ENEL 804

Sustainable Energy Systems

Assignment 2 - Project Report

The Suitability of NZ for Residential PV uptake

Sara Kinghan

17964398

Date: 19 / 06 / 2022

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INTRODUCTION

From the promotion of residential solar PV systems by political bodies to installers heavily marketing to homeowners and distribution companies looking to investigate and examine potential consequences of an increasing uptake of residential solar PV systems, it is clear that "solar power generation from photovoltaics (PV) is receiving a lot of attention in New Zealand from many sectors" (Miller et al., n.d.).

Advances in technology are making solar panel systems "more affordable and accessible to consumers" (New technologies emissions report, vol 1, n.d.). Thus they are often considered in a mix of possible distributed renewable generation for the future electrical energy needs of NZ (Wood et al., n.d.) with numerous studies exploring the various impacts.

There is a belief that when the combination of energy prices and capital cost of PV reach a certain range, solar PV uptake will take off. That may be true, but as someone renting a unit in an apartment, even if this occurred, solar would not be an option. This raised the question of, just how many households could get solar? And of those, what factors affect whether a household adopts a solar PV system and what are the impacts to NZ of a high uptake?

A review of international literature found that the largest drivers in the uptake of this technology are capital cost, environmental concern, and saving money (PV Uptake in NZ The Story so Far, n.d.). But it also uncovered unexpected consequences. NZ can observe what has driven uptake, what factors played a role in it and what have been the consequences, from countries around the world. This report will examine the suitability of NZ for residential PV uptake.

Chapter One will examine solar irradiation in NZ, addressing the question of whether we have enough of the solar resource: sunshine. The follow up question is then whether we have the roofs? The demographics will be explored, looking at how many households might be eligible for rooftop PV systems alongside brief mentions of forecasted levels and current uptake level of PVs.

Chapter Two focuses on the above consumer considerations stated: capital cost & saving money and environmental concern. However, they won't just be assessed from the perspective of the consumer but also looking to see the impact that a high uptake of this technology could have in these areas on NZ.

1 CHAPTER ONE

The first question in the suitability of NZ for residential solar PV systems, is whether we have enough of the source that drives them; solar irradiation. The second question is, how many eligible roof's might there be? This chapter will aim to address the first question and then explore the demographics involved in determining a sense of the eligible households in the target market for residential solar PV systems.

1.1 SOLAR IRRADIATION

One aspect to the popularity of solar PV systems around the world, is the abundance of and renewable nature of their source: the sun (Dhlamini & Daniel Chowdhury, 2018). Living in New Zealand, it would be fair to assume that it may not be sunny enough for rooftop solar PV systems. However, according to NIWA (SolarView, 2019), NZ has plenty of sunshine.

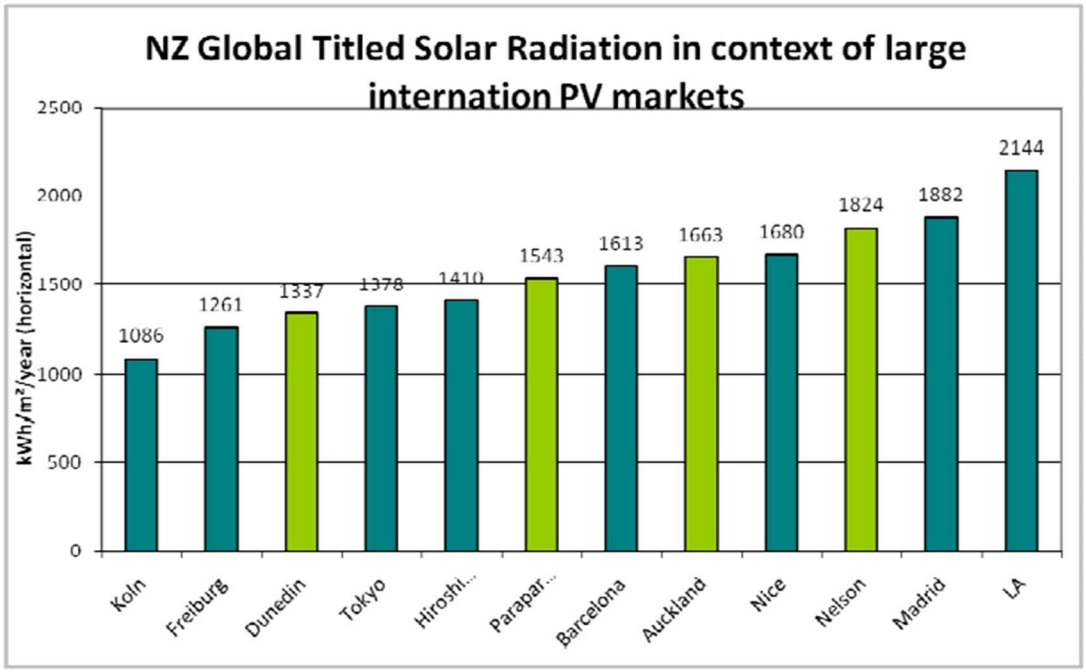

Figure 6.1: NZ Solar radiation vs international sites (based on NIWA (NZ sites) and Meteonorm)

Figure 1: Graph of solar radiation year averages from cities around the world compared to several in NZ. (Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand, n.d.)

"Solar potential is measured through irradiance – the solar potential of a square metre of surface area" (Te Mauri Hiko – the Sun Rises, n.d.). Figure 1 displays the average solar irradiation potential per year for several cities around the world compared with four cities across NZ. Some NZ cities have significantly higher levels of solar radiation than cities in German and Japan, however not as good as areas in Spain and California (Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand, n.d.). Germany and Japan currently have among the highest levels of residential PV uptake in the world (Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand, n.d.).

While solar radiation does vary substantially across NZ, during the seasons as well as during the day, due to the nature of the weather here, sources suggest that cities in NZ have enough solar irradiation for it to be worth further considering. Now to look at whether we have the roofs.

1.2 DEMOGRAPHICS

1.2.1 The PV Market

Before diving into the demographics, the section below will briefly outline some forecasted values of how much uptake might occur in NZ. The reason some studies looked into this was to get a better idea of what the eventual installed capacity of PV systems might be in order to more accurately assess the impacts those levels could have to NZ (Miller et al., n.d.).

In a study done by Concept consulting they had a forecast of 60% of households by year 2040 (New technologies emissions report vol 1, n.d.) would have rooftop solar systems. A study by Transpower suggested that NZ could have 16GW of rooftop solar by 2025 (Transpower - Transmission Tomorrow, n.d.).

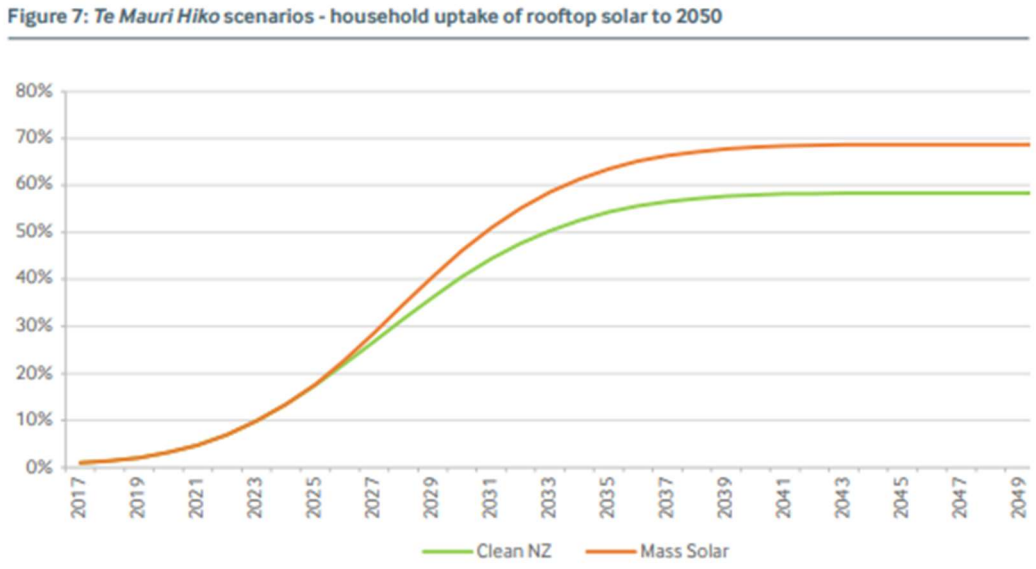

Figure 2: Graph showing a forecasted uptake of rooftop solar by Transpower. (Te Mauri Hiko – the Sun Rises, n.d.)

Figure 2 is a graph from a Transpower study, forecasting the potential household uptake of rooftop solar. Their scenario sees domestic solar installations hit 69% of households as shown by the 'Clean NZ' line. The 'Mass Solar' line was for a different scenario, incorporating uptakes of additional technology. Transpower states that while "some commentators have questioned whether this is possible. The good news is it is. Today, New Zealand has 1.8 million residential households" (Transpower - Transmission Tomorrow, n.d.). I believe they are working their forecasted percentage from the entire pool of households. Other research sources also often gave their values as a percentage of all households. Which begged the question, how many eligible roofs to we have?

1.2.2 Demographics

To start, the total number of households in NZ needed to be found. From the 2018 Census, Stats NZ recorded that there were over 1.8 million private dwellings.

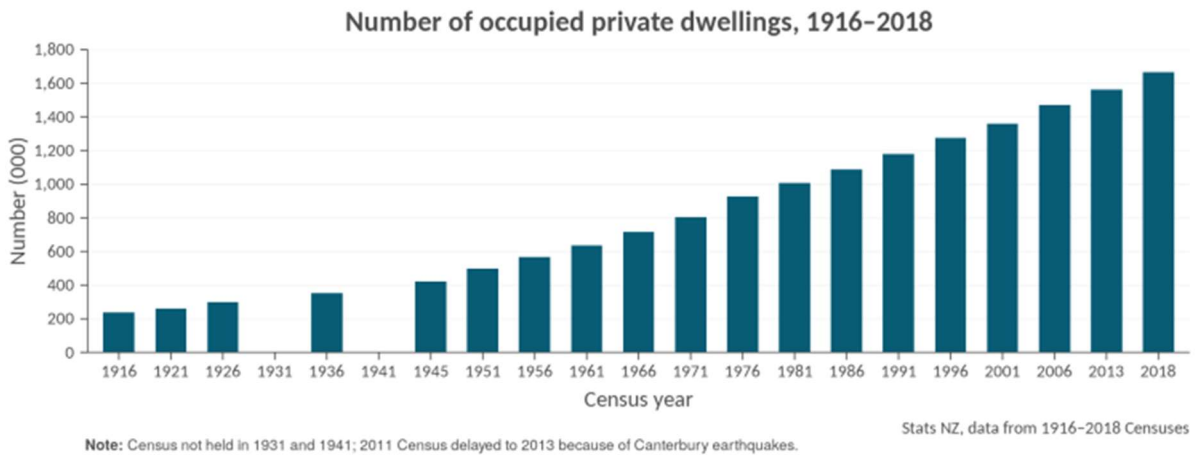

Figure 3: Graph from Stats NZ showing the number of occupied private dwellings in NZ at each census. (Housing in Aotearoa: 2020 | Stats NZ, n.d.)

Of that 1.8 million, almost 1.7 million were occupied. From the Housing in Aotearoa 2020 report by Stats NZ, NZ had 1,664,000 occupied dwellings in 2018 (Housing in Aotearoa: 2020 | Stats NZ, n.d.). Figure 3 provides a visual representation of the trend of the number of occupied private dwellings in NZ as measured at each census.

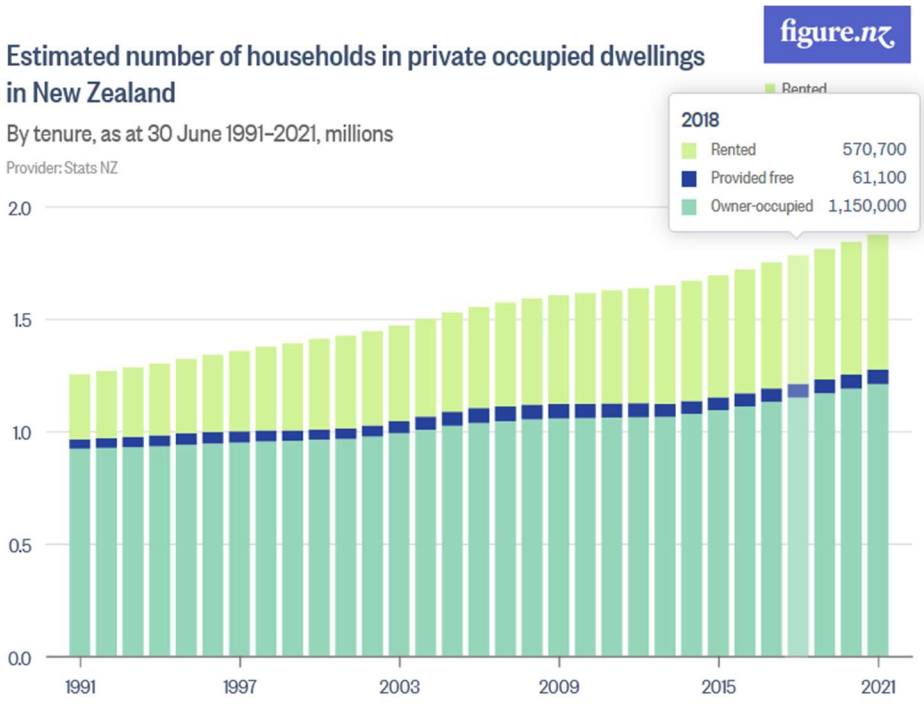

Figure 4: Graph of the estimated number of households in private occupied dwellings in NZ. (Estimated Number of Households in Private Occupied Dwellings in New Zealand, n.d.)

In the search for the number of households in NZ, a graph from Figure NZ (Estimated Number of Households in Private Occupied Dwellings in New Zealand, n.d.) was found as show as Figure 4. It expresses the estimated number of households in private dwellings in NZ across three different types of households: owner-occupied, renters, and provided accommodation. It is an estimated value because only the years of the census have been measured, the non-census years are an estimation. This report will use the census data; therefore the 2018 number will be used.

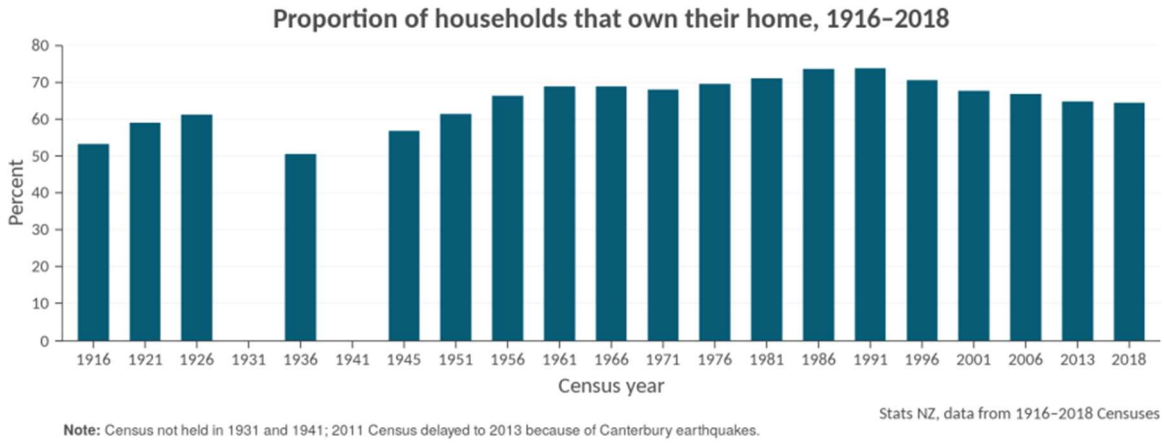

Figure 5: Graph of the percentage proportion of households that own their home. (Housing in Aotearoa: 2020 | Stats NZ, n.d.)

Figure 5 shows the proportion (as a percentage) of households that own their home. Stats NZ states that 64.5% of all occupied households own their own home in 2018. From just under 1.7 million total occupied households, now down to 64.5% of that.

Why remove those that rent? Firstly, landlords are highly unlikely to provide solar power for their tenants. For tenants covering their own power bill, why would this matter to the landlord? Furthermore, the govt had to step in to provide regulations as to what constitutes suitable rental accommodation, such as regarding heating options. It seems fair to assume that landlords will not be providing solar PV for their tenants. There is the risk, however, that the landlord installs the PV system, and charges the tenants a fixed power bill amount each month, while paying the lower power bill and keeping the difference for themselves.

Tenants are also unlikely to commit to putting in a PV system. Landlords might not prevent this, but there is no guarantee that the tenant will be able to remain in that dwelling for long enough for the investment to pay itself off.

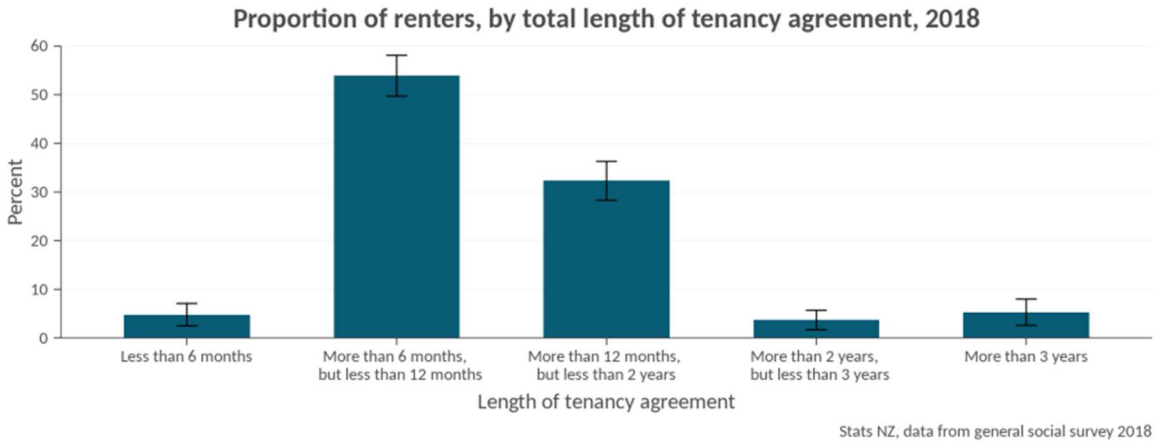

Figure 6: Graph of the proportion of renters by the total length of their tenancy agreement in 2018. (Housing in Aotearoa: 2020 | Stats NZ, n.d.)

Figure 6 shows that typically, over half of all tenancies are less than 12 months and more than 80% were less than 3 years. Tenants are unlikely to remain in a rental long enough to see any benefit from the investment of the system.

Therefore, the first division of the total number of households, is the owner-occupier group, at 64.5% of approximately 1.7 million total occupied households which is 1,073,280 households, just over 1 million.

However, there are two key factors to be examined, the terms: ownership and home. The census doesn't further classify 'households that *own* their *home*'.

Therefore, *ownership* includes the following types (Understanding the Types of Ownership, n.d.)

- Freehold
- Leasehold
- Cross Lease

And *home* includes the following building types (Housing in Aotearoa: 2020 | Stats NZ, n.d.)

- Stand-alone houses
- Flats / Units
- Apartments
- Retirement Villages

It is only guaranteed that rooftop PV system can be installed on a 'Freehold' and 'Stand-alone house'. That is not to say that it can't occur for the other types, it just isn't a guarantee.

With leasehold and cross lease, permission would need to be obtained to do so. With flats/units and apartments is it a bit more complicated. With apartments, the roof might not be suitable for use at all. It may have a pool, or rooftop garden area, or helipad. For both types, it is a decision by the body corporate and for every unit. They might not all consent. Some may not be home enough to get enough use of the system and therefore not want to provide investment funds.

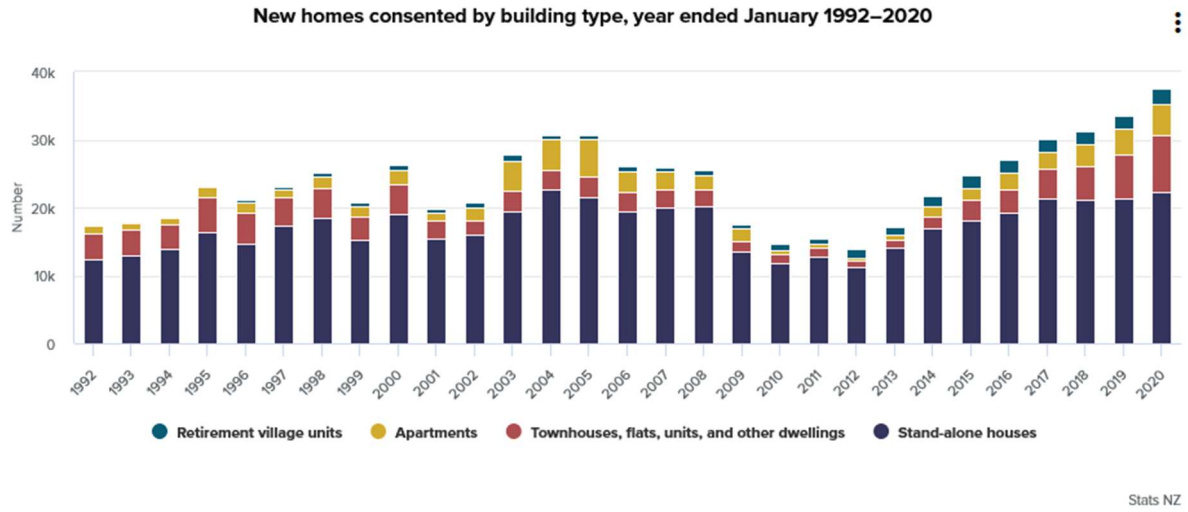

Figure 7: Building consents granted across the four dwellings types. (Record Number of Townhouses, Flats, and Units Consented | Stats NZ, n.d.)

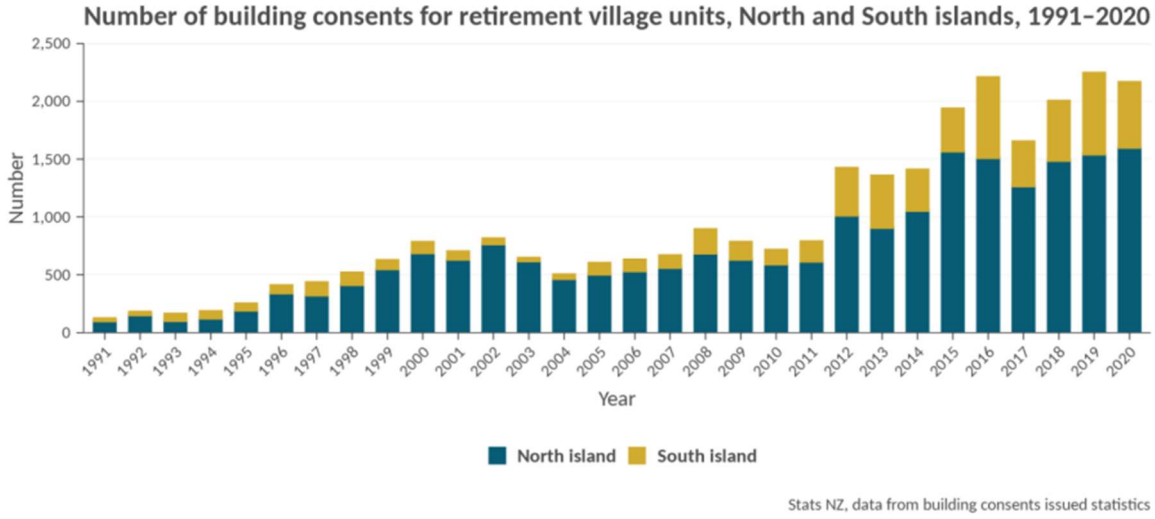

Figure 8: Graph of the number of buildings consents for retirement villages from 1991 to 2020. (Housing in Aotearoa: 2020 | Stats NZ, n.d.)

Figure 7 shows the number of consents for new homes by building type, which can give an indication of the trend and percentage that stand-alone houses might have in the total number of households. Figure 8 shows the number of consents for retirement villages from 1991-2020, also giving an idea of the representation that this building type may have on the total number of households.

Unfortunately, Stats NZ doesn't provide a further break down of the number of households by type of ownership or building type. However, it should be clear that not all occupied households are eligible. When Transpower estimated 69% of households, and Concept with 60%, both by 2040 – that will be almost every owner-occupied household, yet not all of them will be suitable by ownership type or building type.

With the data available, this is as far as the division can go. However, there are other demographics that can be explored and anyone selling solar PV systems should be aware of their target market.

On Stats NZ and in their Housing report, further demographics of home ownership by age and by income bracket can be explored.

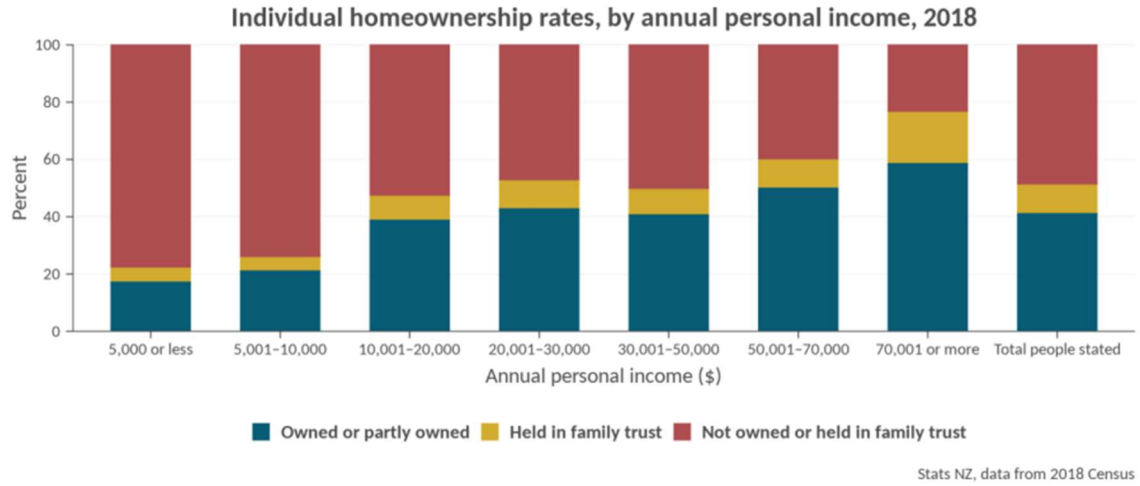

Figure 9: Graph of homeownership by income bracket. (Housing in Aotearoa: 2020 | Stats NZ, n.d.)

For example, Figure 9 shows that home ownership tends to increase with age, reaching a peak in the 70-74 age bracket.

1.2.3 PV uptake so far

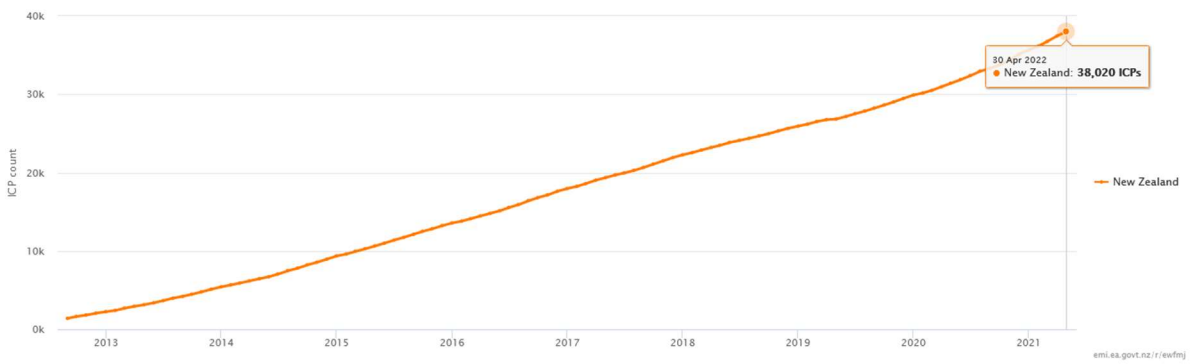

Figure 10: Graph showing the number of connections, the uptake rate over time. (Electricity Authority - EMI (Market Statistics and Tools), n.d.)

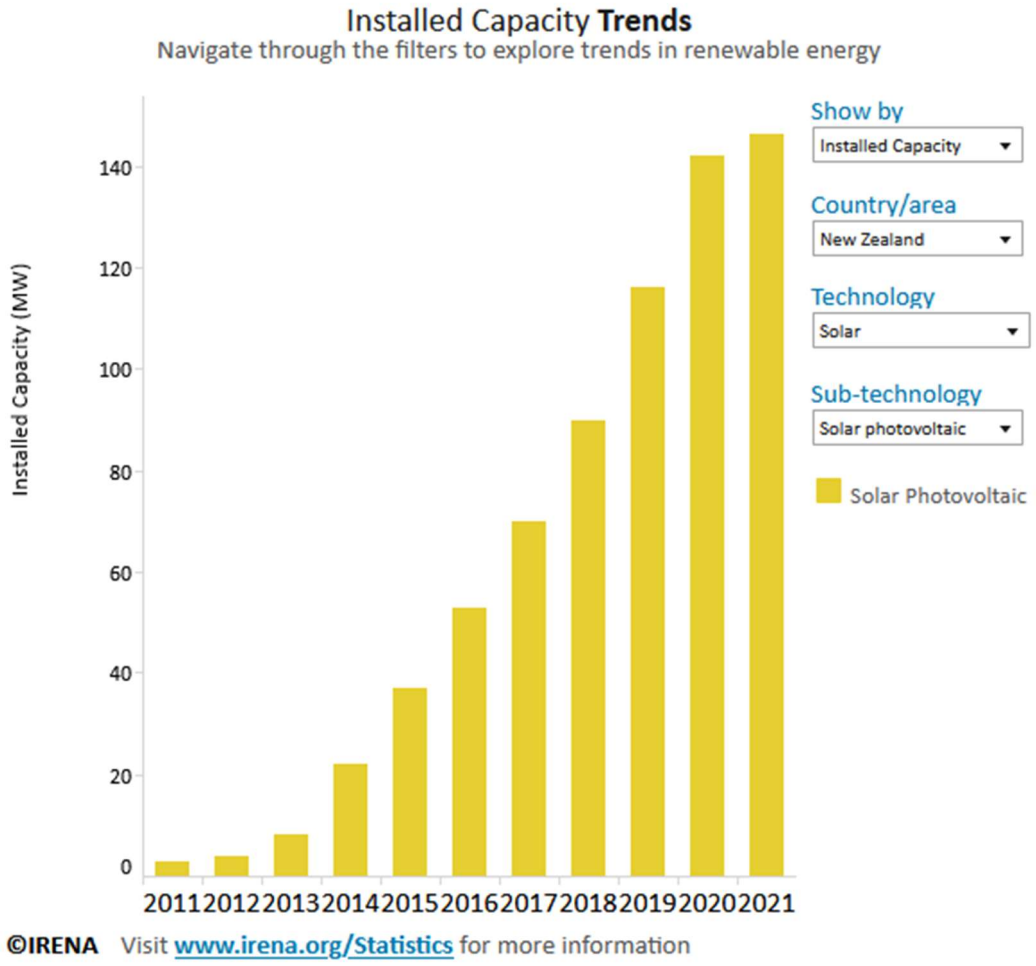

Figure 11: Graph to show the installed capacity of solar PV systems in NZ over time. (Solar Energy, n.d.)

Figure 10 is a graph showing the number of residential solar PV connections over time. Figure 11 shows the installed capacity (in MW) in NZ over time. Currently in NZ, these sources indicate that we have around 38,020 residential solar PV connections to the grid, with a total capacity of 146.5 MW. One study by Transpower suggested that NZ could have 16GW of rooftop solar by 2025 (Transpower - Transmission Tomorrow, n.d.). 38,020 connections are just under 4% of owner-occupied households.

Aside of looking at the number of connections and capacities, some studies have examined the demographics of those that have installed solar PV systems. An "analysis undertaken by the Electricity Authority on uptake across consumers" (New technologies social report vol 3., n.d.) found that "wealthier households are much more likely to install solar panels than poorer households" (New technologies social report vol 3, n.d.).

Part of this was due to having the funds to make the initial investment but Concept consulting identified that it was also due to the income relationship between homeowners and renters. NZ has a strong relationship between renting and lower income groups. "Approximately 75% of households in the most deprived decile live in rented accommodation" (New technologies social report vol 3, n.d.) and recall that NZ also has over 61,000 homes provided free for certain groups.

Studies also identified that those with solar PV tend to come from a considerably older demographic (PV Uptake in NZ The Story so Far, n.d.) due to both their income bracket and home ownership status. One study found that of the people who had solar PV who were interviewed, 69% owned their home mortgage free (PV Uptake in NZ The Story so Far, n.d.).

2 CHAPTER TWO

Before getting into the factors, an assumption has been applied to narrow the scope of the report. Given the current level of PV uptake in NZ and the cost of a battery system, this report only investigated and discusses the factors and impacts for 'grid-tied' PV systems. Off-grid systems, and PV systems with a battery, are other options but are not included.

Table 1: Table representing several considerations in the decision to adopt residential solar PV.

Economic	Environmental	Product
Initial cost	Clean & Green Energy	Standards & Policies
Savings, ROI	Waste	Installers
Buy Back Rates	C02 emissions	Building Consent
Warranty		Age of roof & roof material
Maintenance		
Energy pricing impact		

It is important to understand the drivers and barriers of PV uptake and to assess possible consequences from a large uptake. There are several factors that a household and NZ should consider when assessing the suitability of NZ for residential PV uptake. Table 1 above is a representation of the factors that were identified during research, grouped under three main categories. Unfortunately, this report cannot address them all. However, the primary concerns were identified and will be discussed. Several studies into PV's in NZ have been conducted by a group known as the GREEN Grid, identifying the main concerns for households when determining whether to go solar or not.

- Determining the value of the financial investment against capital cost
- Environmental concerns

I will discuss these each in turn from the perspective of the household factors and then follow with the impact within those factors that could face New Zealanders.

2.1 VALUE OF THE INVESTMENT

In NZ the main argument pushing for solar PV is the value of it as an investment. Many argue that residential solar systems are a good financial investment for households and therefore believe that as the cost of the systems drops, uptake will rapidly rise (Te Mauri Hiko – the Sun Rises, n.d.) (Economics-of-Photovoltaic-Solar-Power-and-Uptake-in-New-Zealand, n.d.) (The-Economics-and-Potential-Uptake-of-PV-Solar-Power-by-Region-and-PV-System-Cost, n.d.) (Miller et al., n.d.).

While many households show a desire for more independence from the power grid, with greater control over their outgoings and concerns over whether electricity will become unaffordable for them particularly heading into retirement (PV Uptake in NZ The Story so Far, n.d.) there was still much hesitation and uncertainty around residential PV's.

A study from members of the GREEN grid, found that it wasn't just concerns over the initial cost but also uncertainty on returns and buy back rates (PV Uptake in NZ The Story so Far, n.d.). Another

study found that there was a lack of understanding around the costing of a PV system (Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand, n.d.) and the "calculations are beyond what most domestic householders are willing to take on" (PV Uptake in NZ The Story so Far, n.d.).

> "*When asked what the biggest problem people thought they would face when deciding to install solar, financial cost was reported as the largest barrier to entry, above the effort involved with choosing the right system, the difficulty of accurately estimating the financial returns*."
> (PV Uptake in NZ The Story so Far, n.d.)

I will not be covering the process of determining the PV system needed and calculating its cost, nor reviewing the tools and information presently available to assist households in that process. This is due to the variation of solar hours throughout NZ (Elbeheiry et al., 2020), grid-electricity pricing structures (low user and prompt payment) and retailer pricing variation, household load and household usage over 24 hours (Wood et al., n.d.). To account for all these factors is beyond the available scope of the report and to simplify through assumptions diminishes its value to households. I do wish to note that for the average household, determining the system size and costing it are barriers to the PV market. The GREEN Grid produced a calculator for this reason and it is "available on the Energy Efficiency Conservation Authority (EECA) website" (The-EECA-Energywise-TM-PV-Solar-Calculator, n.d.).

I will instead focus on the benefit once it is there, where does the real value of the investment lie?

Concept Consulting found that the monetary benefits of a solar PV system come through two financial value streams:

- Savings from not buying in grid-supplied electricity and instead using the electricity generated by the panels (self-consumption)
- Earning money for the un-used amount generated and feed into the grid (Buy back) (New technologies emissions report vol 1, n.d.)

2.1.1 Self-consumption benefit

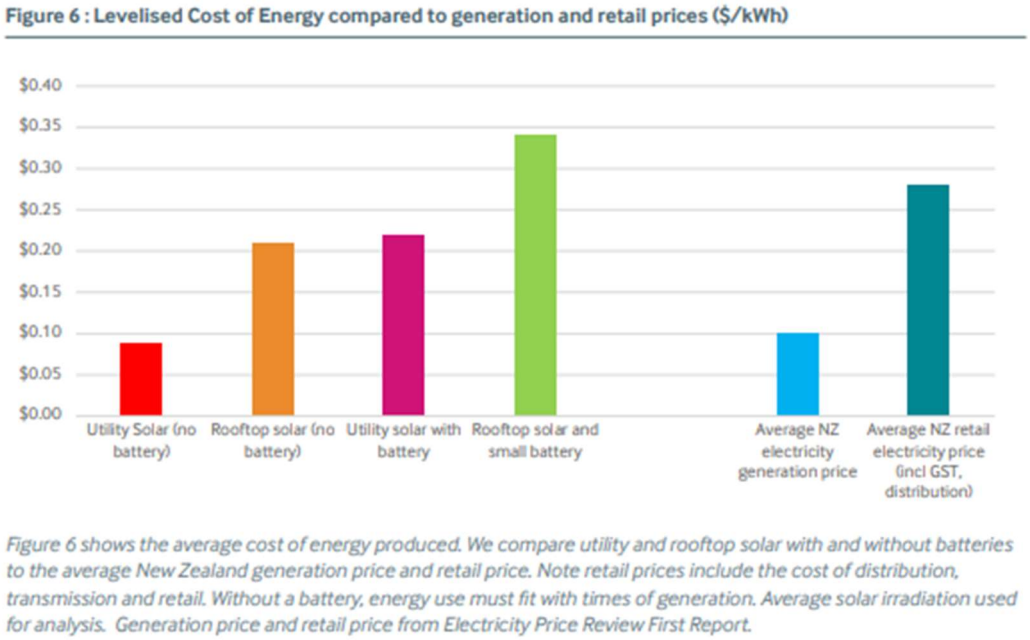

Figure 12: Graph of the levelised cost of energy for solar configurations against average grid retail price. (Te Mauri Hiko – the Sun Rises n.d.)

Figure 8, from a study conducted by Transpower shows that the levelised cost of rooftop solar is below the average retail price for electricity. Which is great but getting a solar PV system doesn't mean you won't be buying grid-supplied electricity, nor does it mean that your pricing structure will remain the same, but that will be discussed under Buy backs.

Concept identified that the greatest benefit to consumers from PV systems comes from self-consumption (New technologies economic report vol 2, n.d.), with the savings from not having to pay for energy by using the electricity generated over the daylight hours.

In order to benefit in this way, someone needs to be home using that power. However, many households will not be home during the day (Wood et al., n.d.). Even with the push for remote working, many jobs can not be done from home. A household needs to determine their daytime usage in order to accurately calculate the effective return on investment (Wood et al., n.d.).

"Christian Hoerning, a senior technical advisor from EECA" (Harris, 2018) recognises that it is not cost effective for everyone and that people are receiving information that is misleading. Such as the graph above. He notes that solar is best for households that will use it during that day. Whether that is having members of the household at home, or for heating a swimming pool or spa (The-EECA-Energywise-TM-PV-Solar-Calculator, n.d.).

"Consequently the value of PV to a household depends on the consumption patterns of a particular household." (Economics-of-Photovoltaic-Solar-Power-and-Uptake-in-New-Zealand, n.d.)

2.1.2 Buyback Rates

Wood et al noted that it is difficult to determine if a household will financially benefit from buy back rates (Wood et al., n.d.). This comes from determining the amount they would be exporting, the price it is sold at (which varies across retailers) and the changes to their pricing scheme to qualify for buy back.

Firstly, any payment received is liable for income tax (Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand, n.d.). This includes payments for selling electricity to the grid system. "The Electricity Commission have recently amended rules to allow gifting of electricity to an electricity retailer, thus avoiding costs of settlement, including any liable tax on income" (Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand, n.d.). For now. It is likely that this will remain in place, mostly due to the second point.

The buybacks themselves are not guaranteed. There is no obligation or requirement for an electricity retailer to purchase electricity from households (Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand, n.d.). This is remarkably different from the situation in Australia, where huge buy back rates were offered for long fixed term periods. Seeing up to 60c/kWh offered, with an average of around 40c/kWh (II, 2016). This was a strong contributing factor in the rapid uptake of PV's in Australia, and not a situation we have in NZ.

Table 2: Table showing a sample of current buy back rates offered from the five main electricity retailers. ('Residential Solar Power Buy Back Rates NZ', n.d.)

Energy Retailer	Maximum System Size	Buy Back Rate
Contact	10kw	8 c / kWh
Genisis	-	12 c / kWh
Mercury	10kw	8 c / kWh
Meridian	10kw	8 c / kWh
Trust Power	10kw	7 c / kWh

Table 2 is provided as a reference to the buyback rates currently on offer in NZ at five of the main electricity retailers.

In addition to this, to qualify to receive a buyback, the retailers are likely to put you onto a different pricing scheme. For example, for Meridian, the prompt payment discount is removed (Wood et al., n.d.). Depending on the household's usage, that discount may be of greater value than the earnings from the buyback.

It is easy to see how difficult it is for households to calculate whether a PV system is a financially beneficial investment for them, particularly if they are close to the break even point.

2.2 IMPACT OF HIGH UPTAKE ON ENERGY PRICES

Assuming that households with rooftop PVs are using much of the energy they generate, they are then contributing less to the network and infrastructure costs of NZ's electricity supply. With a large uptake of residential PV systems, this will be a significant loss in funds. So, while households look to go solar to reduce their electricity bill, others look to see what impact that will have on NZ, with less funds being contributed to our electricity infrastructure.

Concept Consulting found that with NZ's current pricing structure, those costs will likely be shifted onto the non-solar PV owning consumers (New technologies economic report vol 2, n.d.). Concept noted that those consumers would be the poorest. The reason that the poorest will be affected is due to the demographics of those who get rooftop solar and those who don't. Their research showed that the poorer households are much less likely to get solar PV systems. This isn't just due to the capital costs, "it is because the majority of our poorest consumers live in rented accommodation" (New technologies social report vol 3, n.d.).

Beyond the impacts of cost-shifting, is other factors in pricing schemes, such as low user rates.

> *"The LFC regulations effectively require electricity suppliers to offer price options that favour consumers with below-average usage. This shifts costs onto consumers with above-average usage"* (New technologies economic report vol 2, n.d.).

This was to benefit the poorer consumers as they typically had below-average usage. However, it will those using the energy from their solar systems that become the lowest users, impacting poorer consumers again.

The scenario Concept examined with existing pricing structures in place, saw that power bills would increase for non-solar users by at least 10% (New technologies social report vol 3, n.d.). "Chief executive of the Electricity Retailers Association of New Zealand Jenny Cameron" (Edmunds, 2017) stated that this issue had been bought to the attention of retailers and they understand that without reform to the pricing structure, the poorest in NZ will be affected.

2.3 CLEAN AND GREEN ENERGY

One of the reasons in favour of residential solar PV systems is due to environmental concerns, the desire to have clean, green energy. Studies from members for the GREEN grid found that the participants interviewed "were concerned about the environment, and wanted to have a greener and more sustainable lifestyle, and supported renewable energy technologies." (PV Uptake in NZ The Story so Far, n.d.)

Let's exclude the emissions from the manufacturing of the panels on the argument that it doesn't happen in NZ and just consider the electricity that is produced from their use, then you could say it is green energy. But is it cleaner and greener than what NZ are already getting?

Firstly, a look at the sources that produce NZ electricity as it is needed to give context to the following factors, an examination of the impact PV uptake could have on NZ's emissions and then a review of a possible impact to the waste side of the system.

2.3.1 Cleaner and Greener?

The NZ government aims to meet a "target of generating 90% of the country's electricity needs from renewable sources by 2025" (Economics-of-Photovoltaic-Solar-Power-and-Uptake-in-New-Zealand, n.d.). Yet, if you were to ask the average person how green their electricity currently was, I doubt they could say.

New Zealand's electricity production does come from both renewable and non-renewable sources. However, "New Zealand is in the extremely fortunate position that over 80% of our generation is from renewable sources" (Transpower - Transmission Tomorrow, n.d.).

This percentage varies a bit by year due to the renewable nature of our sources. Their production ability is weather dependent. "In 2016, about 85% of electricity generation came from renewable sources, marking the country's highest production level in 35 years." (Esolar, n.d.)

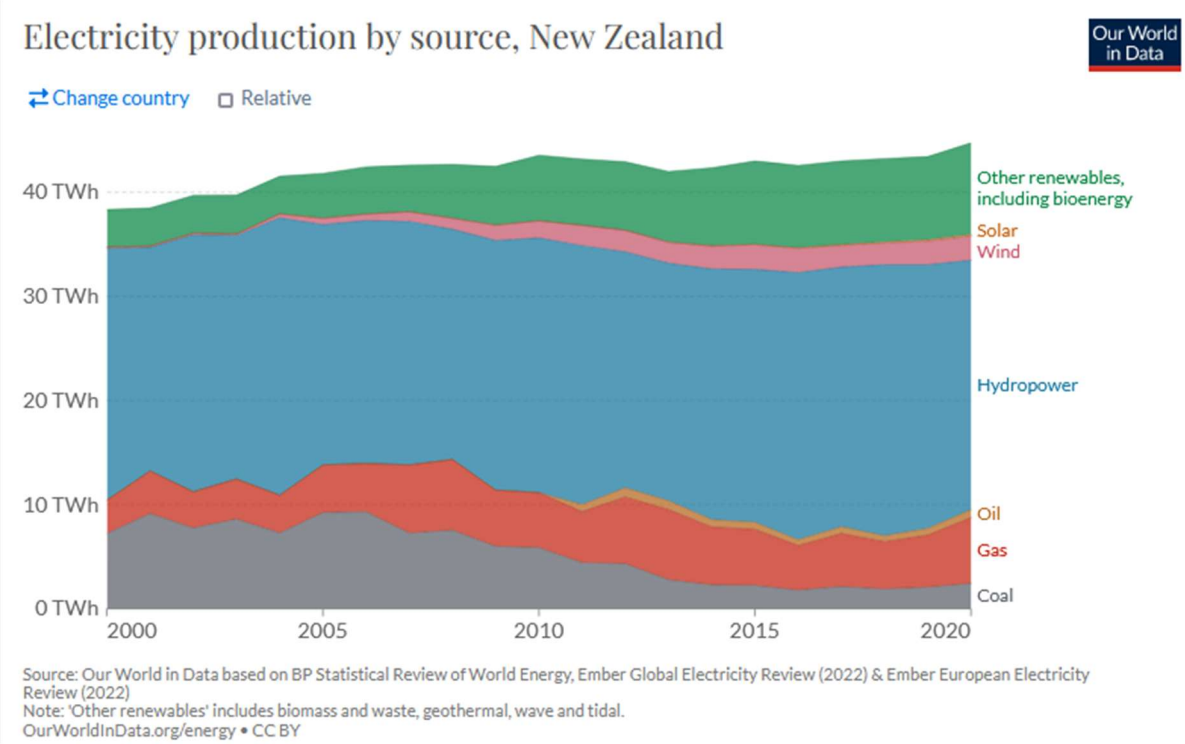

Figure 13: Graph of NZ's electricity production by source. (Ritchie et al., 2020)

Figure 13 shows NZ's electricity production by source. We do use oil, gas and coal, but at a much smaller percent than the other sources which are considered renewable.

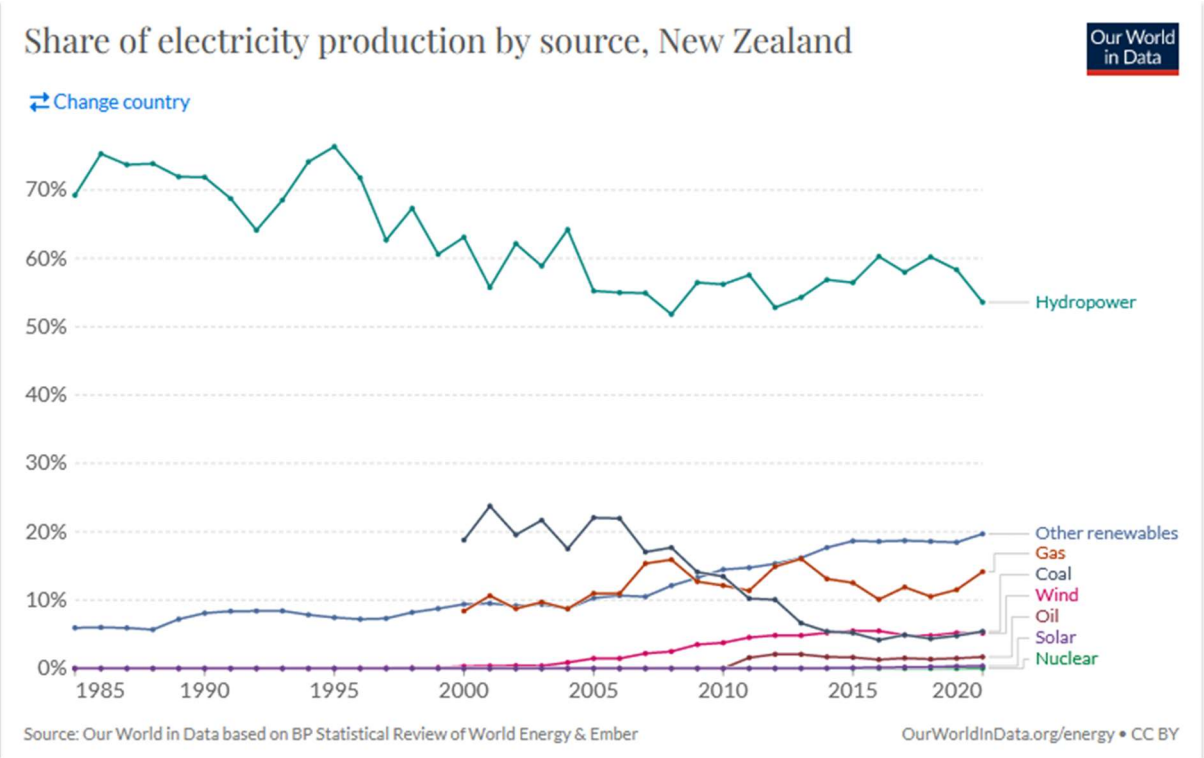

Figure 14: Graph to show the share of electricity production by each source in NZ. (Ritchie et al., 2020)

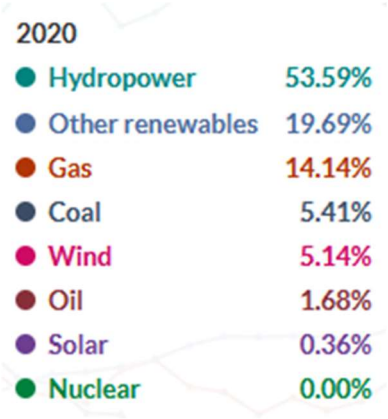

Figure 15: The percentage share of electricity production by source from Figure 14. (Ritchie et al., 2020)

Figure 14 is a graph to show the percentage share of electricity production by each source, and Figure 15 shows the percentage values.

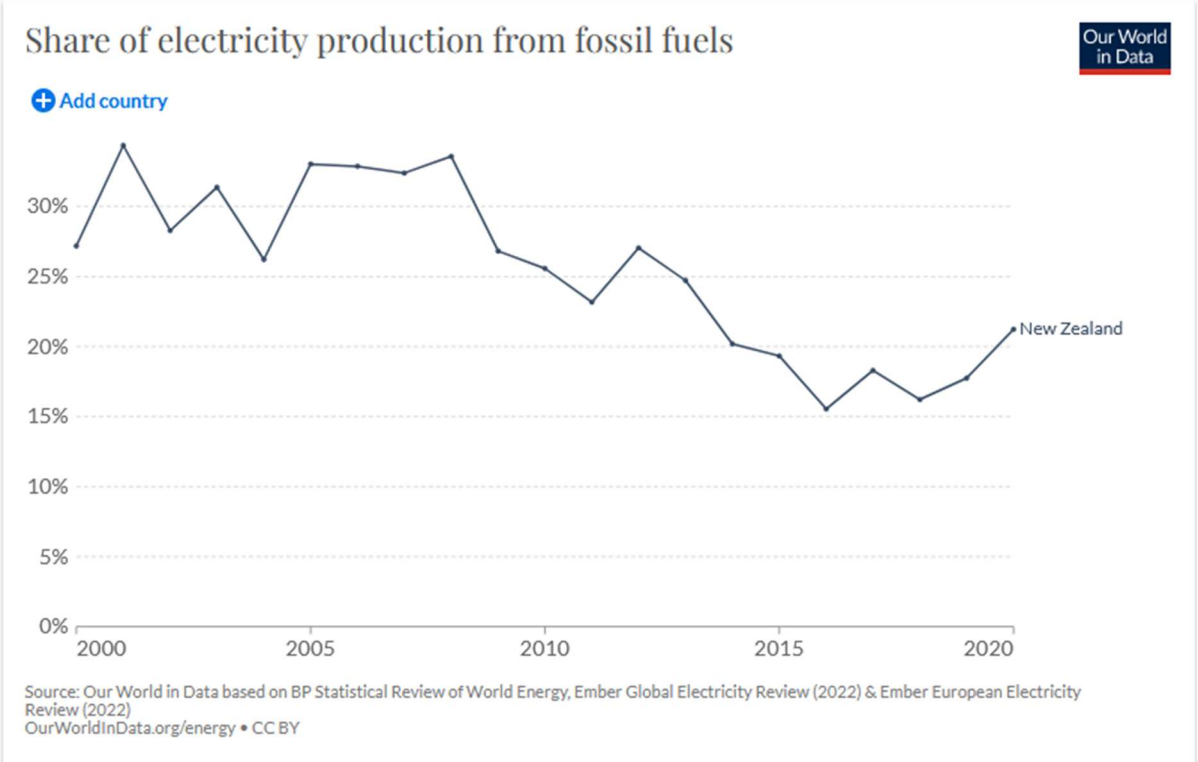

Figure 16: Graph of the percentage share of electricity production from fossil fuels. (Ritchie et al., 2020)

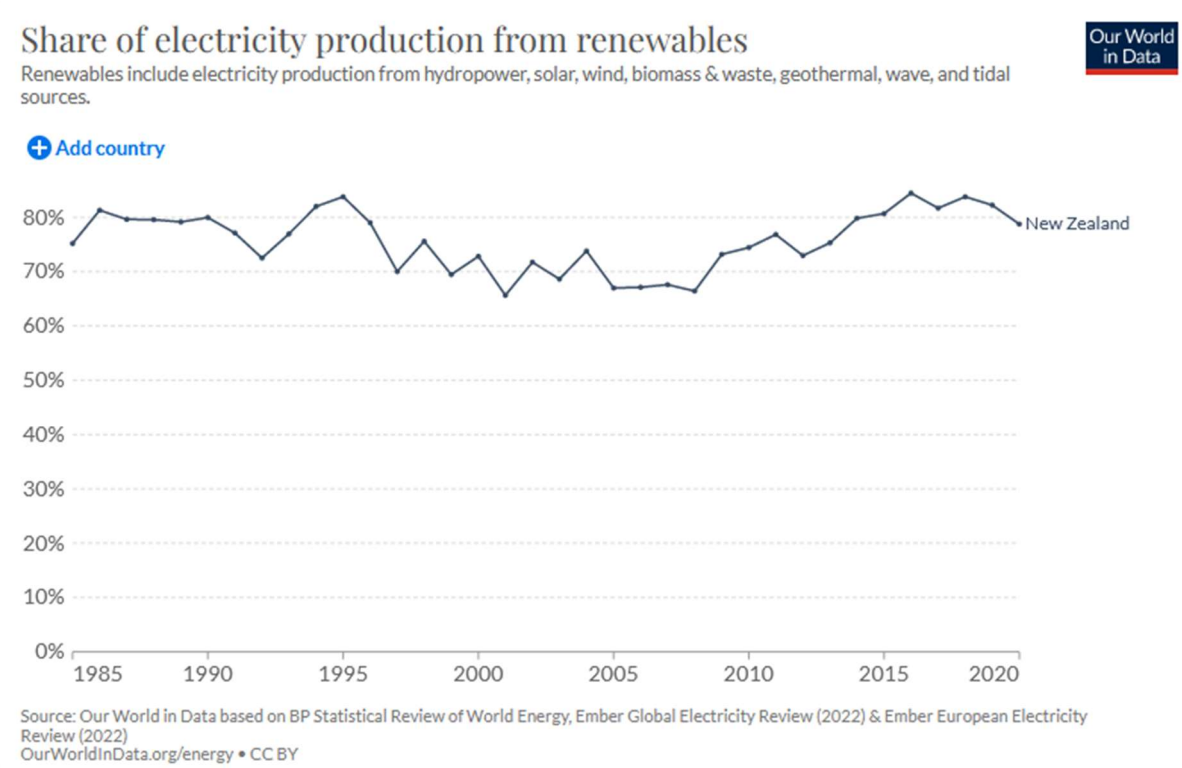

Figure 17: Graph of the percentage share of electricity production from renewable sources. (Ritchie et al., 2020)

As seen in Figure 16, in 2020, 21.23% of our electricity production came from fossil fuel sources. Figure 17 shows that in 2020, 78.77% of our electricity production came from renewable sources. The 2016 peak of 84.45% can be seen on this graph.

Our electricity is among the greenest in the world. If consumers were more aware of the make-up of NZ electricity sources, would the environment still be as much as a concern? The uptake of solar doesn't substitute the use of a heavy fossil fuel generation. Further impact of this for NZ is discussed below.

2.3.2 Impact of high uptake to co2 emissions

Concept Consulting did a study into the emissions impacts from residential solar PV adoption. They found that over the medium and longer term and with large uptake, it would cause an increase. Their reasons were several interwoven factors tied into the nature of our current electricity production sources.

Firstly, as NZ is mostly renewable energy as discussed above, Concept found that having the residential sector substituting one type of low emission power generation type (from our grid) for other (rooftop solar) would have little impact on our emissions.

The CO^2 savings from a household utilizing PV systems are greater in countries such as "Australia and the United States, where coal or gas-fired power stations are the predominant source of grid electricity" (New technologies emissions report vol 1, n.d.) with residential solar PV's providing substantial benefits to the amount of emissions offset. This has far less of an impact in NZ because of the nature of our renewable electricity sources. We are largely renewable already, around 80%.

Secondly, they found that with high PV uptake, there may be less demand for electricity overall and this could displace investment and development of low emissions generation stations that may have otherwise been built (New technologies emissions report vol 1, n.d.).

In addition, Concept expects that a high uptake of residential PV's to increase our use of and reliance on our current fossil-fuel generators. They say this is due to the widening in the seasonal demand differentials that solar systems will cause. "Solar generates more in summer than winter, which is the opposite of NZ power demand needs" (New technologies emissions report vol 1, n.d.) and more in the day than the morning and evening peaks.

Our fossil fuel peaking systems are our back-up to support variability in our renewable energy generation, such as dry year impact on hydro. On cold winter evenings, our time of greatest energy demand, our fossil fuelled generators run to meet the demand. Residential solar use doesn't supply during our times of greatest demand.

"New Zealand will need more power from controllable sources that operate for only part of the time. We expect this to be met mainly from operation of fossil-fuelled power stations."
(New technologies emissions report vol 1, n.d.).

Instead of retiring our peaker plants, they are likely to be required to stay to support our ability to meet demand.

Overall, ignoring the emissions from manufacture and from waste, but focusing on the emissions impact that large residential PV uptake could have to NZ, Concept found that PV systems, while not directly producing emissions themselves, do not deliver environmental benefits in NZ and could in fact increase it.

2.3.3 Waste

NZ is in the position to observe impacts from around the world. The following example is not from NZ nor a model on our environment. However, it was an unexpected impact that effects waste management and an example that NZ should be aware of.

Northern Territory Australia is overrun with disposed of solar panels. A regional waste coordinator for five regional councils in the Northern Territory (Mathur et al., 2021) got a call one day from a contractor who asked if he was permitted to dispose of 800 solar panels into the local landfill (Mathur et al., 2021). This prompted a study into why this was happening, when the panels had an estimated end-of-life age of 30 years. "Do solar energy systems have a mid-life crisis?" the study by Mathur, Gregory and Hogan found that solar panels were being removed after just 10 to 12 years of use.

The reasons they found for removal included:

- Weather damage
- Damage from vandalism
- Technical failure
- Refurbishments
- Regulations
- Commodity item – to be upgraded

In the case where failure or damage occurred, the reason for removal over repair varied over the life of the product.

In the early life of the panels, under insurance or manufacturer policy, is it to be made new, so the whole system is replaced. So even the working panels were removed, prematurely making them waste.

In the older life of the product, the insurance or manufacturer policy no longer dictated the action, so ideally just the affected panels would be replaced. However, the technology advanced so quickly, that the electrical properties and capacity of the new panels are not compatible and couldn't be installed.

The study also discovered that the life of solar inverters was working out to be around 10-12 years. At the time when the inverter needed to be replaced, many people used this as an opportunity to upgrade to a whole new system instead. This was mostly a consequence of the rebate in Australia. The rebate is only available for installing completely new systems, not for a part. "So, it's more economical for them to get the rebate and replace it all and get a fresh warranty and a newer, cheaper system, than just buy a new inverter" (Mathur et al., 2021).

This is causing a huge solar panel waste problem in Northern Territory. "Researchers predict Australia will accumulate 1 million tonnes of solar panel waste by 2047 — the same weight as 19 Sydney Harbour Bridges" (Mathur & Muhammad, n.d.). Victoria has banned panels from going into

the landfills, after recognising the fast growing rate at which they were heading into them (Mathur & Muhammad, n.d.).

NZ doesn't seem to have this waste issue yet and may not as the Australian rebates play a large role, but it is a warning that should be known.

CONCLUSIONS

Initial research found claims of the number of households that might be expected to get solar PV systems. This prompted a search to explore and examine the demographics that makeup an eligible household. While an exact percentage could not be found nor a full demographic profile, it is clear that the figure of the total number of households or even of owner-occupied households is not representative enough of the likely target market.

There are many factors that influence the decision for a household to get solar and many impacts to NZ for a high uptake of solar. Likely many more than was thought of for this report, or apparent at present. This is rich area to be explored, with a very real effect to the market available to solar installers and the impact to NZ if a high residential uptake occurred.

This report could not explore them all. Instead, it focused on two main concerns; value of the investment and environmental concerns. The main drivers and arguments for getting residential solar PV systems are to save money by spending less on your energy bill and to help the environment. This report aimed to investigate these claims and also look beyond the immediate impact to the household, to the effect on NZ.

It was found from studies that the main benefit from a residential solar system comes from using the energy it generates. This requires someone to be in the house to use it. While individual households might benefit from savings from not buying power during the day, their reduction in contribution to NZ's electricity infrastructure will likely be shifted onto non-solar users, which due to the demographics will be lower income groups.

Many people are concerned with the impact of emissions in the environment, but few likely realise the renewable make-up of NZ electricity supply. Substituting one low emission source for another does not reduce emissions. In fact, with a large uptake of PV systems, sources found that our reliance on fossil fuels to balance the load at peak times is likely to increase, therefore increasing our emissions.

The considerations for getting residential solar are not as simple as 'you will save money and its good for the environment'. This report hoped to highlight that and to propose that it be further considered and explored.

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