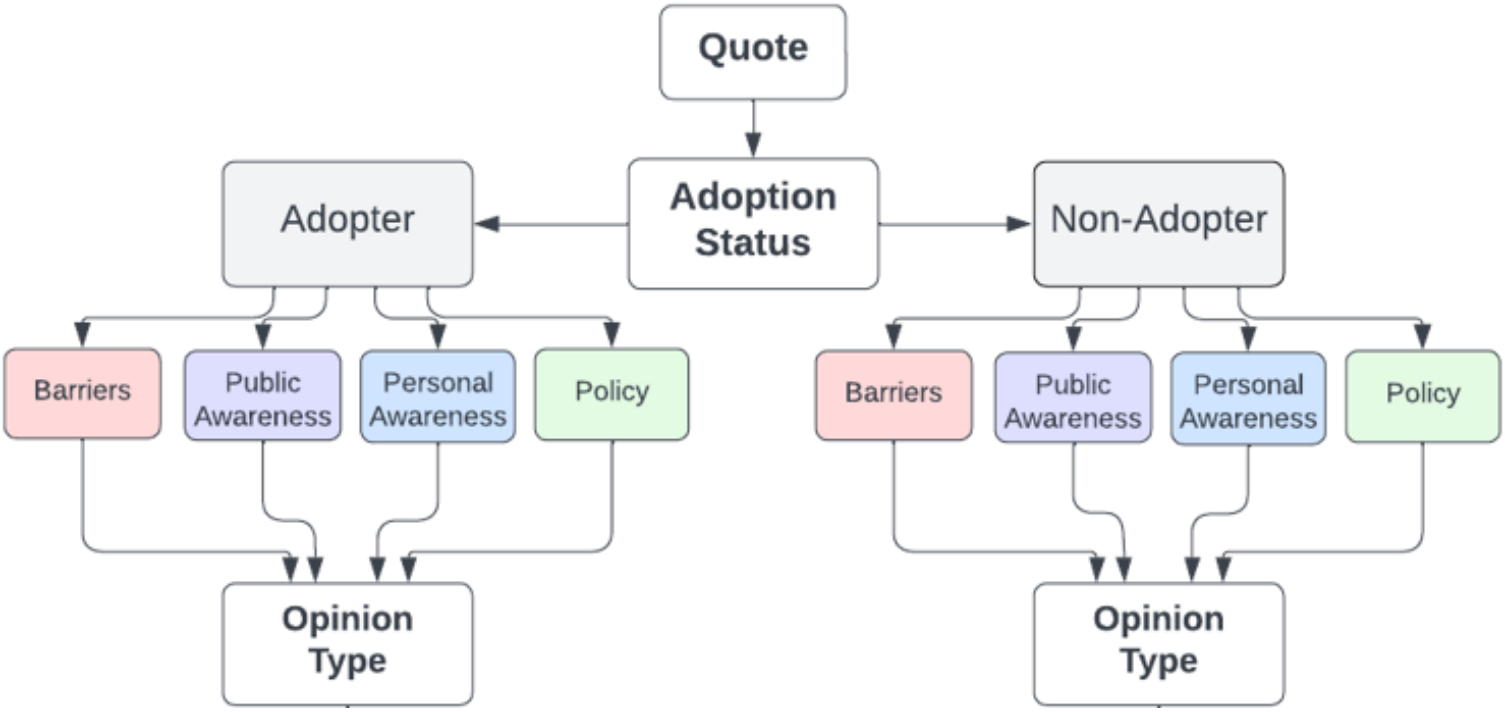
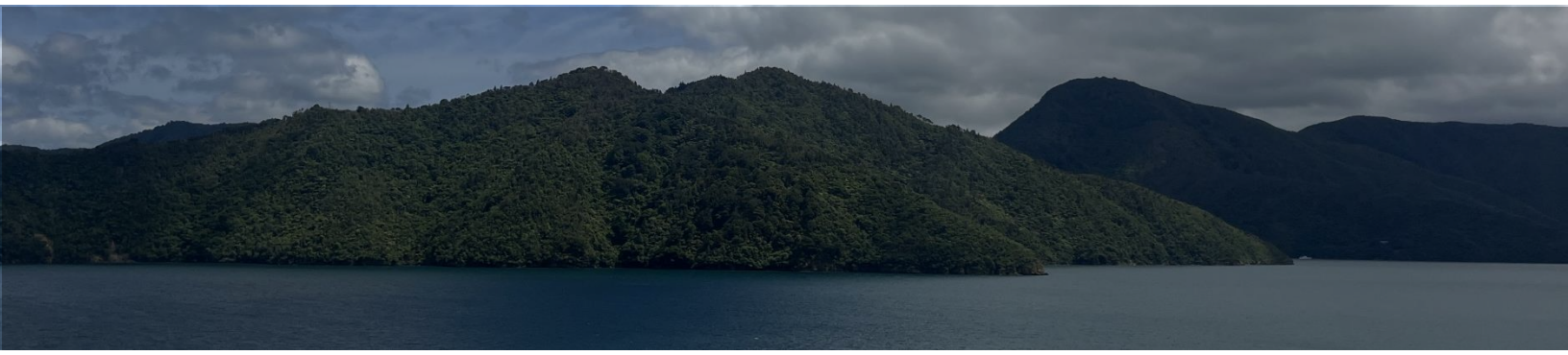


Figure 17. Flow chart visualizing the coding process for organizing each quote used in qualitative data collection

In the second phase of the coding process, which involves analysis, participants' identified barriers were systematically ranked in terms of significance or type. Each quote was categorized into either the adopter or non-adopter subgroups. All collected quotes were then organized, and subcategories with high frequencies were used to establish a ranking for each qualitative barrier based on its frequency of mention. The team proceeded to examine whether these highly mentioned barriers exhibited any discernible trends within the interviewees' adoption statuses. ***Figure 17*** provides a visual representation of this process. The insights gained from interviews and the survey responses enabled a deeper understanding of which barriers were more prevalent throughout all survey participants.



4 Results

After compiling the data collected from the survey and interviews, we found trends and plausible correlations relating to the varying awareness levels of residential solar panels systems and electric vehicles, as well as barriers preventing the uptake of these technologies. These trends, addressed below, will later be discussed, and further correlated to produce additional insights that could help inform Ara Ake on the current landscape among Wellington Residents.

4.1 Demographics of Survey Sample

In this section, we present a few demographic results obtained through the survey. The data we collected loosely replicates the current Wellington population, with the following section specifically relaying self-reported ethnicity, income levels, and adoption status.

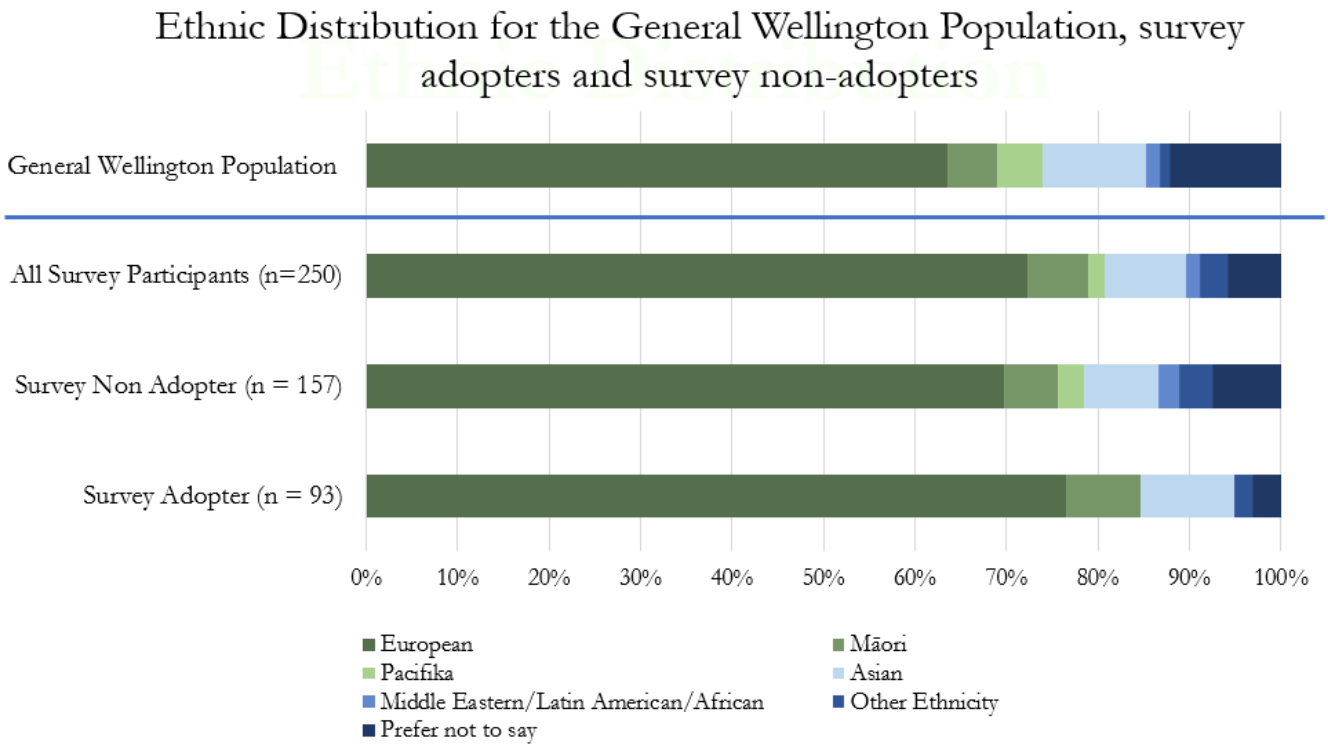


Figure 18. Ethnic breakdown of survey respondents as well as the general Wellington population

Note. An individual could select more than one ethnicity (n = 244).

The demographic makeup of our respondents divided according to the adoption status of participants is displayed in ***Figure 18.*** Overall, our surveyed participants exhibit a moderately representative distribution in terms of ethnic ratios, reflecting the diversity observed within the Wellington region. Compared to the Wellington population, European and Asian adopters are slightly over-represented in our survey results. On the others hand, Pacific peoples are under-represented.

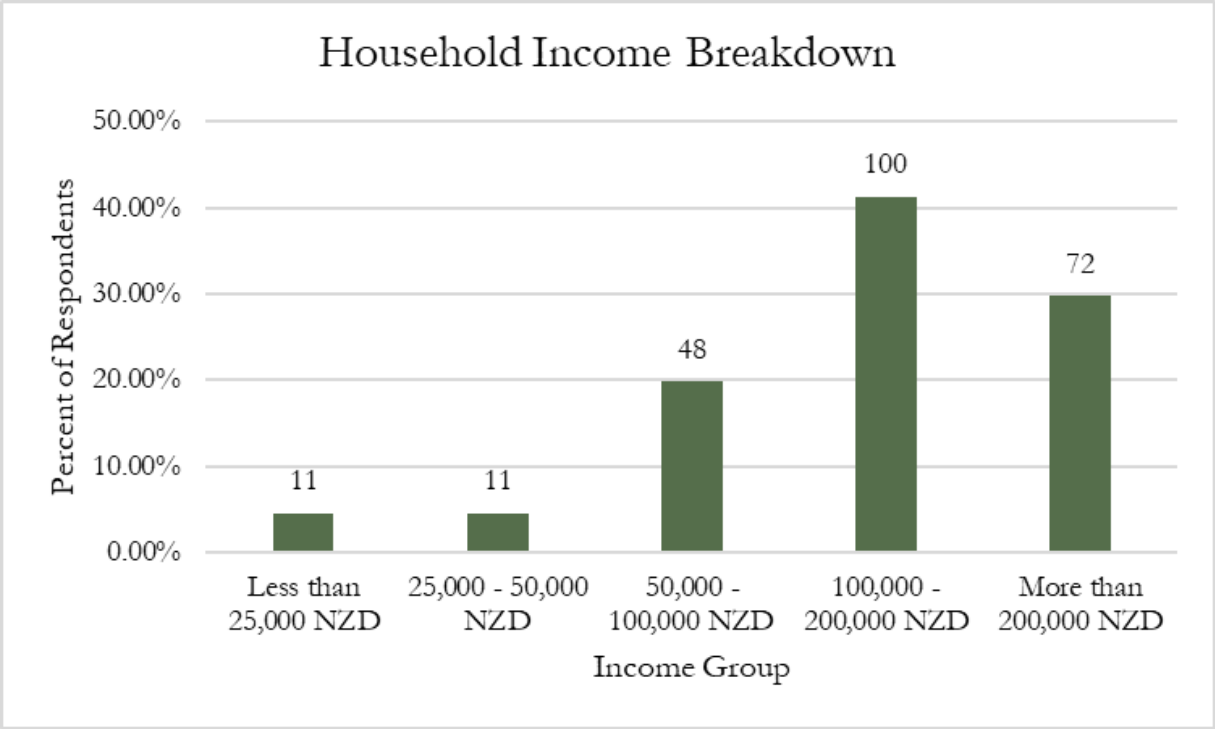


Figure 19. Distribution of household income reported by all survey respondents

Note: (n = 242)

Figure 19 displays the household income makeup of our respondents. The majority of respondents earn between 100,000 and 200,000 NZD annually, making up 41.32% of the total participants surveyed. The mean household income for our respondents is around 146,000 NZD, which is somewhat representative of the Greater Wellington Region where, "the region boasts an average gross annual income of about 133,000 [NZD]" (Household Income, 2023).

4.2 Adoption Status

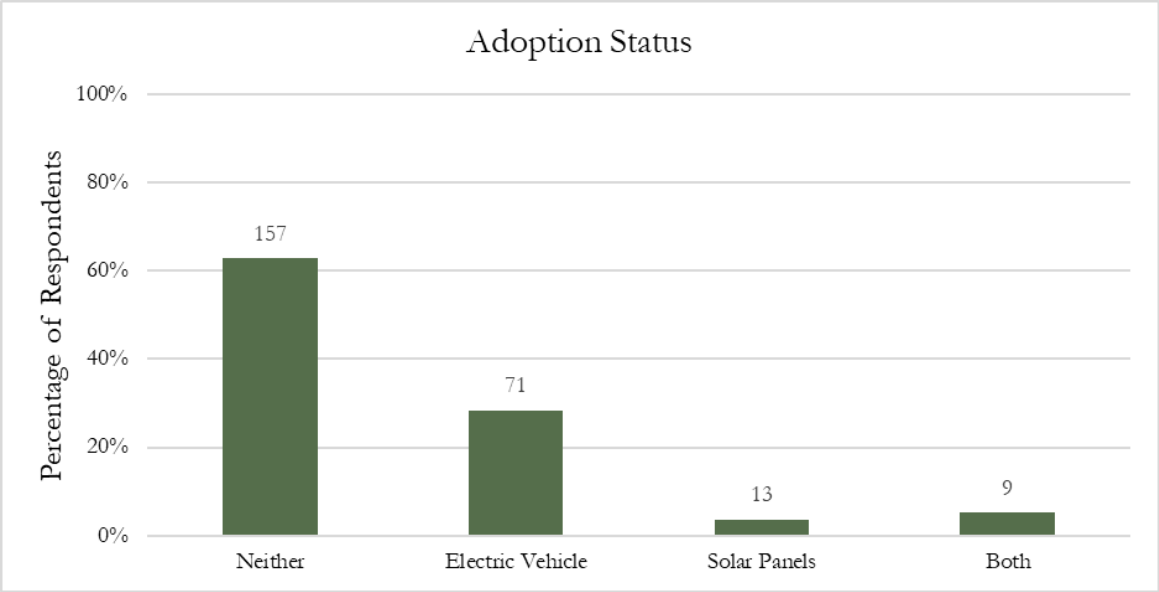


Figure 20. Adoption status of all survey respondents

Note: (n = 250)

Figure 20 summarizes the adoption status of the survey participants. Most respondents, 157 people, are non-adopters of either solar panels or electric vehicles. This is consistent with research in an earlier chapter regarding low adoption rates of sustainable energy technologies across New Zealand. There were also 71 electric vehicle adopters, 9 solar panel adopters, and 13 adopters of both technologies that participated in the survey.

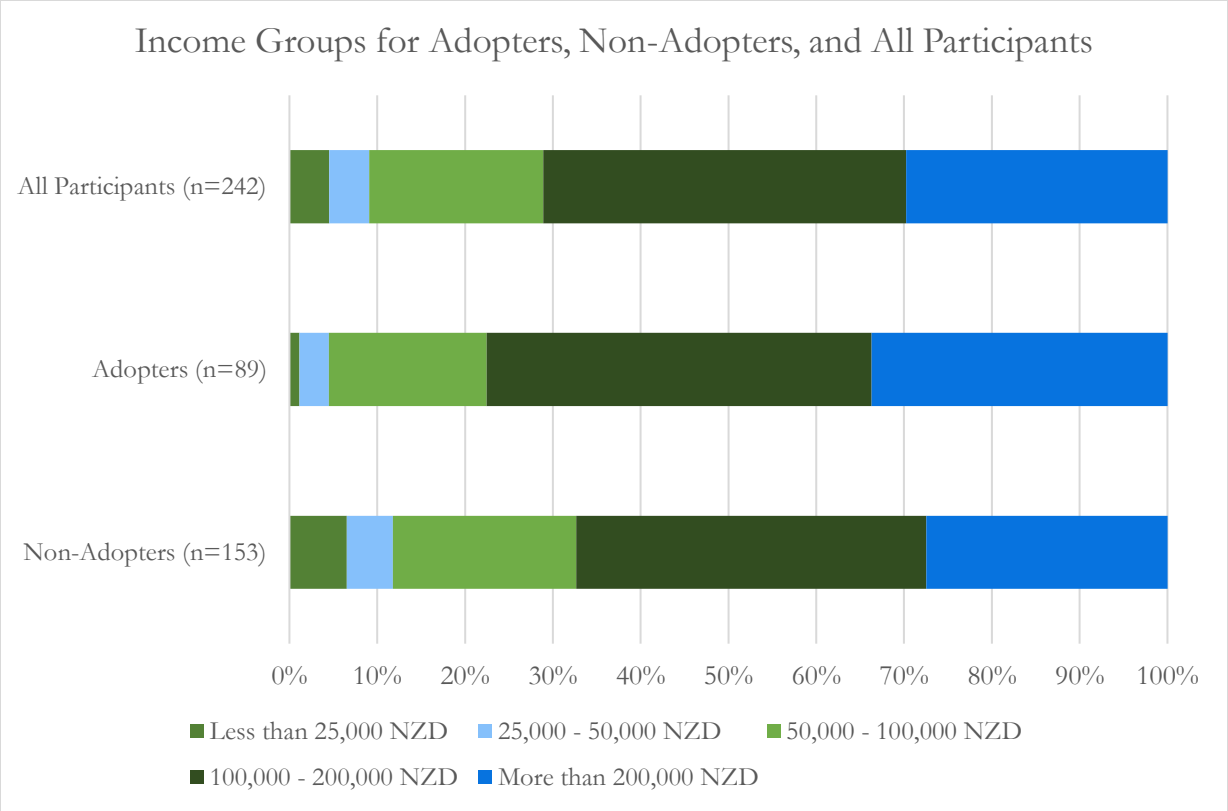


Figure 21. Breakdown of adoption status by income level

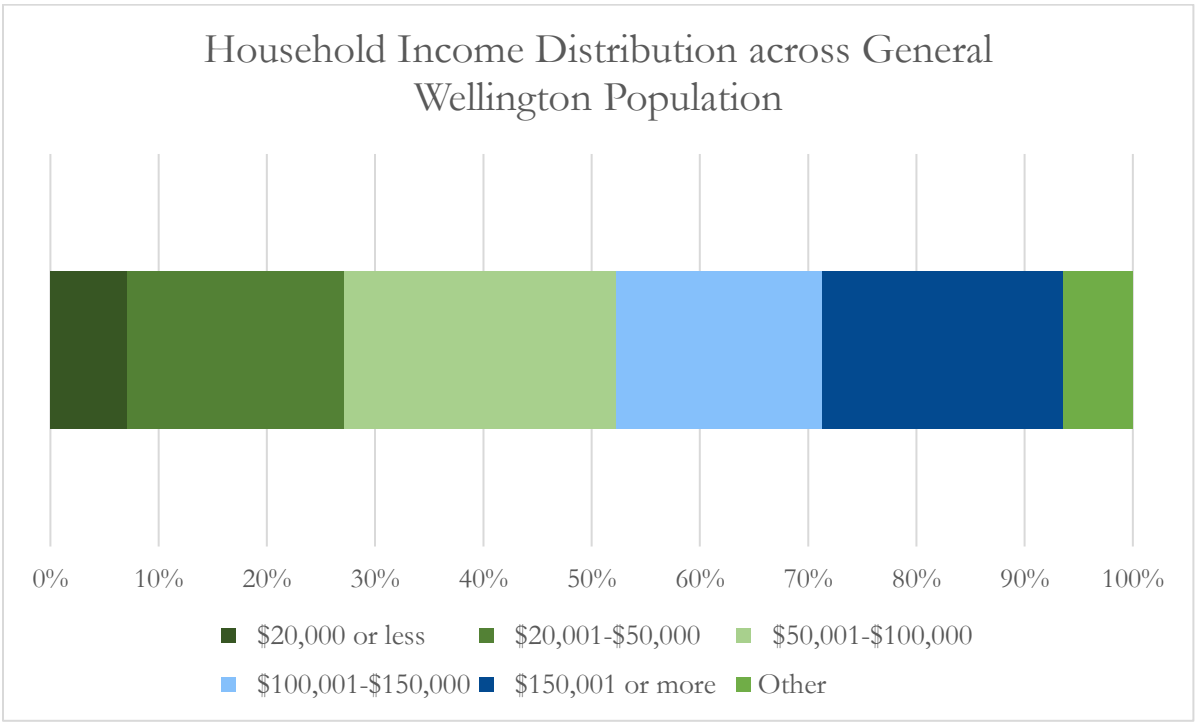


Figure 22. Breakdown of household income levels of the general Wellington population

Figure 21 illustrates the distribution of income brackets among survey adopters, non-adopters, and all participants while ***Figure 22*** shows the same distribution for the general Wellington population. The consistent distribution observed across all three groups suggests that our survey is somewhat reflective of the broader Wellington population in terms of income brackets.

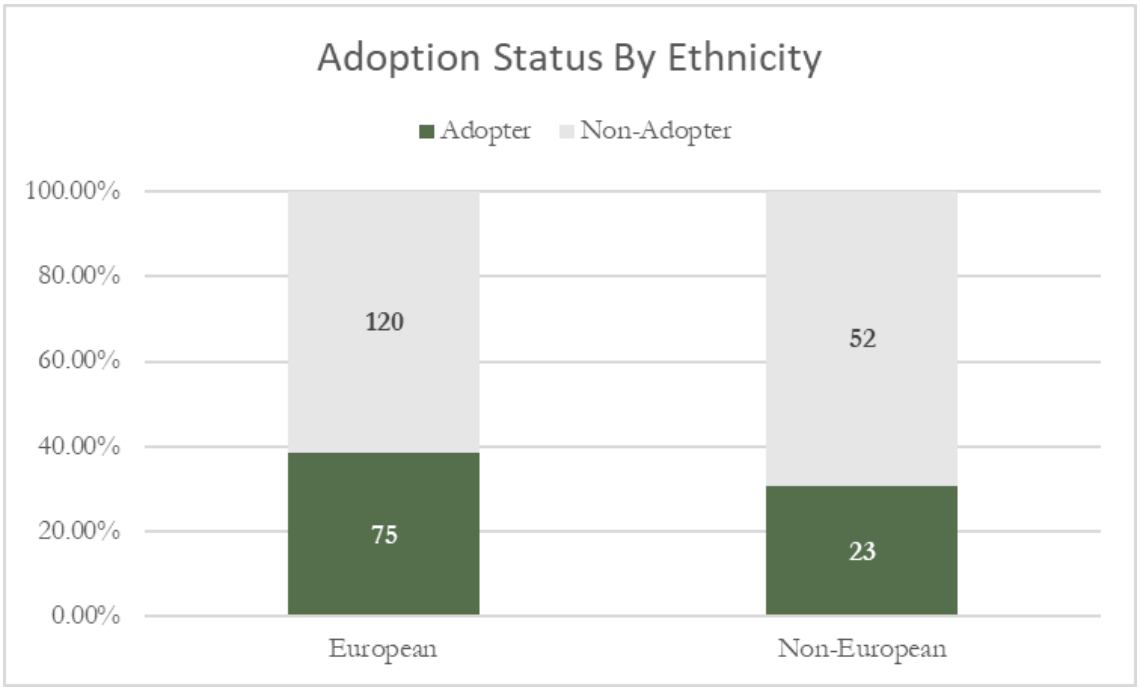


Figure 23. Breakdown of adoption status by ethnicity

Note: (n = 270)

When analyzing adoption status by ethnicity, we split up European and non-European respondents. 38.46% of Europeans were adopters of EVs or solar panels, compared to just 30.67% for non-Europeans. It is inconclusive whether individuals of a certain ethnic background are more or less likely to be an adopter of solar panels and/or electric vehicles.

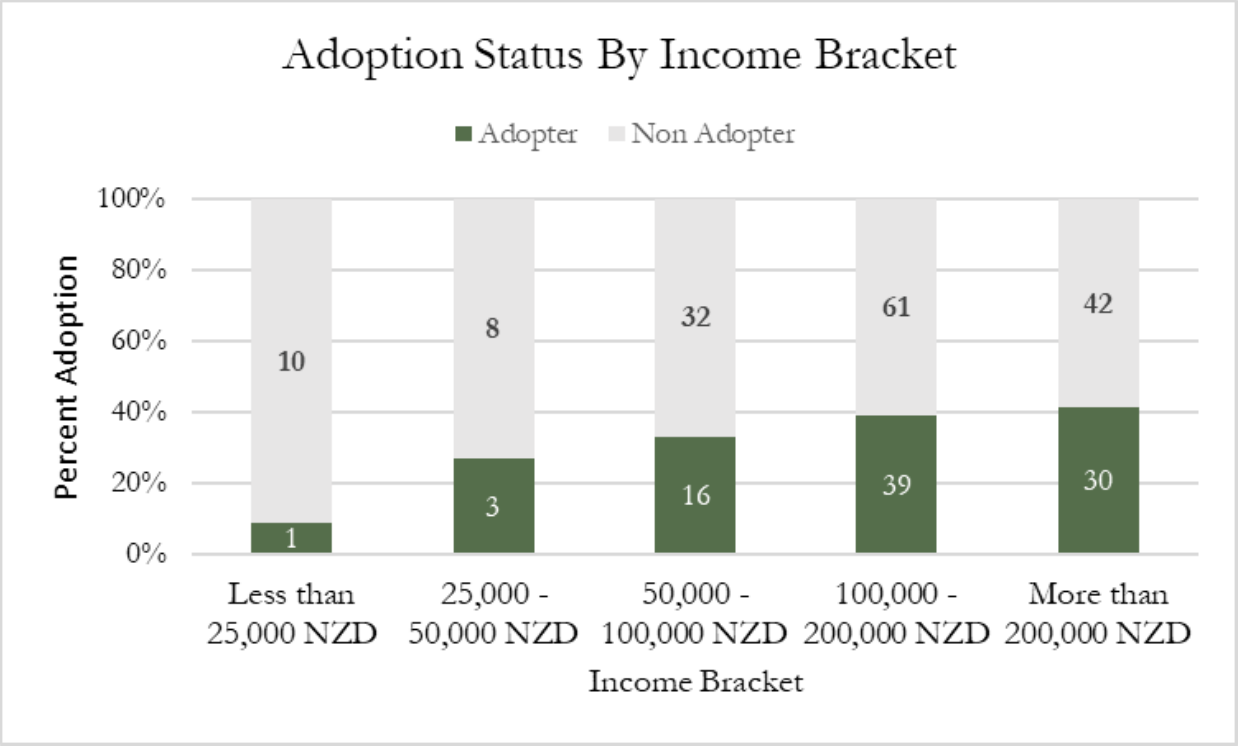


Figure 24. Breakdown of adoption status by income bracket

Note. (n = 242)

There appears to be a trend when analyzing adoption status by income bracket. Survey respondents in higher income brackets were more likely to be adopters of household energy innovations than survey respondents in lower income brackets. In fact, a strong positive correlation of r(240)= .80 was found between an individual's income bracket and the percentage of adopters using the Pearson correlation coefficient. This suggests that the uptake of electric vehicles and household solar panels may not be equitable across income brackets. However, more research would be beneficial with just 11 responses in the bottom two income groups.

4.3 Awareness

In this section, we delve into the results derived from our survey, focusing on the self-reported awareness levels expressed by participants. This section will provide a foundational understanding of the knowledge landscape within the surveyed population.

4.3.1 Solar Panel Awareness

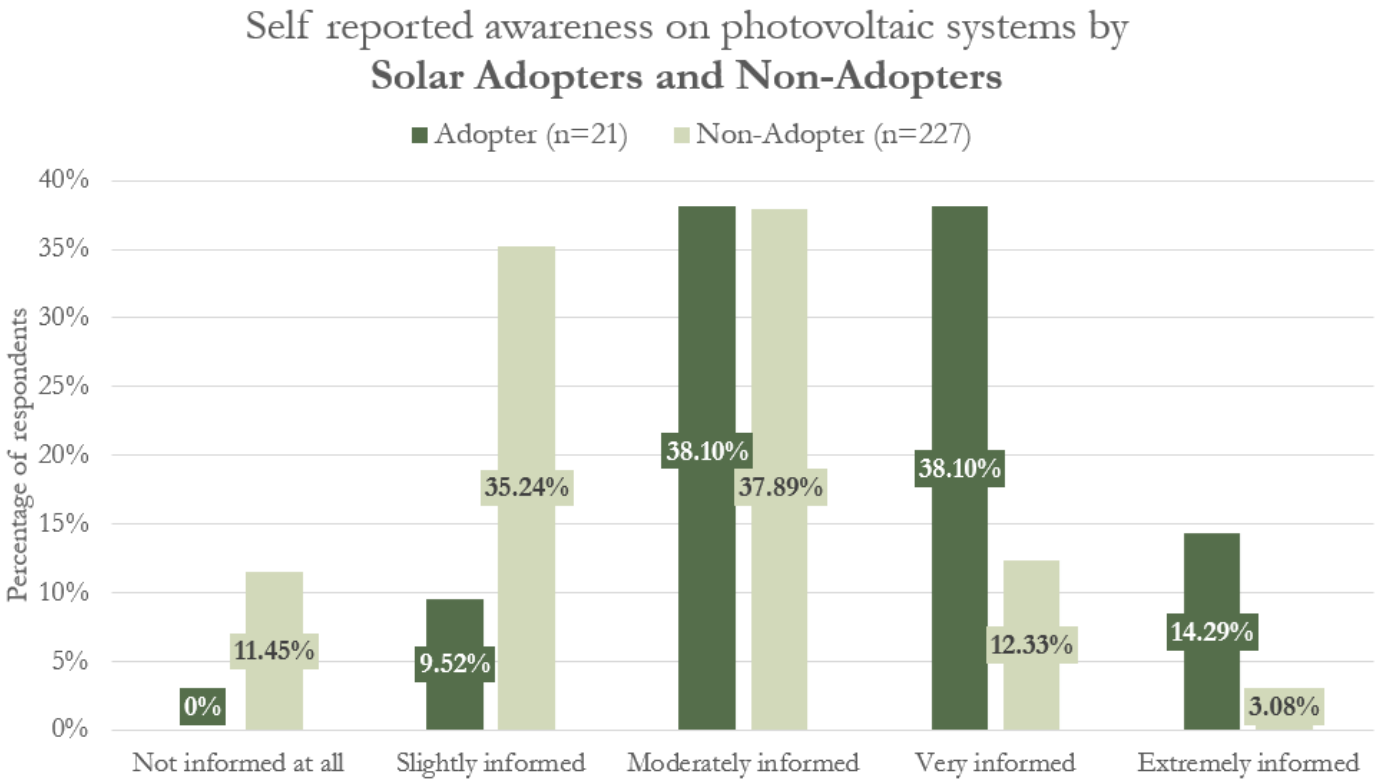


Figure 25. Self-reported awareness levels on solar panel technology

Note: Non-adopter (n = 227), adopter (n=21)

Figure 25 illustrates that only 15.5% of non-adopters reported higher levels of understanding, meaning 84.5% of respondents felt moderately informed or less. Of that 84.5% more than half feel slightly informed or less. This results in a distribution curving away from the normal towards lower levels of knowledge by 31.4%.

A total of 52.4%, over half of solar adopter respondents, feel very informed (38.1%) or extremely informed (14.3%) about solar panel technology. It is worth noting that a segment of 9.5% of adopters consider themselves slightly informed on the technology they have adopted, and that 38.10% also report themselves as being "Moderately informed" even after adopting sustainable energy technologies.

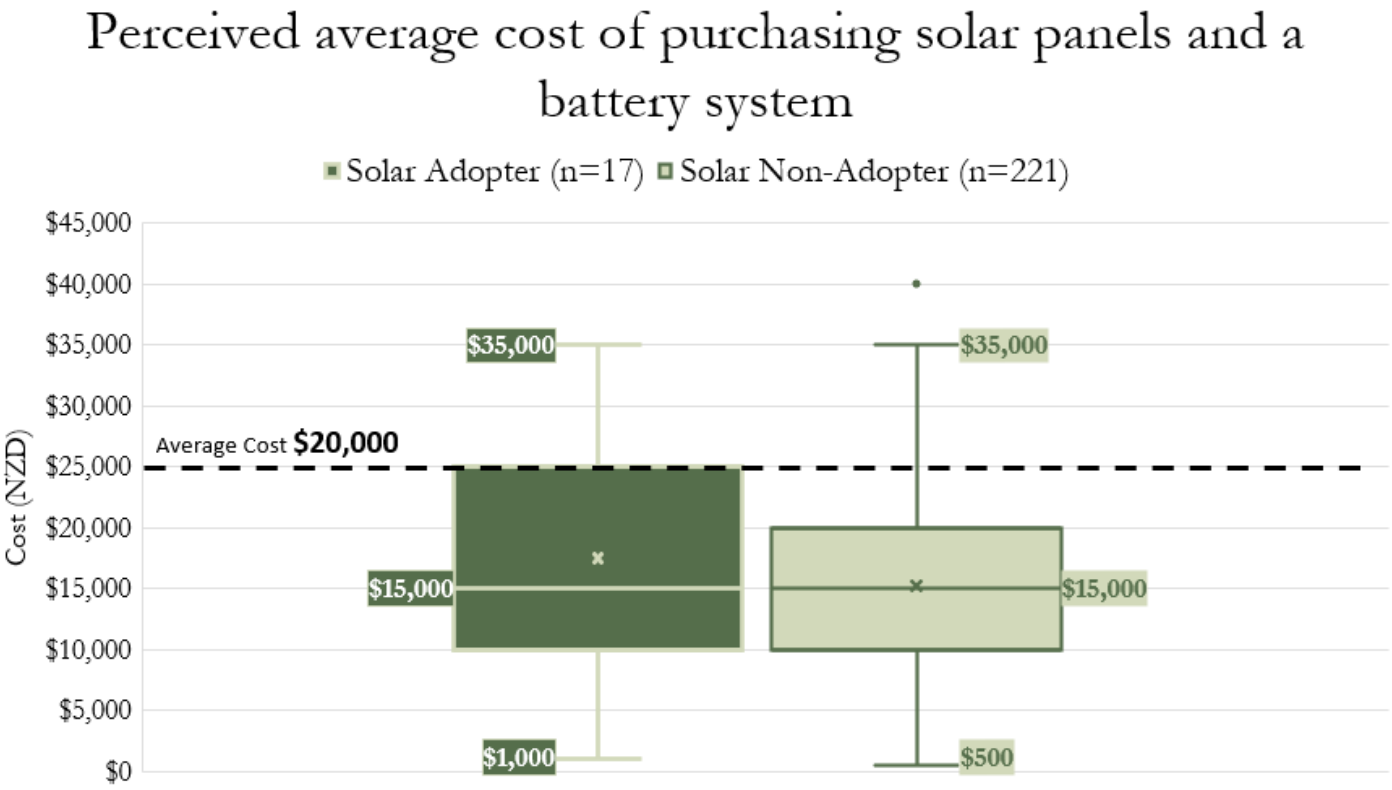


Figure 26. Perceived average cost of purchasing solar panels and a residential battery system

Note: Adopter (n = 17) and perceived average cost: $17,474. Non-adopter (n = 221) and perceived average cost: $15,250.

Figure 26 highlights the perceived average cost of purchasing and installing a solar panel and battery system for both adopters and non-adopters which was 15,000 NZD based on the median values. Both adopters and non-adopters shared a 25% error in their perceived cost. However non-adopters were more in agreement with one another regarding the average cost of purchasing and installing a solar panel and battery system as can be observed by the spread of the interquartile range of the two box and whisker plots. It is also important to note that the difference in size of the quartiles is also due to the sample sizes not being equal.

4.3.2 Electric Vehicle Awareness

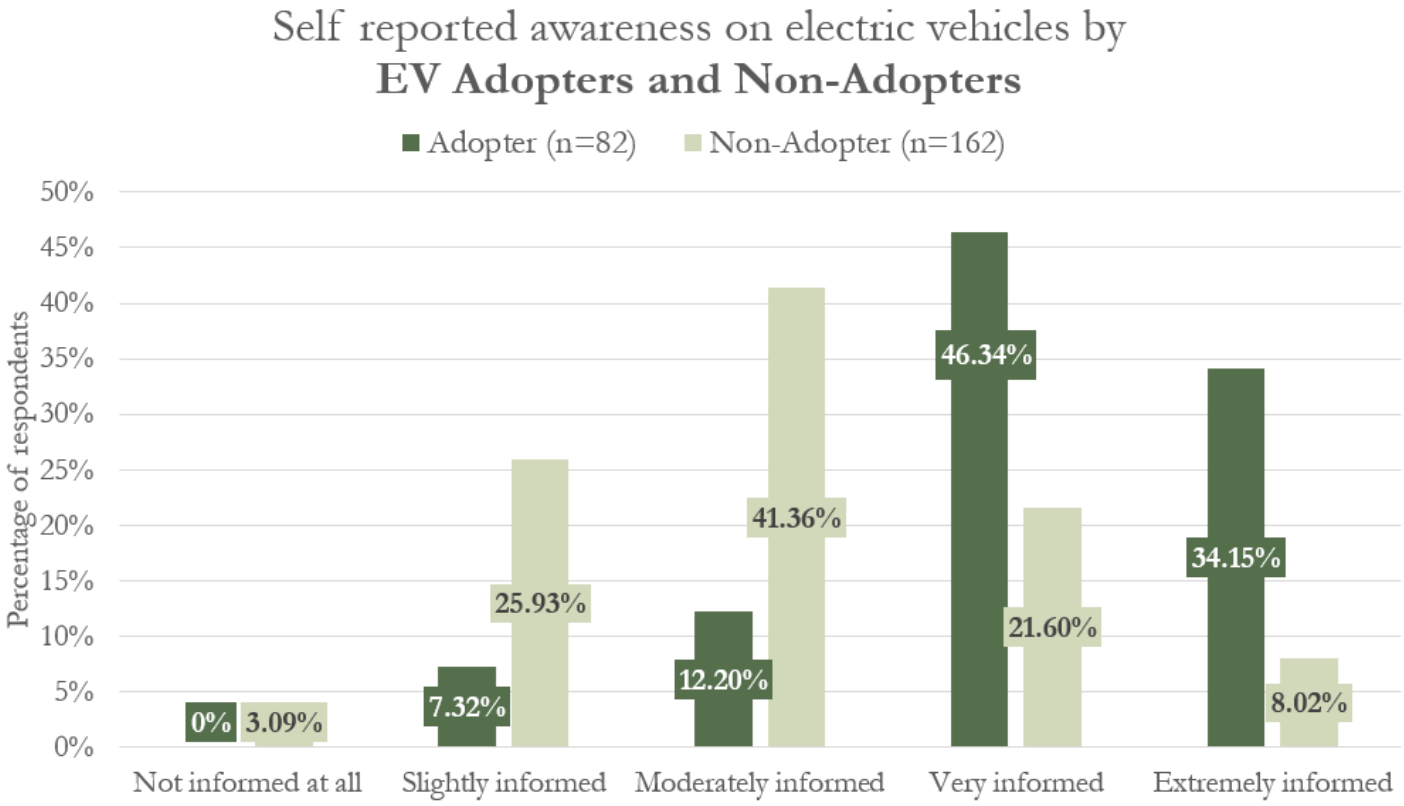


Figure 27. Self-reported awareness levels on electric vehicle technology

Note. Non adopter (n=162), adopter (n=82)

The portion of respondents with lower knowledge levels of electric vehicle technologies ('Not informed at all' and 'Slightly informed') makes up 28.7% of responses of EV non-adopters. Similarly, the combined percentages of "Very informed" and "Extremely informed" are 29.4%. The percentage of respondents with higher knowledge levels (right side of the graph) is slightly higher compared to those with lower knowledge levels (left side of the graph), indicating a normal distribution.

Most of the respondents who have already adopted an EV report high levels of knowledge about the technology. This is represented by 80.4% of adopters feeling either 'Very Informed (46.3%) or 'Extremely Informed' (34.1%) about electric vehicles. On the other hand, a small percentage of adopters consider themselves slightly informed (7.3%).

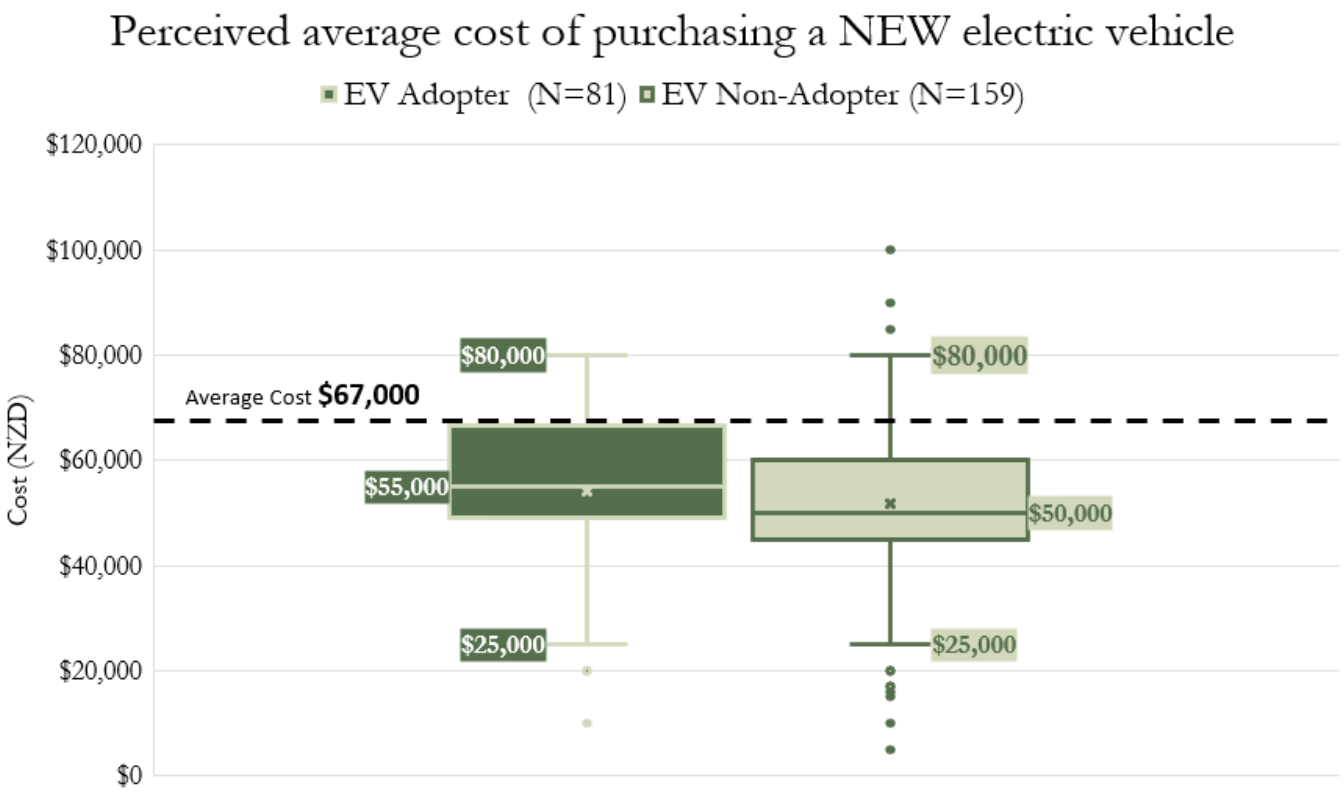


Figure 28. Perceived average cost of purchasing a new EV

Note. Adopter (n = 81) and average perceived cost: $54,210. Non-adopter (n = 159) and average perceived cost: $51,786.

The perceived average cost of purchasing a new electric vehicle for adopters was 55,000 NZD based on the median values, while non-adopters estimated 50,000 NZD to be the cost. Adopters underestimated the average cost of a new electric vehicle by 17.91%, while non-adopters underestimated by 25.37%. Moreover, while both distributions were left-skewed, there were 7 more outliers varying from 5,000 to 100,000 NZD from the non-adopter estimates than the adopter ones. It is also important to note that the difference in size of the quartiles is due to the sample sizes not being equal.

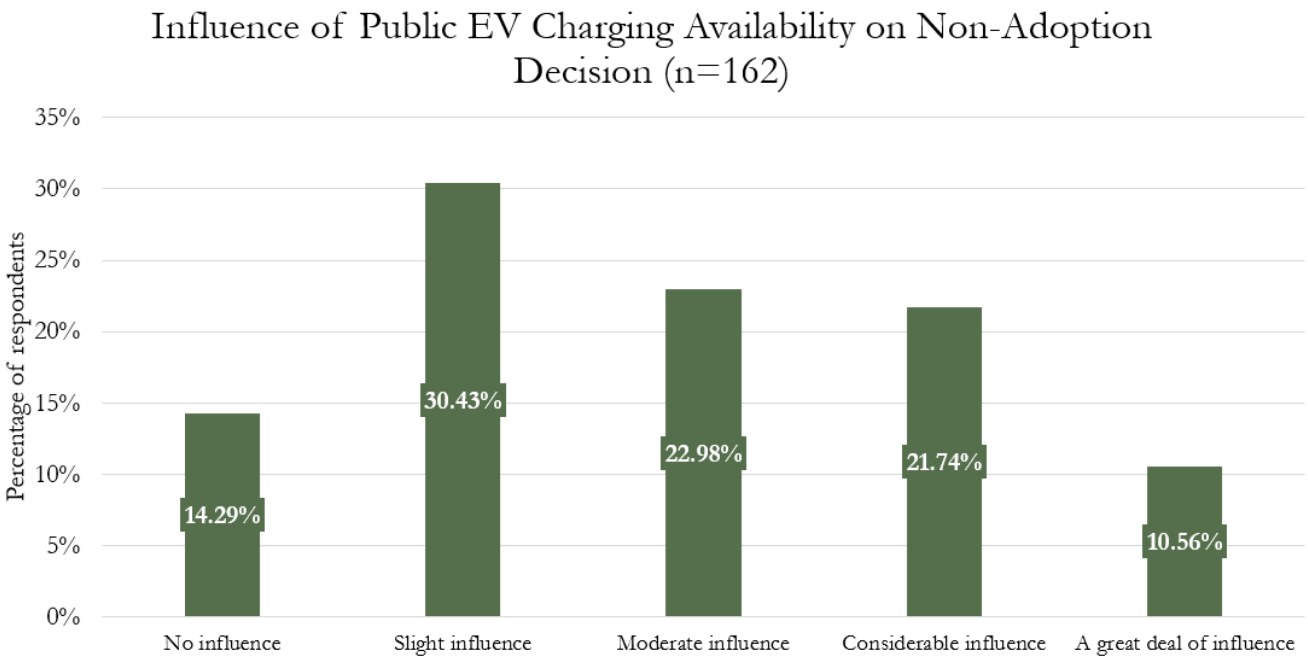


Figure 29. Influence of public EV charging availability on non-adoption decision

Note. Non-adopters (n = 162)

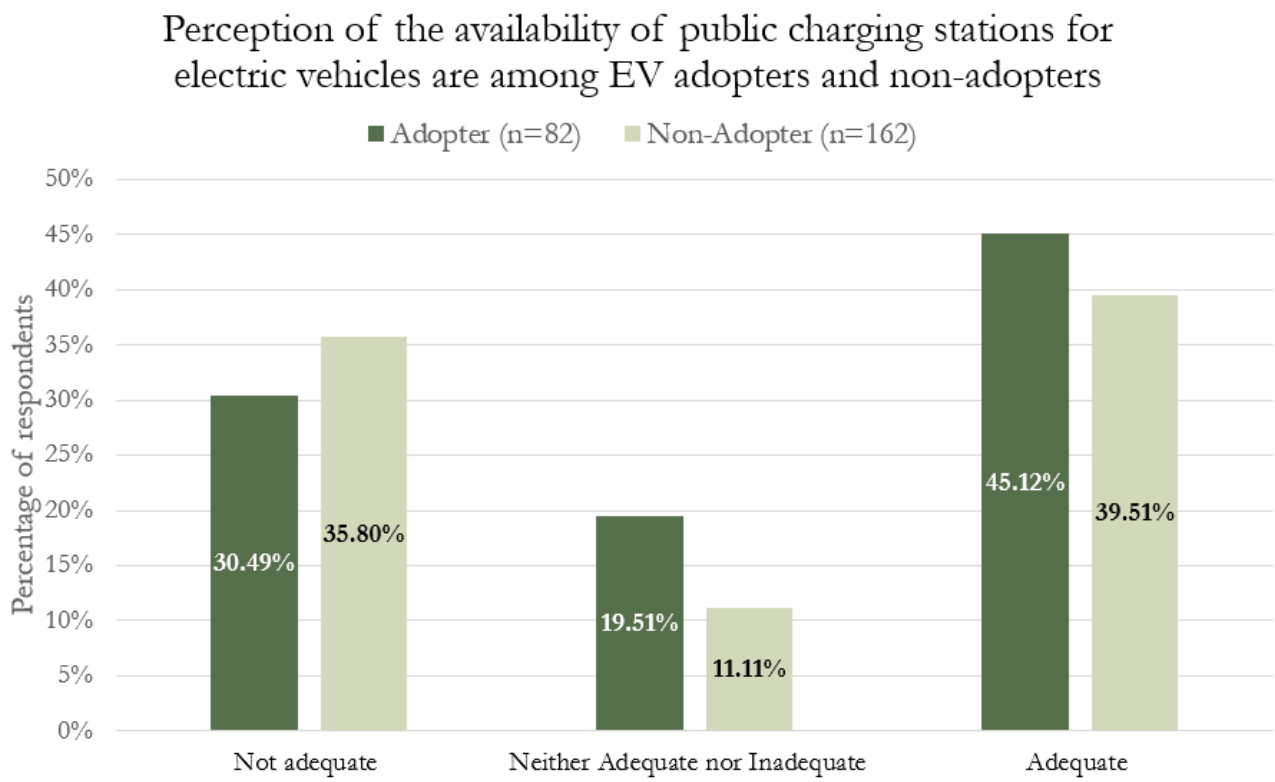


Figure 30. Perception of public charging infrastructure

Note. Adopters (n = 82), non-adopters (n = 162)

Figure 30 illustrates how participants viewed the availability of public charging stations for electric vehicles across Wellington. Since two sets of data with different sample sizes were being compared, proportions were used instead of raw counts. This normalization helps compare the relative distribution of selections across both EV adopters and EV non-adopters without the bias of differing sample sizes. The options 'Not adequate' and 'adequate' include the grouped values of two options, for the full breakdown please refer to Appendix B. While 85.7% of non-adopters indicated the availability of charging infrastructure had at least *some* influence over their decision to not adopt as shown in ***Figure 29***, less than 50% of both EV adopters and non-adopters viewed the current availability of charging infrastructure as adequate.

4.4 Identifying and Ranking Barriers

The second and third objectives for our project were to identify and rank any barriers preventing an equitable uptake of solar panel technology and electric vehicles. We addressed these objectives by including questions in our survey that would allow adopters to select concerns that applied to them during their adoption process. We enabled non-adopters to select which barriers they believe apply to themselves, or others, when considering adopting solar panels and electric vehicles. Furthermore, we included questions that allowed adopters and non-adopters to rank the barriers they selected.

4.4.1 Residential Solar Panels

4.4.1.1 Non-Adopters

Non-Adopters	Average Rank Position	Median Rank Position	Rank Range
1. High Initial Cost	1.71	1.0	1.0 – 5.0
2. Maintenance costs	3.49	3.0	1.0 – 5.0
3. Lack of information	3.60	4.0	1.0 – 5.0
4. Homeownership Status	3.65	4.0	1.0 – 5.0
5. Shading and obstructions	3.74	4.0	1.0 – 5.0

Table 2. Distribution of non-adopter ranking barriers for solar panels

Note: Non-adopter, (n = 223). A smaller number (closer to 1) means the barrier was ranked as more significant

When non-adopters were asked to rank barriers in terms of how likely they are to prevent individuals from adopting solar panels, "High initial cost" was the barrier that was ranked the highest on average. This suggests that the greatest barrier to entry of residential solar panels is the high upfront cost associated with the technology. The next highest ranked barrier, 'Maintenance costs,' suggests a concern about the ongoing expenses or potential long-term financial commitments associated with residential solar panels. Three barriers tied for third place in terms of median rank, including 'Lack of information,' 'Homeownership status,' as well as 'Shading and obstructions.' The barrier 'Lack of information' ranked moderately high on average which suggests that individuals might be discouraged from adopting the technology due to limited knowledge on the topic and the benefits associated with it. Additionally, the barrier related to 'Homeownership status' indicates that certain individuals might be unable to consider adopting solar panels due to their rental status, irrespective of their willingness in doing so. In fact, 'Homeownership status' was the second most common barrier ranked in first place, behind only 'High initial cost.'

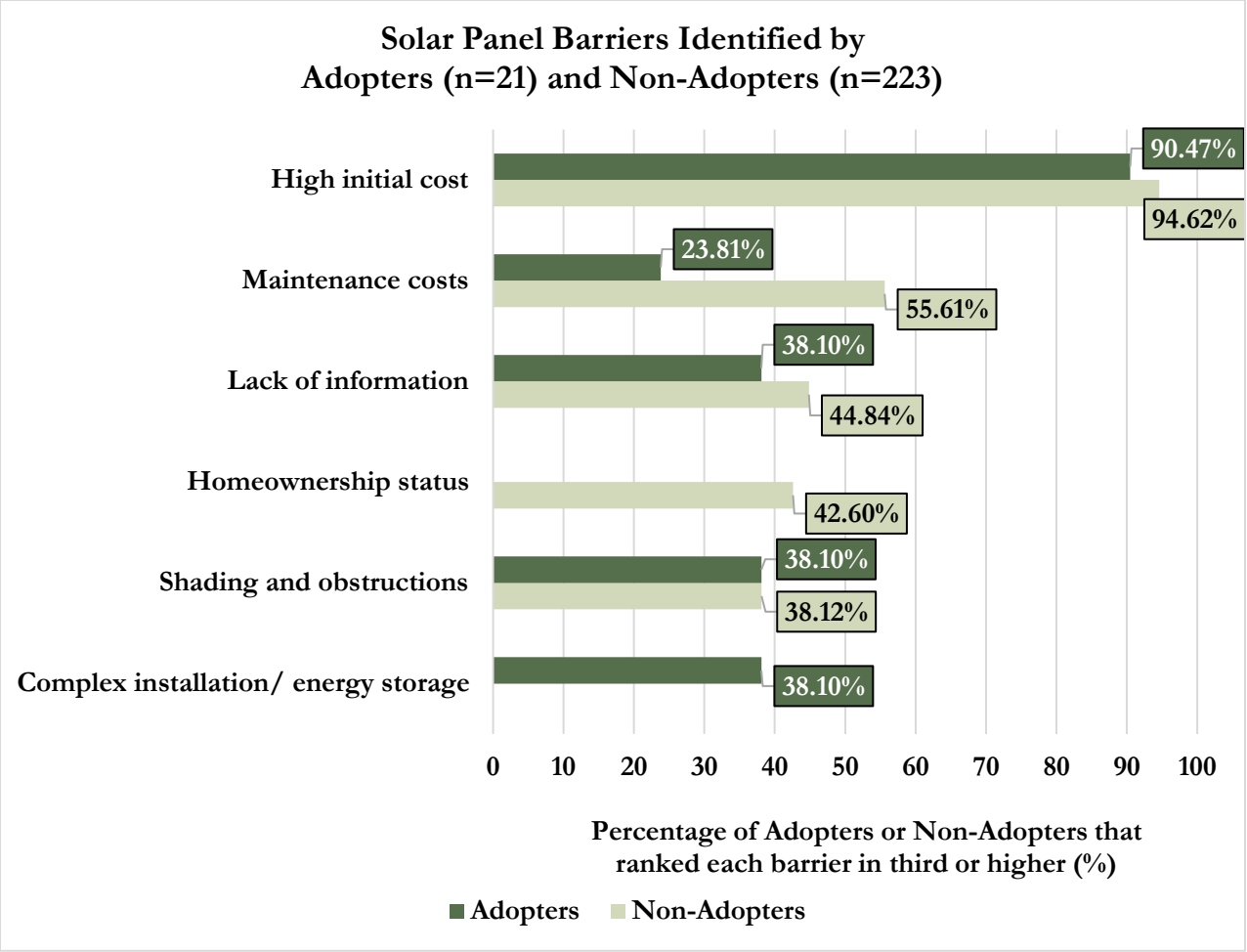


Figure 31. Percentage of times each barrier for solar panels was ranked in the top three out of all adopters and non-adopters, respectively

Figure 31 shows the difference in how adopters and non-adopters ranked barriers. One notable difference is that while non-adopters ranked maintenance costs higher on average (on average in 2nd place), adopters ranked it quite low (on average in 7th place). This could reflect some misinformation surrounding long-term costs associated with solar panel technology. For the option to include a barrier or concern that was not listed, the responses included but were not limited to concerns about long payback periods, recycling of the materials, presence of high winds/other weather, and concerns surrounding the ethics of solar panel manufacturing and disposal.

4.4.2 Electric Vehicles

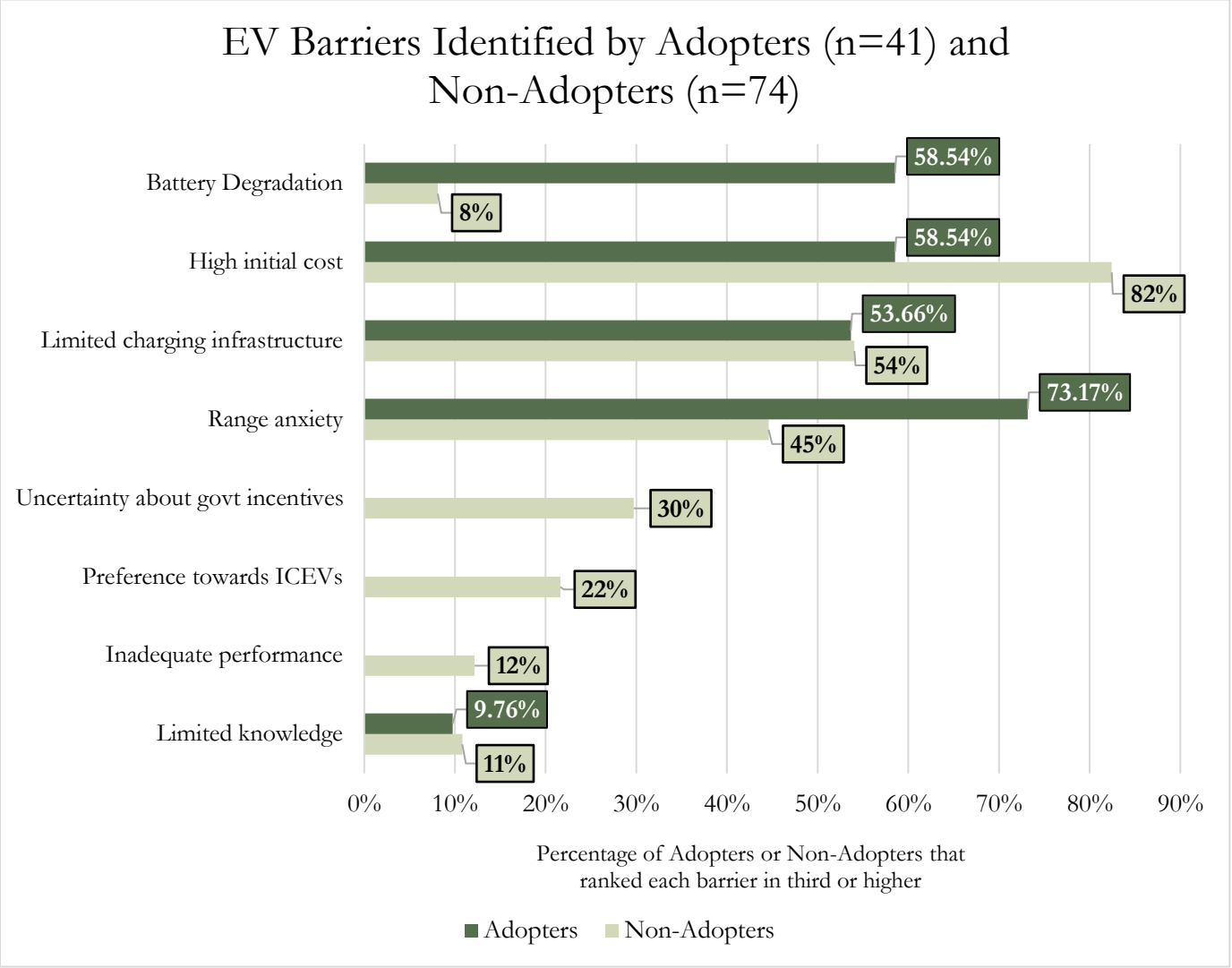


Figure 32. How EV adopters and non-adopters ranked barriers

Non-Adopters	Average Rank Position	Median Rank Position
High initial cost	1.45	1.0
Not listed	1.72	2.0
Preference towards ICE vehicles	2.16	2.0

Range anxiety	2.67	2.0
Limited charging infrastructure	2.76	3.0
Limited knowledge/information	3.0	3
Uncertainty about government incentives	3.0	3
Inadequate performance	3.5	3

Table 3. *Distribution of non-adopter ranking barriers for EVs*

Note. Non-adopter, (n = 166). A smaller number (closer to 1) means the barrier was ranked as more significant

Non-adopters of electric vehicles, like non-adopters of solar panels, ranked 'High Initial Cost' as the highest barrier on average. Two barriers tied for second place in terms of median rank, including preference towards ICE vehicles and range anxiety. Furthermore, the option to add a barrier that wasn't listed was ranked highly with a median of second place. Responses for this option varied widely and included, but were not limited to, concerns around battery recycling and degradation, limited/no space for a car or charger at the residence, not having a need for a vehicle in general, lack of EV options, and high electric bill costs.

Adopters of electric vehicles ranked high initial cost as the highest barrier on average as can be seen in Figure 31. The two barriers for second place in terms of median rank were limited driving range and battery degradation over time.

4.5 Qualitative Results

In the following section, the analysis of 13 interviews is represented. The following mentions the adoption statuses of the interviewed survey takers and professionals.

- Non-Adopters: 6
- Adopters of Both: 4
- EV Only Adopters: 2
- Solar Only Adopters: 1

During each interview, the participant and interviewer discussed topics highlighting our three objectives: personal and public awareness of renewable technologies, participants' barriers towards adoption, and how those barriers ranked.

4.5.2 Residential Solar Panels

By assessing the frequency of quotes within each category, it becomes evident that the most prevalent negative barriers mentioned encompass 'Homeownership Status' and 'High Initial Cost.' However, 'Homeownership Status' seemed to be a barrier primarily for non-adopters of the technology. We discovered that most non-adopters that had mentioned their homeownership status had an interest in the technology but were prevented from adopting due to extended payback periods or housing status.

> "
>
> ***I would expect it to be quite heavily subsidized if the government wants to push the incentive on homeowners to transition to more sustainable type of energy.***
>
> "
>
> **- Non-Adopter**

'High Initial Cost' was another common barrier shared by both solar panel adopters and non-adopters. Among non-adopter interviewees, there was a prevailing perception that regarded solar power as an added expense. On the other hand, adopters of solar panels perceived the technology as an investment that would eventually pay themselves back.

However, the costs of not only the solar panels but also a battery system seemed to be an issue for non-adopters and adopters of the technology, with this adopter of solar explaining his dilemma with the high expense of purchasing and installing a battery alongside solar panels below.

> “
>
> ***It's something I've been interested in for a very long time, and I've just never had the opportunity or been in the position to be able to install.***
>
> ”
>
> **- Adopter**

> “
>
> ***I mean, they are expensive, solar panels, and getting them installed is expensive, but there is a decent payback, and if people wanted them, I don't think cost is the issue; [the cost] is just a bit overwhelming.***
>
> ”
>
> **- Adopter**

Individual awareness displayed favorable trends, whereas public awareness had fewer encouraging associations. Many adopters felt knowledgeable about solar technology and mentioned a positive relation towards their knowledge of solar or how they researched the technology 18 times. However, adopters mentioned 13 times how difficult it was to maneuver online sources and become interested in the technology.

> “
>
> ***It can be confusing in the sense that there's lots of different equipment and technology to choose from and, unless you're in that industry, I think it's quite hard to understand, even at a technological level, it was even difficult for me.***
>
> ”
>
> **- Adopter, and CEO of an Energy Technology Company**

4.5.3 Electric Vehicles

After assessing the frequency of quotes in each category, it is evident that the most prominent barriers for both adopters and non-adopters were ‘High Initial Cost’ and ‘Charging Infrastructure/Range anxiety.’ Non adopters, whether interested or not in the technology, commonly cited ‘High Initial Cost’ as a decisive barrier influencing their decision regarding adoption. As one interviewee pointed out, most people have a desire to reduce emissions and contribute to environmental causes, however cost is still so prohibitive for most individuals.

> “
>
> ***People want to have lower emissions and contribute but the ceiling to get into there is too high. I know the government put in their incentive to help it, but I think it was still too high for a lot of people.***
>
> ”
>
> **- Non-Adopter**

Another interviewee provides their perspective on why they did not adopt an electric vehicle,

> “
>
> ***...the cost was probably the biggest factor that discouraged us from purchasing [a hybrid or fully electric vehicle]***
>
> ”
>
> **- Non-Adopter**

The significance of a ‘High Initial Cost’ is further emphasized by a senior research fellow from the Department of Public Health with the following quote,

> “
>
> ***Cost is definitely going to be a barrier for people that are already experiencing energy hardship and pushing them into transport poverty further, if they are not able to access these technologies.***
>
> ”
>
> **-Energy Poverty Expert**

In addition to the barrier of a ‘High Initial Cost,’ another inhibiting factor arises for non-adopters: concerns about inadequate charging infrastructure paired with range anxiety. This is best expressed by the following non-adopter:

> “
>
> ***I just like knowing that I can pull over anywhere I can fuel up anywhere and not have to worry about the battery going flat.***
>
> ”
>
> **- Non-Adopter**

When asking an adopter if they shared similar concerns prior to adopting their electric vehicle they described their concern on range anxiety was influenced by what other non-adopters were saying.

> “
>
> ***I was only concerned because I had read about people having range anxiety, I was influenced by what I'd heard and read...***
>
> ”
>
> **- Adopter**

When asking an adopter about their experiences with the charging available in the area they said the biggest inconvenience was not the availability of charging stations, rather the queue some of the chargers may have.

> “
>
> ***it's only the inconvenience factor of getting there and finding out that somebody's on the charger.***
>
> ”
>
> **- Adopter**

There also exists a prevailing perception concerning battery degradation in EVs, wherein the potential loss of range capability over time influences people’s decision about adopting EVs.

> “
>
> ***I think the biggest thing for me is the batteries, the [little] information that is out there [on] what happens to them when you've got to get rid of them; and they don't last long.***
>
> ”
>
> **- Non-Adopter**

This perception highlights a critical area where improved understanding on the advancements in battery technology could address any apprehensions individuals may have and encourage a higher uptake of electric vehicles.

> “
>
> ***there's a lot of, misinformation about batteries, and there is a huge anti EV and social media presence, and that will highlight that they're catch fire...***
>
> ”
>
> **- Adopter**

> “
>
> ***if they're going to do tests and stuff to show that they're safe, they can last for a long distance and their charge range is really long, It's something I'd look into.***
>
> ”
>
> **- Non-Adopter**

By thoroughly examining interview participants’ perspectives, concerns, and experiences, a few connections were found between the qualitative and quantitative data. Most participants in both the survey and interview felt underinformed about solar panel technologies. Conversely, most interviewees said they were knowledgeable about electric vehicles; however, the team identified a few misconceptions regarding battery degradation and range anxiety, which we go deeper on in the discussion. ‘High Initial Cost’ was consistently shown in qualitative and quantitative data analysis to be the most significant barrier/concern for adopters and non-adopters of both technologies. Barriers such as the high costs and prevailing lack of awareness surrounding these technologies provide a holistic perspective on the potential challenges that need to be addressed in order to encourage wider access and a more equitable uptake of these technologies.

5 Discussion

In this section we investigate relationships between various trends in our data to further delve into the data previously discussed. These data sets are then further analyzed using a collection of qualitative and quantitative data.

5.1 Residential Solar Panels

5.1.2 Solar Awareness and Barriers

The results discussed in section 4.3.1 on solar panel awareness indicate that a notable portion of the solar non-adopters surveyed may benefit from educational programs, accessible information resources, or awareness campaigns aimed at increasing their understanding of solar panel technology. This portion of the population is comprised of 84.5% of solar non-adopters who report being moderately or less informed on the technology, with over half of these being under informed. When asked to rank barriers that could be influencing an individual's decision to adopt residential solar panels, 'Lack of Information' was found to be ranked the 3rd most significant, subsequent only to 'High Initial Cost' and 'Maintenance Costs.' This indicates that non-adopters feel less informed about solar panel technologies, and also rank it highly as a barrier to uptake of the technology. Maintenance costs may also be an issue due to a lack of information amongst non-adopters about solar panel technologies. Lack of information being such a significant barrier to the equitable uptake of residential solar panels is further supported through the interviews conducted. The qualitative results for non-adopters also suggested that most participants with lower levels of awareness were likely to be less willing to adopt these technologies.

> ***What do [solar installations] even look like? I think I'm entry level understanding, I don't even know what [residential solar panels] look like.***
>
> **- Non-Adopter**

The need for enhancing public knowledge and understanding of these technologies has become crucial. By not addressing the lack of awareness, the idea of installing residential solar panel systems might not even enter someone's considerations as a viable option for their household.

> ***I wouldn't make a financial purchase on something that I'm not fully understanding of.***
>
> **- Non-Adopter**

While lack of awareness presents a significant barrier to solar panel adoption due to its influence on decision-making, there were additional barriers in the results section 4.4.1. 'High Initial Cost' was one of the most reported barriers by far, always ranking first among adopters and non-adopters by a considerable margin. Some interviewees addressed that they would not even consider adopting solar if a subsidy were not provided by the government due to its unaffordable cost.

> “
>
> ***I think there definitely should be some responsibility on the government's behalf, enough to provide a decent subsidy, because I don't see how many people could be adopting solar unless they had a disposable income.***
>
> ”
>
> **- Non-Adopter**

‘Maintenance cost’ was another significant barrier reported as impeding one’s inclination to adopt. Concerns about the upkeep of installed solar panels, including potential component replacements, were sources of worry for numerous interviewees that had not adopted the technology. This points towards a lack of awareness or knowledge among non-adopters. This is because maintenance costs are not as concerning for adopters, as they ranked quite low on average (see ***Figure* 30)**.

> “
>
> ***I'm just fairly ignorant about this sort of thing, is that going to be ongoing? that you must have people come in and maintaining it?***
>
> ”
>
> **- Non-Adopter**

However, solar adopters found very few costs associated with maintaining these solar panel systems in their residences.

> “
>
> ***There's no maintenance to a panel other than cleaning them, I jump out every now and then and just give them wipe down with some water and the brush.***
>
> ”
>
> **- Non-Adopter**

Addressing the lack of awareness effectively seems essential, possibly through government or government-funded agencies providing accessible, accurate information about solar technology. In addition, offering incentives, or rebates, to Wellington and all New Zealand residents in general could result in a more informed and receptive public. Thus, reducing the frequency of reported barriers such as ‘Lack of awareness’ and ‘High upfront costs’ could indicate a future where individuals that are interested in solar panel technology are able to adopt it.

5.2 Residential Solar Panel System Correlations

From the data we have received and analyzed, our team has been able to determine plausible correlations in terms of participant awareness along with how income levels determine a person's accessibility to own these renewable energy technologies.

5.2.1 Non-Adopters

Within our non-adopter section, there were a few interesting relationships related to income and the role it plays in adopting residential solar. When analyzing the data, we discovered that there seemed to be a lot of participants that selected a high upfront cost as their highest barrier. This was determined from analyzing the question that asked participants to rank and prioritize their barriers for adopting solar technology on a scale of 1-5 (***Figure 30***). When analyzing the results, we decided to compare them with each participant's average income to see how their income status correlated with where they ranked price as a barrier (See ***Figure 33***).

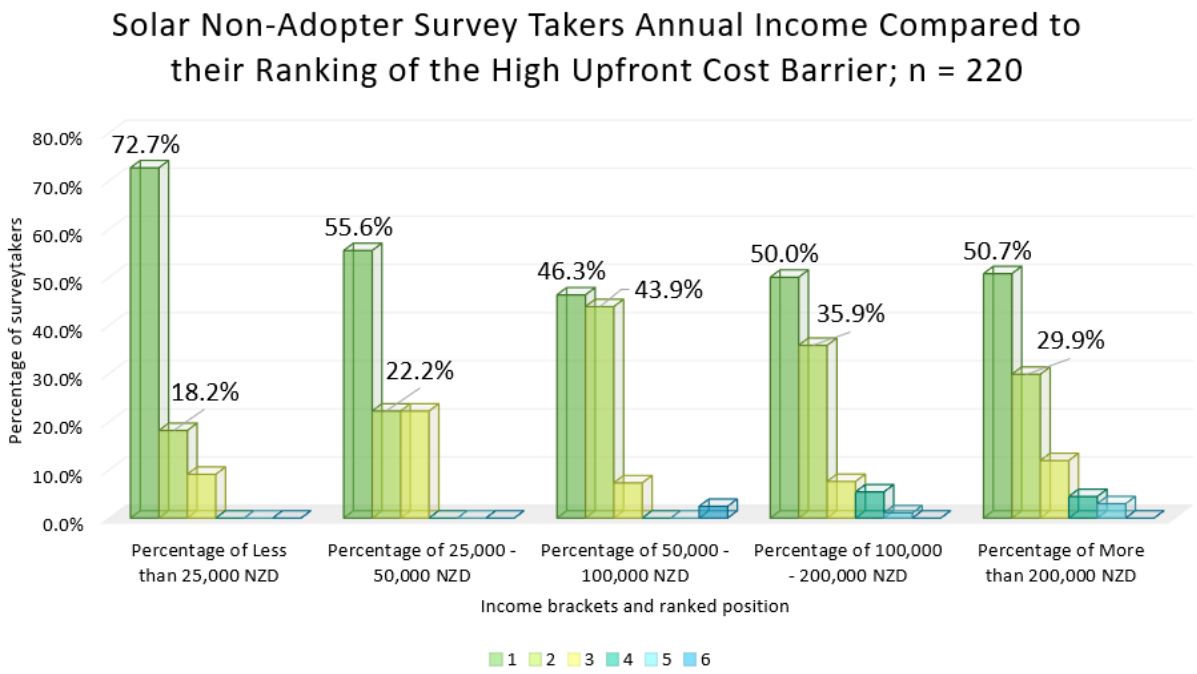


Figure 33. Distribution of how survey respondents ranked high up-front cost compared to their household income level

In **Figure 33**, individuals with an average annual income of less than 25,000 NZD and between 25,000-50,000 NZD were the most likely respondents to place 'High Initial Cost' in 1st place when ranking their barriers, with 72.7% and 55.6% of these respondents placed 'High Initial Cost' as their 1st barrier, respectively. Survey respondents that had a higher income were more likely to rank 'High Initial Cost' in 2nd place or lower when asked to rank the barriers.

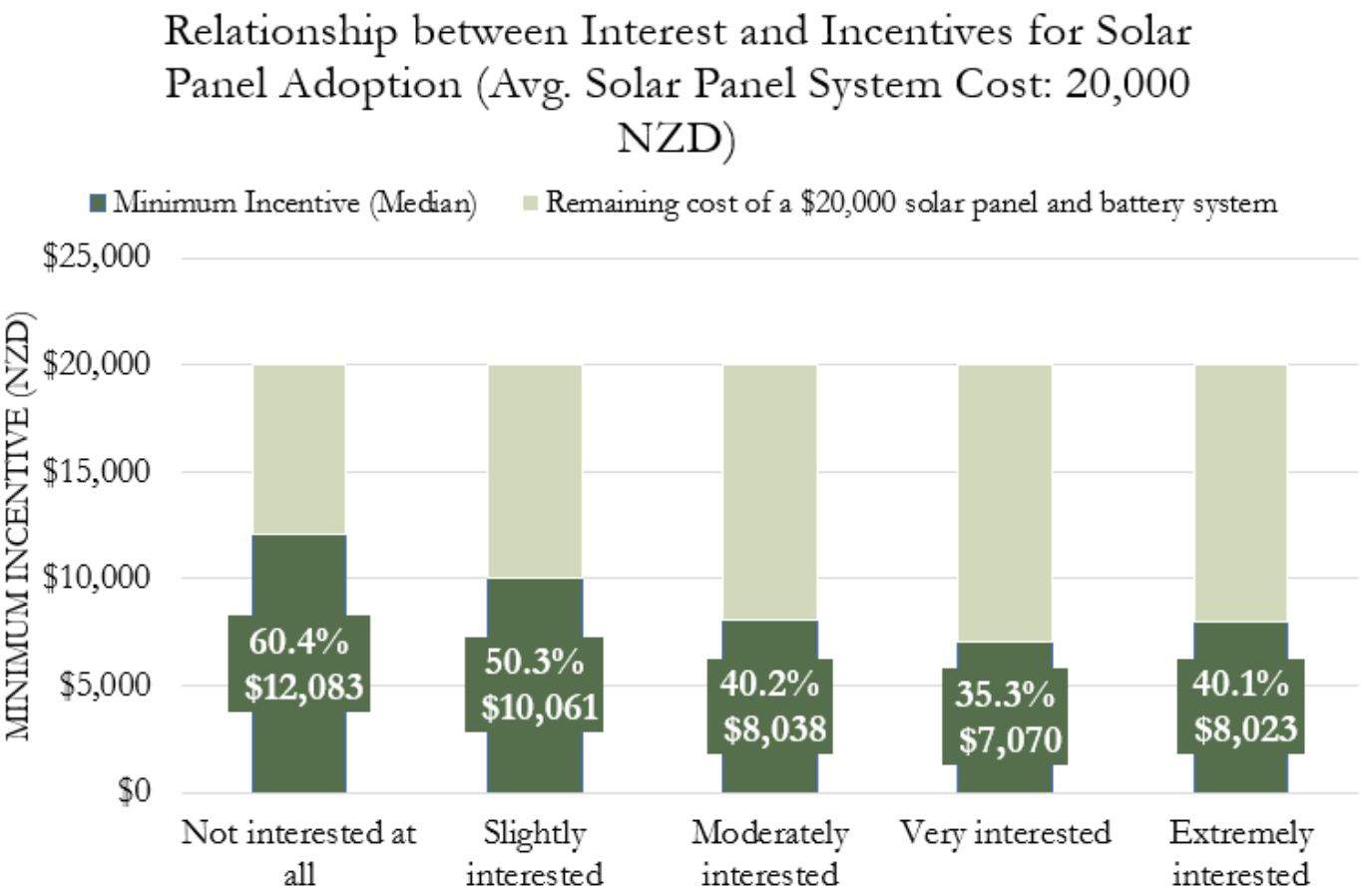


Figure 34. Average minimum incentive required by non-adopters as it relates to their interest level in solar panels

Figure 34 indicates a correlation between the minimum incentive that a person would require to consider adopting residential solar panels and their overall interest in adoption. Participants that were more interested in adopting solar technology (this includes extremely, very, and moderately interested) on average asked for a lower incentive on the order of 7,000-8,000 NZD or about 35-40% of the overall cost of the technology. Whereas individuals that were not interested in the technology at all expressed the need for higher incentive amounts overall at around 12,000 NZD or around 50-60% of the overall cost of the technology.

An individual's varied interest level in adopting solar panels and the corresponding minimum incentives (median) they would require was found to be negatively correlated, $r(222) = -.87$, $p = .004$ using the Pearson correlation coefficient. This suggests a strong negative correlation between interest levels in adopting solar panels and the desired minimum incentives. In other words, as the

interest in adopting solar panel technology increases, the minimum incentive required to adopt tends to decrease significantly.

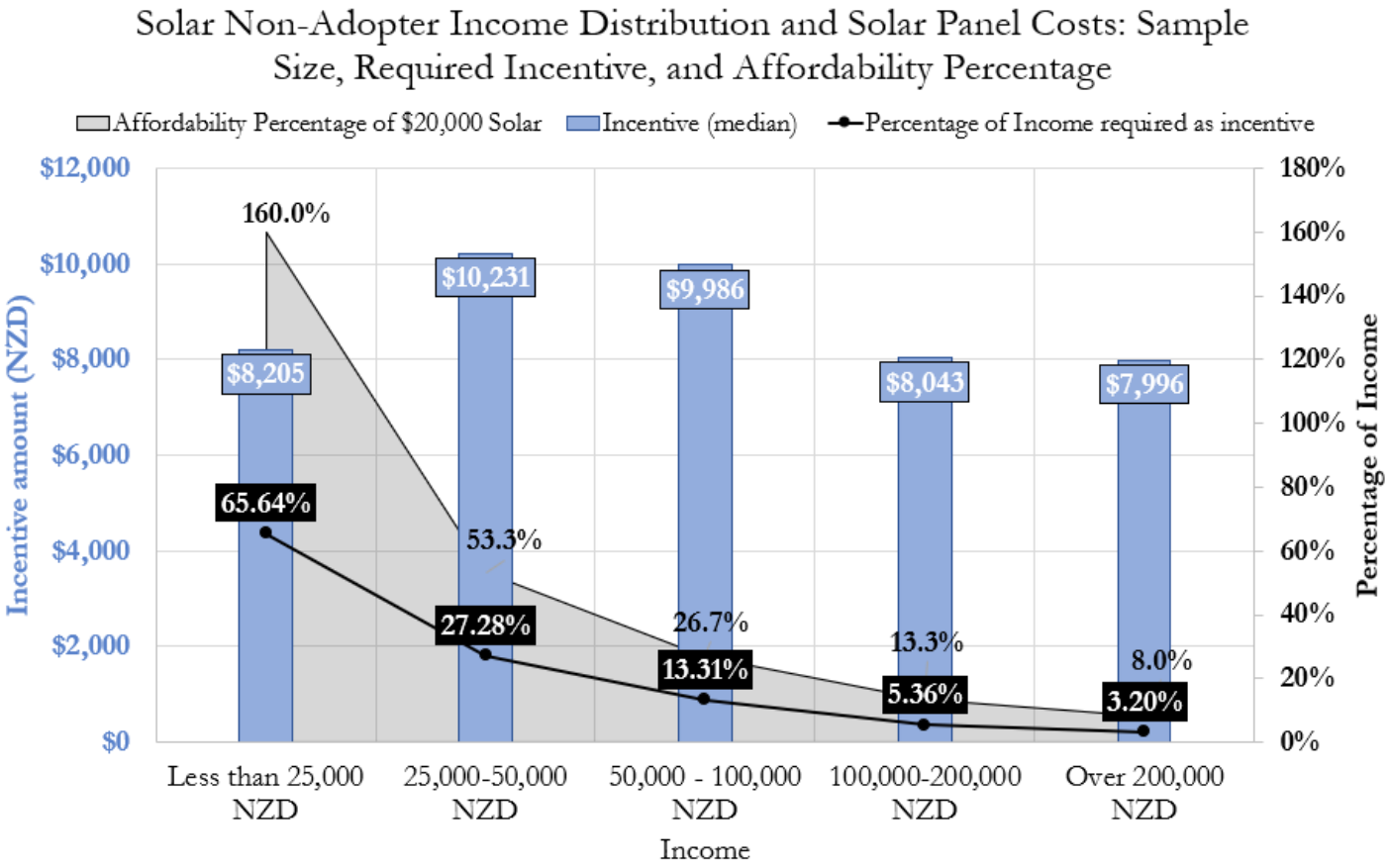


Figure 35. Ratio of average minimum incentive required by solar panel non-adopters by income bracket.

Note: (n = 228) For each income range the average value was used to calculate the affordability percentage and required incentive percentage (ie. for an income bracket of 100,000 - 200,000 NZD, 150,000 NZD was used). For the more than 200,000 NZD group, we used 250,000 NZD.

Figure 35 indicates that a participant with an income below 25,000 NZD would need an incentive, on average, that would compare to about 65.64% of their average annual income (which is equivalent to 13,128 NZD) to consider adopting residential solar panels. Whereas participants with an income of over 200,000 NZD would require an incentive, on average, that would compare to about 4% of their average annual income. The drastic difference between these two income brackets on either side of the range strongly suggests that a high up-front cost would pose a disproportionately more influential barrier to entry for someone of lower income.

5.3 Electric Vehicle Correlations

From the data we have received and analyzed, our team was able to determine plausible correlations for non-adopters of electric vehicles.

5.3.1 Electric Vehicle Awareness and Barriers

The results discussed in section 4.3.2 of the electric vehicle awareness section indicated that, while individuals might benefit from additional information sources, a significant portion of those who have not adopted electric vehicles already feel knowledgeable about it. However, this portion of the population that feels knowledgeable about the technology already might have been fed quite a bit of misinformation regarding knowledge about EVs. There were times in interviews where people specifically mentioned the disinformation being spread about battery longevity and range anxiety.

> “
>
> ***The whole situation with electric vehicles is a bit of a hornet's nest at the moment. There is a lot of fear, uncertainty, and disinformation being spread about the viability of EVs...***
>
> ”
>
> **- Adopter**

Even with the accurate and trustworthy information that is presented online, it can often be confusing for people to navigate.

> “
>
> ***It's a disadvantage; the fear, uncertainty and disinformation people will push...***
>
> ”
>
> **- Adopter**

While the team identified misinformation as a potential barrier through interviews, there were other barriers reported by non-adopters that were deemed more prominent. Of which, high costs emerged as a significant barrier limiting adoption.

> “
>
> ***If I could afford both, I'd have both.***
>
> ”
>
> **- Non-Adopter**

About 12.6% of non-adopters (n = 159) expressed a preference to toward ICE (internal-combustion-engine) vehicles. This preference, further highlighted in interviews, stemmed from concerns about range anxiety, uncertainties regarding the lifetime of EV batteries and a genuine disinterest in EV technology. Range anxiety, partly influenced by the charging infrastructure in New Zealand, appeared to be a significant barrier preventing an uptake of EVs compared to an ICE counterpart.

> “
>
> ***I've got a little bit of existential fear about EV's, you'll be driving up on a road trip and you just run out of energy. How do I fuel up? Because there's gas stations everywhere, and I only know of one EV rechargeable place.***
>
> ”
>
> **- Non-Adopter**

Through the government facilitating easier access to precise and reliable information about EV technologies, offering improved incentives or rebates to New Zealand residents, and enhancing charging infrastructure, the public could become more informed and receptive. This would be the first proactive step in reducing the frequency of reported barriers such "High Initial Cost", "Range anxiety" and "Lack of awareness" for the adoption of EVs. As seen in approving the uptake of EV adoption in Europe and the U.S. case study, a mix of policies that address these barriers are likely needed to substantially improve rates of EV adoption.

5.3.2 Non-Adopters

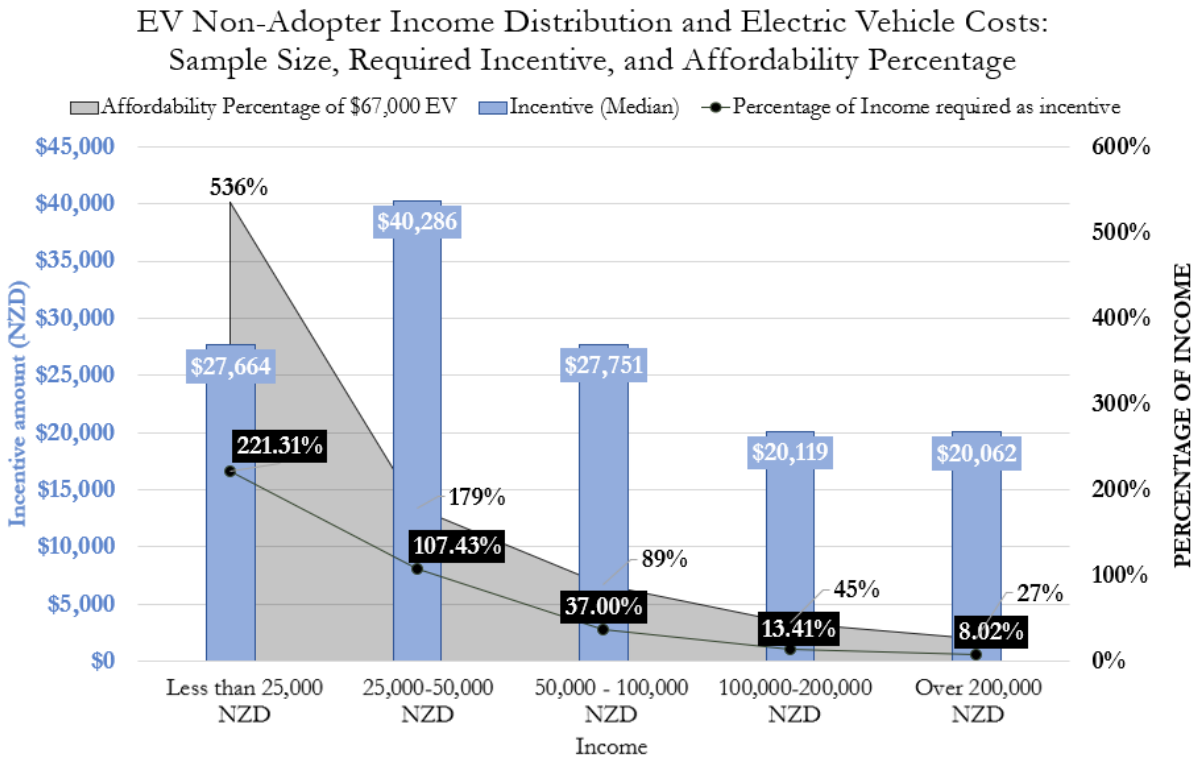


Figure 36. Ratio of minimum incentive required by EV non-adopters by income bracket

Note: (n = 166) For each income range, the average value was used to calculate the affordability percentage and required incentive percentage (ie. for an income bracket of 100,000 - 200,000 NZD, 150,000 NZD was used).

Figure 36 shows the percentage of the individual's income it would take to adopt an electric vehicle (based off the median incentive in NZD required). This graph indicates that the higher the annual household income, the lower the minimum incentive required to adopt relative to their annual household income. For example, a participant with an income below 25,000 NZD would need a minimum incentive that would compare to, on average, 221% of their average annual income to consider adopting an electric vehicle (27,660 NZD). Whereas participants with an average household income of over 200,000 NZD would need an incentive that would compare to about 8% of their average household annual income (20,000 NZD). The incentive required for lower income households to adopt an electric vehicle is significantly higher compared to their income. Conversely, higher income households require a substantially lower percentage of their income as an incentive to adopt. This discrepancy highlights a disparity in the proportion of income needed to consider EV adoption, indicating that lower income households could find it more financially burdensome to adopt the technology. The incentives needed to make the uptake of EV equitable might be challenging to achieve because the previous clean car discount, which is disappearing, offered a maximum of about 7,000 NZD. This amount falls short—less than half of what people with household incomes over $200,000 said they need as a minimum incentive according to the survey, which was $20,687.

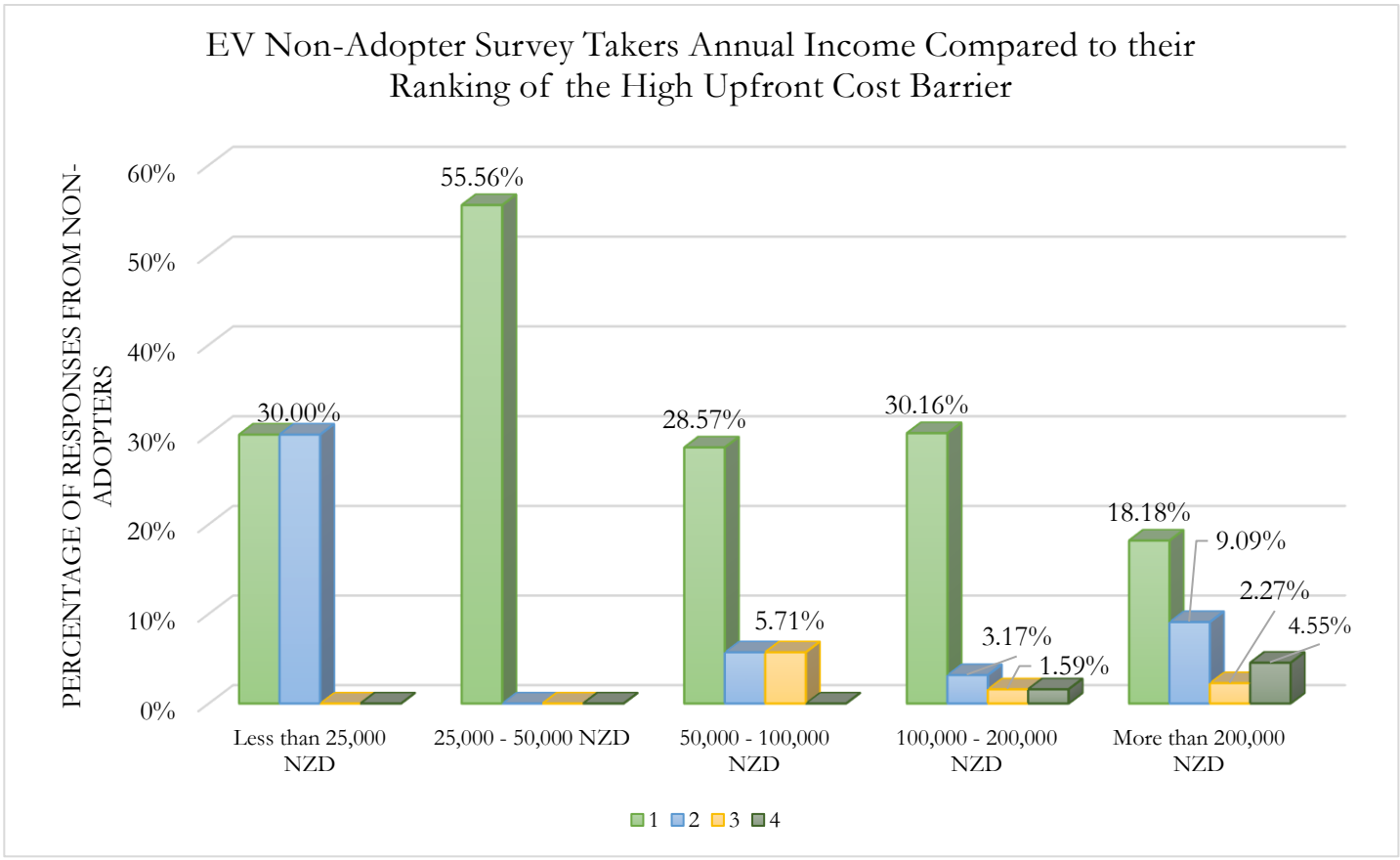


Figure 37. How "High upfront cost" EV barrier ranked across income groups

Note. (n = 161) Each bar represents the percentage of people from that income group that ranked "High upfront cost" in its respective rank

Figure 37 shows how the "High upfront cost" EV barrier ranked among different income groups of EV non-adopters. The 25,000 – 50,000 income group had the largest percentage who ranked it first, at 55%. Furthermore, groups with higher household incomes were less likely to rank "High upfront cost" as first and rather, put it lower than other barriers.

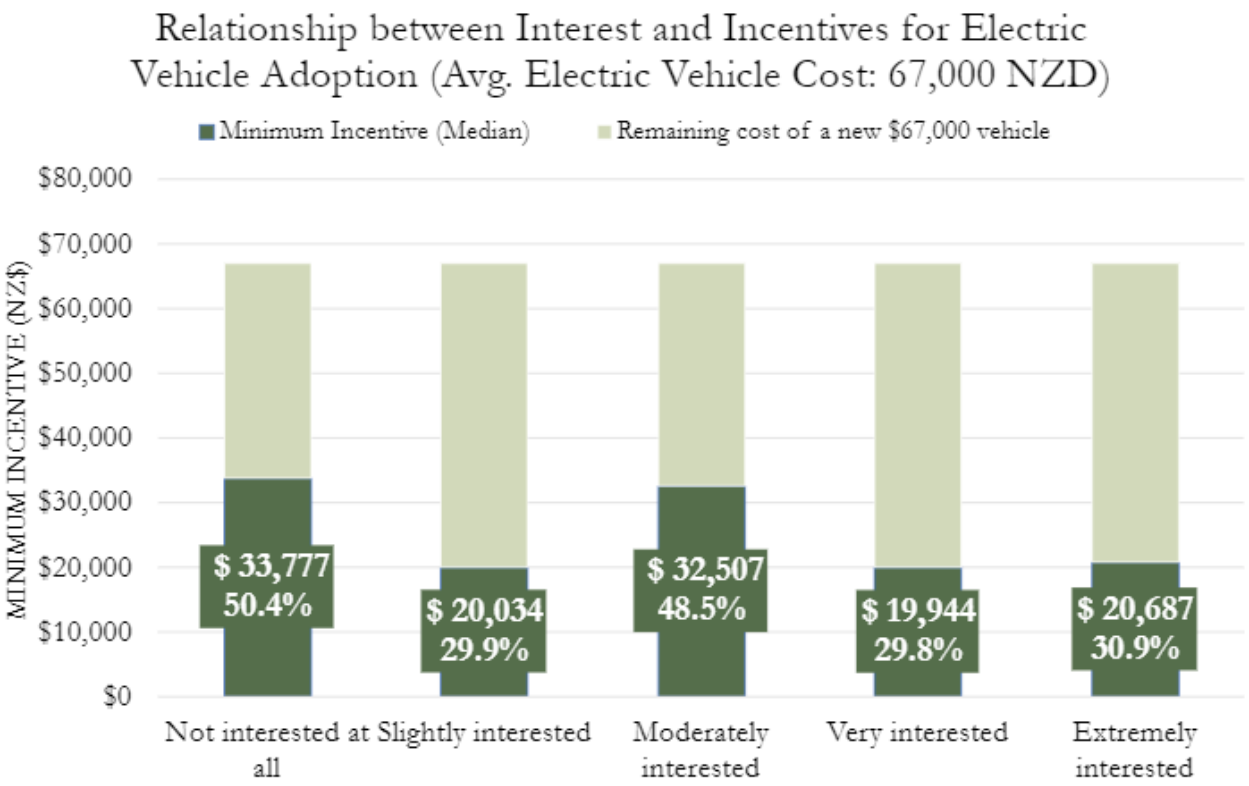


Figure 38. Average minimum incentive required across interest levels of EV non-adopters

Note: (n = 158)

Figure 38 shows the relationship between the minimum incentive that a person would require to consider adopting an electric vehicle and their overall interest in adoption. Participants that were more interested in adopting electric vehicles (this includes extremely and very interested) on average asked for a lower incentive on the order of 19,000 - 20,000 NZD or about 29.8-30.9% of the overall cost of the technology. Whereas people that were not interested in the technology at all expressed the need for higher incentive amounts overall at around 33,000 NZD or around 50% of the overall cost of the technology.

An individual's interest in adopting an electric vehicle and the corresponding minimum incentives (median) required to do so was found to be moderately negatively correlated, $r(156) = -.58$, $p = .046$ using the Pearson correlation coefficient. This suggests a strong negative correlation between interest levels in adopting solar panels and the desired minimum incentives. This emphasizes the tendency for higher interest to align with lower desired incentives for purchasing an EV.

6 Conclusions

This research project aimed to assess the awareness surrounding residential solar panels and electric vehicles, as well as identify the most significant barriers preventing an equitable uptake of both technologies. Our findings indicate a general lack of awareness regarding residential solar panel technologies, accompanied by some misconceptions surrounding electric vehicles. Additionally, notable barriers were identified for both electric vehicles and residential solar panels.

Objective 1: Assessing Public Awareness

Our findings indicate that awareness levels for residential solar panels are low, especially for non-adopters. As can be seen in ***Figure 24,*** 46.9% of solar non-adopters' report being 'Not Informed at All' and 'Slightly Informed' regarding residential solar panels. This results in a distribution curving heavier towards less knowledge by 31.4%.

Public awareness on electric vehicles proved to be a bit better than that of solar panels. The distribution shown in ***Figure 26*** shows 28.7% of responses with lower reported levels of knowledge, while 19.4% of non-adopters reported being "Very informed" and "Extremely informed". Furthermore, from conducting interviews and analyzing open responses dispersed throughout the survey, we found that there are misconceptions surrounding electric vehicles. For example, we heard concerns from non-adopters regarding battery life and degradation, meanwhile adopters cited that these were misconceptions regarding the technology. We also heard a few individuals who were apprehensive regarding the expense of replacing an entire EV battery in case of failure. However, an adopter shared an experience with a used EV where mechanics successfully resolved battery issues by replacing a single cell instead of the entire battery unit. It is important to note that studies have shown that the total cost of ownership of electric vehicles, with battery

degradation considered, can be on par with or sometimes lower than that of ICE vehicles ("Electric Vehicle Battery Life" 2017).

Objectives 2 & 3: Identifying and Ranking Barriers

The three most significant barriers we found preventing an uptake in the adoption of residential solar panels were high initial cost, maintenance costs, and lack of information. Participants indicated that solar panel technology still seems to be far too costly for it to be a viable option for many people. Furthermore, 'Lack of information' being ranked so significantly goes to show that awareness surrounding the technology is not ideal. While non-adopters ranked maintenance costs quite high as a barrier, it was ranked very low among adopters of residential solar panels. There was no correlation between income levels and the rank of 'Maintenance costs' as a barrier (when split by adoption status). This discrepancy in how 'Maintenance cost' is positioned among the barriers between the two adoption statuses may suggest an exaggerated perception of its significance compared to its actual impact.

The most significant barriers we discovered for the adoption of electric vehicles were high initial cost, limited charging infrastructure, and range anxiety. Like solar panels, electric vehicle technology was expressed to be too expensive to be adopted equitably, with 158 non-adopters requesting a minimum incentive between 19,900-33,800 NZD to consider adopting a new EV with an average cost of 67,000 NZD ("Compare EV Models" n.d.) as highlighted in ***Figure 35***. That would equate to 29.7% and 50.0% of the average cost. Furthermore, enhancing the availability of public charging infrastructure across the Greater Wellington region would prove beneficial for those considering the adoption of EVs but that are reluctant due to range anxiety.

7 Recommendations

7.1 Solar Panel Technology

Our team's first recommendation to increase the equitable uptake of solar panels in Wellington is to increase public awareness levels. As seen in ***Figure 24***, public awareness levels regarding solar panels are insufficient. From our research, we believe an increase in awareness could spark more interest in solar panels.

The first aspect of this is for Ara Ake to initiate public awareness campaigns about household solar panel technology. The purpose for these campaigns should be to provide people with factual information, so they can make well-informed decisions about solar panel technology. This will hopefully shift the focus away from solar installers, who often distribute information with the motivation of increasing sales. Ara Ake's campaigns can emphasize commonly misunderstood aspects of solar panel installation, such as installation costs, maintenance costs, and payback periods.

Another key component of our recommendation to Ara Ake is the use of centralized information sources focused on the types of incentives that are currently available. As it currently stands, it is difficult for the common person to find independent sources that provide reliable, unbiased information about solar panels. For example, some companies allow solar panel users to sell energy back to the grid. A centralized source can give an overview of which companies allow this, as well as details of how the process works, keeping their information as up to date as possible. This can simplify the process for the public so that information is more digestible for the average person.

We observed two peaks in our data regarding homeownership status. The first peak came with participants placing it as a barrier between rank 1-3 and the second peak when it was ranked

between 3-6. The extent that homeownership status has on an individual's decision to adopt is currently unclear. We recommend further research investigating the affect homeownership status has on a person's decision to adopt solar panel technology (and perhaps even electric vehicles).

Finally, with High Initial Cost being a significant barrier, we recommend that incentives should be provided to increase the uptake of solar panels. From insight through our interviews, multiple participants identified rebates and feed-in tariffs as incentives they would love to see implemented in the future. Rebates will alleviate the high upfront cost from potential customers, making solar panels a more attractive purchase. When rebates were discussed in interviews, the majority of participants mentioned their preference for rebates to vary based on income level. This would additionally help level the playing field. Feed-in tariffs, another preferred incentive, are a way of selling excess energy back to the grid for a fixed payment, usually above market rate. This allows solar adopters to save on their power costs and can offset some of the initial upfront cost in the long run.

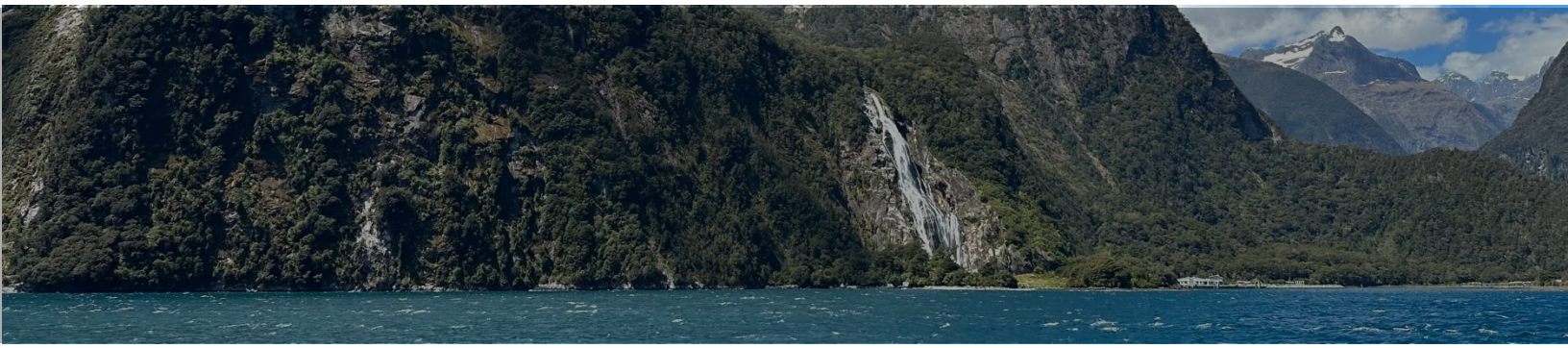
7.2 Electric Vehicle Technology

Similar to solar panels, our team recommends an attempt to increase public awareness levels to increase the equitable uptake of electric vehicles.

For electric vehicles, we recommend more specialized awareness campaigns compared to those for solar. Our survey respondents were more informed about electric vehicles on a general level, but there were some misconceptions in specific niche areas. Notably, our research indicated that many EV non-adopters have misconceptions about range anxiety, battery degradation, and ethical concerns towards manufacturing and recycling of batteries. EV adopters mentioned Range anxiety and battery degradation as concerns they used to have before adoption, but after owning one, have found those concerns to be untrue. Adopters also mentioned furthermore that the media continues to accelerate these concerns by distributing false or misleading information. Survey respondents and interviewees mentioned that when it came to ethicality of the production of electric vehicles and recycling of batteries, the majority of the information found online was concerning their adoption of the technology. Addressing concerns of the production and salvaging of batteries as well as the misconceptions towards battery degradation and range anxiety through a centralized and verified source is a critical step towards the uptake of electric vehicles.

Additionally, improving public charging infrastructure should be a priority. With financial incentives being removed, the government should be able to invest that money into public charging infrastructure. With range anxiety and charging infrastructure being significant concerns for non-adopters, improving the infrastructure should lessen this concern, and encourage more people to consider buying electric vehicles. This will also improve the lives of current electric vehicle owners, resulting in more positive reviews and recommendations for those who have not adopted.

Despite government incentives being offered for electric vehicles in New Zealand, High Initial Cost was consistently a top barrier among all respondents. Interview participants mentioned that if rebates were to be reestablished, their preference for these rebates would be to vary in assistance based on income level. We believe that in establishing varied incentives, they will be effective in leveling the playing field across income groups. Unfortunately, New Zealand's new government does not seem to be favorable of incentives, but this is something for Ara Ake to consider in the future.



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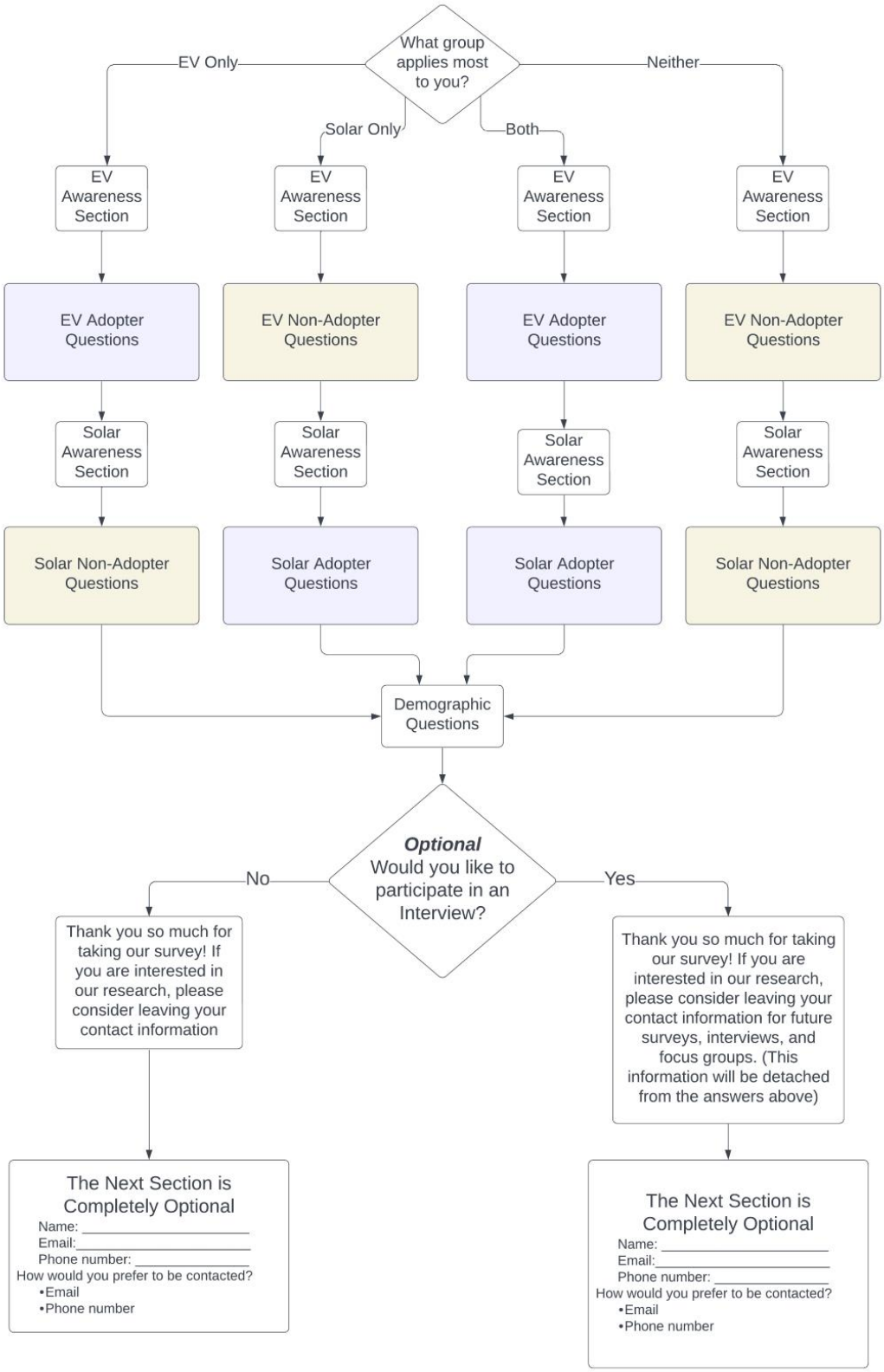
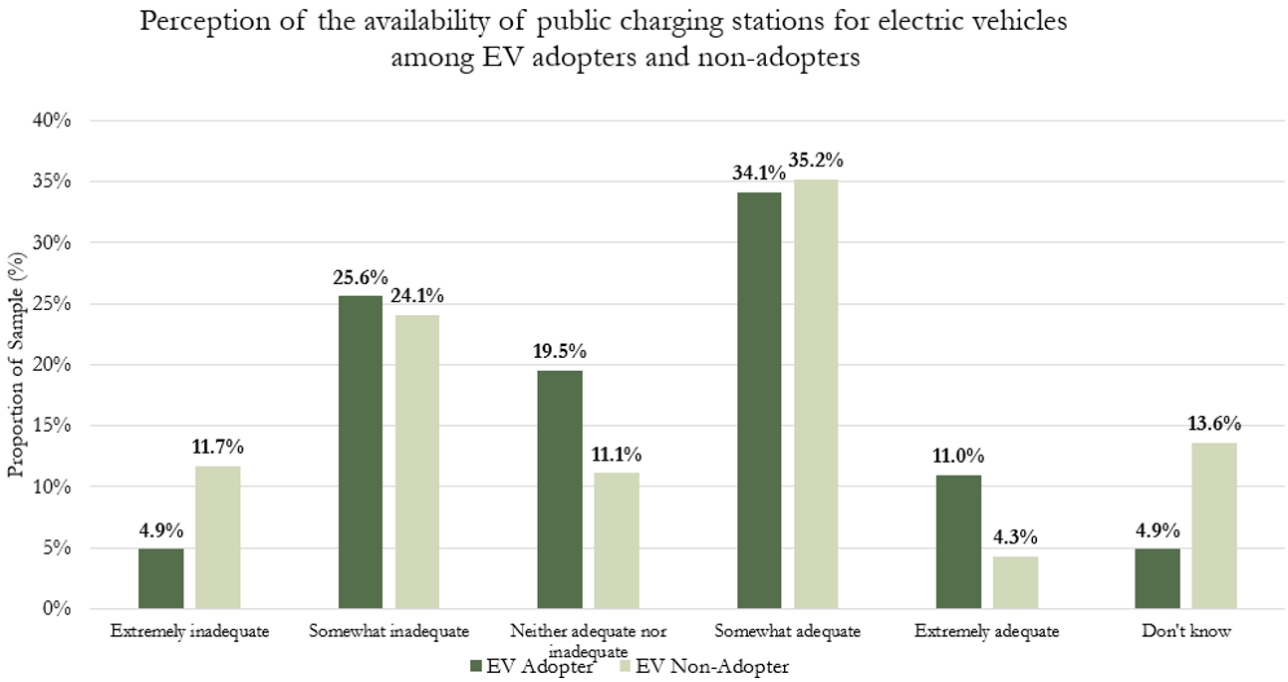
Appendix A: Survey Flowchart



Appendix B:


Perception of the availability of public charging stations for electric vehicles among EV adopters and non-adopters
Proportion of Sample (%)
40%
35%
30%
25%
20%
15%
10%
5%
0%
4.9%
11.7%
25.6%
24.1%
19.5%
11.1%
34.1%
35.2%
11.0%
4.3%
4.9%
13.6%
Extremely inadequate
Somewhat inadequate
Neither adequate nor inadequate
Somewhat adequate
Extremely adequate
Don't know
EV Adopter
EV Non-Adopter

WPI Barriers to Adoption of EVs and Solar

Start of Block: Residence Location

Residence Header **Residence Location**

Residence Question 1 Which area within the Greater Wellington region do you currently reside in?

- Wellington City (1)
- Upper Hutt City (2)
- Lower Hutt City (3)
- Porirua City (4)
- Kapiti Coast District (5)
- Masterton District (6)
- Carterton District (7)
- South Wairarapa District (8)
- Other/Don't Know (9)
- Do not reside in Wellington (10)
- Not a New Zealand Resident (11)

End of Block: Residence Location

Start of Block: Adoption Status

Adoption Header **Adoption Status**
* Electric vehicles in this survey refer to battery electric vehicles (BEVs) & plug-in hybrid electric vehicles (PHEVs).
* Solar panel technology in this survey refers to residential solar panel systems for electricity generation.

Adoption Status Question 1 Which of the following technologies have you adopted?

- ○ Residential solar panels (1)
- ○ Electric vehicle (2)
- ○ Both (3)
- ○ Neither (4)

End of Block: Adoption Status

Start of Block: Solar Awareness

Solar Header **Residential Solar Panels**
* Solar panel technology in this survey refers to residential solar panel systems for electricity generation.

Solar Awareness Question 1 How informed do you feel about solar panel technology?

- ○ Not informed at all (1)
- ○ Slightly informed (2)
- ○ Moderately informed (3)
- ○ Very informed (4)
- ○ Extremely informed (5)

Solar Awareness Question 2 What do you think the average cost (NZD) is to purchase and install a **solar panel and battery system** in New Zealand?

_____

End of Block: Solar Awareness

Start of Block: Solar Non-Adopter

Solar Header **Residential Solar Panels**
* Solar panel technology in this survey refers to residential solar panel systems for electricity generation.

Solar Non-Adopter Question 1 How interested are you in adopting solar panel technology in your residence?

- ○ Not interested at all (1)
- ○ Slightly interested (2)
- ○ Moderately interested (3)
- ○ Very interested (4)
- ○ Extremely interested (5)

---

mSolar Non-Adopter Question 2 Rank the following barriers in terms of how likely they are to prevent individuals from solar panel adoption, with 1 as the most significant.
(Drag and drop)

_____ Not listed (please specify) (4)
_____ High initial cost (1)
_____ Shading and obstructions (2)
_____ Lack of information (5)
_____ Homeownership status (7)
_____ Maintenance costs (11)
_____ Payback periods (12)

Solar Non-Adopter Question 3 The average cost to purchase and install a **solar panel and battery system** in New Zealand is around **20,000 NZD***.
* Prices vary greatly and can range from around $7,500 to $42,500.

---

na_s_q3 If monetary incentives were available, what would be the **minimum amount** which would motivate you to install a solar system in your residence?

0 10000 20000

Incentive (NZD) ()	

Solar Non-Adopter Question 4 (Optional) Do you have any additional comments or feedback that you would like to express regarding future policies on solar panel technology?

_____

_____

_____

_____

_____

End of Block: Solar Non-Adopter

Start of Block: Solar Panel Adopter

Solar Header **Residential Solar Panels**
* Solar panel technology in this survey refers to residential solar panel systems for electricity generation.

Solar Adopter Question 1 Which of the following encouraged you to purchase a solar panel system? (Select all that apply)

- [ ] Not listed (please specify) (9)
  _____
- [ ] Environmental impact (1)
- [ ] Potential for long-term financial benefits (4)
- [ ] Selling excess energy back to the grid (5)
- [ ] Resilience to grid blackouts/Energy independence (7)
- [ ] Personal satisfaction (8)

Solar Adopter Question 2 Please rank any concerns you had about adopting solar panels before making your decision, with 1 as the most significant
(Drag and drop)

_____ Not listed (please specify) (4)
_____ High initial cost (1)
_____ Shading and obstructions (2)
_____ Lack of information (5)
_____ Maintenance costs (11)
_____ Structural integrity concerns for roof (12)
_____ Complex installation and energy storage (13)

Solar Adopter Question 3 (Optional) Do you have any additional comments or feedback that you would like to express regarding future policies on solar panel technology?

_____

_____

_____

_____

_____

End of Block: Solar Panel Adopter

Start of Block: Electric Vehicle Awareness

EV Header **Electric Vehicles**
* Electric vehicles in this survey refer to battery electric vehicles (BEVs) & plug-in hybrid electric vehicles (PHEVs).

EV Awareness Question 1 How informed do you feel about electric vehicle technology?

- ○ Not informed at all (1)
- ○ Slightly informed (2)
- ○ Moderately informed (3)
- ○ Very informed (4)
- ○ Extremely informed (5)

Page Break

EV Awareness Question 2 What do you estimate the average cost (NZD) to be for purchasing a **NEW** electric vehicle (EV) in New Zealand today?

_____

EV Awareness Question 3 How adequate is the availability/accessibility of public charging stations for electric vehicles in your area?

- Extremely inadequate (1)
- Somewhat inadequate (2)
- Neither adequate nor inadequate (3)
- Somewhat adequate (4)
- Extremely adequate (5)
- Don't know (6)

End of Block: Electric Vehicle Awareness

Start of Block: EV Non-Adopter

EV Header **Electric Vehicles**
* Electric vehicles in this survey refer to battery electric vehicles (BEVs) & plug-in hybrid electric vehicles (PHEVs).

EV Non-Adopter Question 1 How interested are you in purchasing an electric vehicle as your next vehicle?

- ○ Not interested at all (1)
- ○ Slightly interested (2)
- ○ Moderately interested (3)
- ○ Very interested (4)
- ○ Extremely interested (5)

EV Non-Adopter Question 2 What are the main factors preventing you, or influencing your decision, from purchasing an electric vehicle?

- [ ] High initial cost (1)
- [ ] Limited charging infrastructure (4)
- [ ] Preference towards internal combustion engine vehicles (11)
- [ ] Range anxiety (10)
- [ ] Uncertainty about governmental incentives (9)
- [ ] Inadequate performance (5)
- [ ] Limited knowledge or information (7)
- [ ] Not interested in owning a vehicle (12)
- [ ] Car Appearance and Variety (14)
- [ ] Battery longevity (16)
- [ ] Ethical Concern (18)
- [ ] Not listed (please specify) (8)

_____

Skip To: EV Non-Adopter Price If Condition: Selected Count Is Less Than or Equal to 1. Skip To: The average cost to purchase a NEW el....

Q86 **Electric Vehicles**
* Electric vehicles in this survey refer to battery electric vehicles (BEVs) & plug-in hybrid electric vehicles (PHEVs).

Carry Forward Selected Choices - Entered Text from "What are the main factors preventing you, or influencing your decision, from purchasing an electric vehicle?"

EV Non-Adopter Question 3 Please rank the main factors preventing you, or influencing your decision, from purchasing an electric vehicle, with 1 being the **most** significant. (Drag and drop)

_____ High initial cost (1)
_____ Limited charging infrastructure (2)
_____ Preference towards internal combustion engine vehicles (3)
_____ Range anxiety (4)
_____ Uncertainty about governmental incentives (5)
_____ Inadequate performance (6)
_____ Limited knowledge or information (7)
_____ Not interested in owning a vehicle (8)
_____ Car Appearance and Variety (9)
_____ Battery longevity (10)
_____ Ethical Concern (11)
_____ Not listed (please specify) (12)

EV Non-Adopter Price The average cost to purchase a **NEW** electric vehicle in New Zealand is around **67,000 NZD***.
*Prices vary greatly with a range starting at around $43,000

EV Non-Adopter Question 4 If monetary incentives were available, what would be the **minimum amount** that would motivate you to purchase a **NEW** electric vehicle for your next vehicle?

0 33500 67000

Incentive (NZD) ()	

EV Non-Adopter Question 5 How much of an influence does the availability of public EV charging have on your decision to not adopt EV technology?

- ○ No influence (1)
- ○ Slight influence (2)
- ○ Moderate influence (3)
- ○ Considerable influence (4)
- ○ A great deal of influence (5)

EV Non-Adopter Question 6 (Optional) Do you have any additional comments or feedback that you would like to express regarding future policies on electric vehicles?

_____

_____

_____

_____

_____

End of Block: EV Non-Adopter

Start of Block: EV Adopter

EV Header **Electric Vehicles**
* Electric vehicles in this survey refer to battery electric vehicles (BEVs) & plug-in hybrid electric vehicles (PHEVs).

EV Adopter Question 1 What were the key considerations that encouraged you to purchase an electric vehicle?
(Select all that apply)

- [ ] Not listed (please specify) (6) _____
- [ ] Lower operating/ maintenance costs (1)
- [ ] Government incentives or rebates (2)
- [ ] Improved technology and performance (3)
- [ ] Reducing carbon footprint (4)
- [ ] Positive reviews or recommendations (5)

EV Adopter Question 2 What concerns, if any, did you have about the performance and reliability of electric vehicles before making your decision?
(Select all that apply)

- [ ] Not listed (please specify) (8) _____
- [ ] Limited driving range (1)
- [ ] Insufficient charging infrastructure (2)
- [ ] Battery degradation over time (3)
- [ ] High upfront cost (4)
- [ ] Lack of knowledge (6)

Skip To: ad_ev_q4 If Condition: Selected Count Is Less Than or Equal to 1. Skip To: How often do you experience range anx....

Q87 **Electric Vehicles**
* Electric vehicles in this survey refer to battery electric vehicles (BEVs) & plug-in hybrid electric vehicles (PHEVs).

Carry Forward Selected Choices - Entered Text from "What concerns, if any, did you have about the performance and reliability of electric vehicles before making your decision? (Select all that apply)"

EV Adopter Question 3 Please rank the concerns about the performance and reliability of electric vehicles selected in the previous question, with 1 being the **most** significant. (Drag and drop)

_____ Not listed (please specify) (1)
_____ Limited driving range (2)
_____ Insufficient charging infrastructure (3)
_____ Battery degradation over time (4)
_____ High upfront cost (5)
_____ Lack of knowledge (6)

EV Adopter Question 4 How often do you experience range anxiety (i.e., worrying that your vehicle won't be able to make it to your destination on a single charge)?

- ○ Never (1)
- ○ Sometimes (2)
- ○ About half the time (3)
- ○ Most of the time (4)
- ○ Always (5)

EV Adopter Question 5 How important were government incentives or rebates in your decision to adopt an electric vehicle?

- ○ Not at all important (1)
- ○ Slightly important (2)
- ○ Moderately important (3)
- ○ Very important (4)
- ○ Extremely important (5)

EV Adopter Question 6 (Optional) Do you have any additional comments or feedback that you would like to express regarding future policies on electric vehicles?

_____

_____

_____

_____

_____

End of Block: EV Adopter

Start of Block: Demographics

Demographics Header **Demographics**

Demographics Question 1 What is your age (in years)?

- Age (1) _____
- Prefer not to say (2)

Demographics Question 2 What gender do you identify as?

- Male (1)
- Female (2)
- Non-binary / third gender (3)
- Prefer not to say (4)

Demographics Question 3 What is your annual household income level?

- Less than 25,000 NZD (1)
- 25,000 - 50,000 NZD (2)
- 50,000 - 100,000 NZD (3)
- 100,000 - 200,000 NZD (4)
- More than 200,000 NZD (5)

Demographics Question 4 What is the highest level of education you have completed?

- ○ No qualification (1)
- ○ NCEA level 1 (2)
- ○ NCEA level 2 (3)
- ○ NCEA level 3 (4)
- ○ Overseas secondary school qualification (5)
- ○ Apprenticeship (level 4 certificate) (6)
- ○ Advanced trade certificate (level 5 or 6) (7)
- ○ Bachelor's degree or equivalent (8)
- ○ Postgraduate certificate/diploma or honors level degree (9)
- ○ Master's degree or equivalent (10)
- ○ Doctorate degree or equivalent (11)

Demographics Question 5 Please specify your ethnicity
(Select all that apply)

- [ ] New Zealand European (1)
- [ ] Māori (2)
- [ ] Pacifika (3)
- [ ] Asian (4)
- [ ] Middle Eastern (5)
- [ ] Latin American (6)
- [ ] African (7)
- [ ] European (11)
- [ ] Other ethnicity (please specify) (8)

_____

- [ ] Prefer not to say (9)

End of Block: Demographics

Start of Block: Contact Information

Raffle Contact Info **Raffle Contact Information**
* This information will not be connected to the answers given in this survey

Please provide your contact information if you would like to be entered into the **$200** supermarket

voucher raffle. Leave the fields blank if you are not interested.

○ Name (1) _____

○ Email (2) _____

○ Phone number (3) _____

Interview Info **Interview Contact Information**
If you would like to be considered for an interview regarding this research, please leave your contact information below, regardless of if you entered it above.

All selected interviewees will receive a **$40** supermarket voucher.

○ Name (1) _____

○ Email (2) _____

○ Phone number (3) _____

End of Block: Contact Information