# HEALESVILLE NET ZERO TOWN PROJECT

## OPPORTUNITIES AND CHALLENGES

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# Executive Summary

This report was prepared for Healesville Community Renewable Energy (Healesville CoRE) by Monash University students Luke Barry and Nicholas Seymour as part of their engineering final year project unit. Founded in June 2017, Healesville CoRE is embarking on the journey to transition their town to net zero emissions by 2027, and greater energy independence. In the long term, the group's vision is for Healesville community to feel empowered and have more control and ownership over the production, distribution and storage of the town's renewable energy.

## Drivers

Healesville CoRE's primary driver for transitioning the Healesville community toward net-zero is the environmental benefits of reduced carbon emissions. A secondary driver is the excitement the project generates, which engages the Healesville community. Healesville CoRE want the residents of Healesville to benefit from the project's outcomes in the form of minimising cost and ensuring accessibility of energy.

## Scope

The purpose of this report is to help Healesville CoRE in providing options on how the town could transition to net zero emissions and 100% renewable energy. There are three scopes of greenhouse gas emissions.

- **Scope 1:** Direct greenhouse gas emissions – i.e., Gas, transport and waste
- **Scope 2:** Indirect greenhouse gas emissions – i.e., Purchasing of electricity
- **Scope 3:** Other indirect greenhouse gas emissions – i.e., Emissions from production of purchased goods

This report primarily addresses the reduction of emissions from the purchasing of electricity (scope 2) by the implementation of energy efficient measures. Scope 1 emissions are not analysed, but residential gas use is expected to decrease with the implementation of energy efficient appliances, and waste and transport emissions are noted for further consideration. Scope 3 emissions are too difficult to quantify in the context of this report.

## Focus

Based on the Zero-Net Energy Town Blueprint (Moreland Energy Foundation Limited, 2015), prepared for the town of Uralla but applicable to other towns, this report focuses on two questions:

1. **What is the context?**
2. **What is possible and will it work?**

Defining the context of Healesville and its residents enables a better understanding of what needs to be addressed to achieve the goals outlined by Healesville CoRE. The context helps define the opportunities and barriers of the project. ClimateWorks Australia's pillars of deep decarbonisation (energy efficiency, fuel switching/electrification, renewable energy, addressing residual emissions) were guidance tools for the recommendations outlined in this report.

## Overview and Next steps

Healesville CoRE is seeking practical solutions to tackle climate change. This report presents the advantages of setting up a short-term win with solar and energy efficiency bulk buy schemes, designed to activate the community, while having a long-term vision and strategy.

By implementing bulk buy programs for the uptake of energy efficiency practices and rooftop solar, the residents of Healesville could reduce emissions associated with the purchase of electricity (scope 2) by 7.1% within 18 months. The following assumptions were made: 12% of home owners install solar panels, 15% upgrade to efficient lighting, 15% optimise their solar use, 15% implement energy saving strategies from educational programs, 5% install insulation, and 5% install heat pumps.

If a rate of 7.1% electricity reduction for every 18 months was maintained, Healesville could achieve net zero emissions (for scope 2 emissions) by 2040. This result is 13 years beyond the ambitious target of 2027 set by Healesville CoRE. In order to accelerate the transition to net zero emissions, Healesville CoRE would have to work with partners and incorporate any combination of three long term strategies:

- Power Purchase Agreement to procure off-site renewable energy;
- a social enterprise to help manage and accelerate the transition;
- a Healesville mini-grid to accelerate safe and reliable deployment and management of on-site renewable energy.

Based on this options study, a feasibility study will be needed to further assess what are the viable, feasible, and desirable options Healesville CoRE should be pursue.

**What is the context?**

**Healesville's population**

Healesville has an estimated population of 10,700 people residing in 4,316 dwellings, comprising mostly of separate houses, resulting in roughly 2.4 people per household. 42% of the community are aged over 50 years with evident ageing over the past two decades. Healesville and surrounds has less percentage of its earners in the high-income bracket (greater than $2500 per week) and higher percentage of its oncome earners in the low-income bracket (less than $650 per week), compared to Greater Melbourne.

**Healesville's climate**

Healesville experiences four distinct seasons of temperature, with hot summers, cold winters, and mild springs and autumns. Cold weather throughout the winter is common, with minimum night time temperatures below freezing point roughly 25 times a year. Similarly, extreme hot weather (greater than 37°C) during summer occurs roughly 5 days a year.

**Healesville's renewable energy resources**

A 2007 report prepared by Climate Managers outlines the potential of renewable energy resources in the Yarra Ranges Shire. In particular, the study focuses on hydropower. These would involve installing turbines in Melbourne Water pipelines to produce power from excess water pressure. A second potential source is the capturing of capped landfill methane gas. However, these sites are located outside of the Healesville community boundaries. Solar radiation was also analysed in the report but no comments or recommendations were made on solar generation. This is likely due to the lack of cost effectiveness of solar technology in 2007 when compared to other renewable technology options. Climate Managers report the lack of a suitable site for large scale wind farm or adequate geothermal resources in the area.

**Healesville's electricity**

Healesville's residents used over 43,000 MWh of electricity in 2017, with just over 5000 consumer accounts. Winter displays the highest average usage period due to increased demand for heating and hot water during cold weather. However, the peak load of the system was during summertime, on a day of extreme heat. Daily profiles of energy use for each season varied slightly, but all of them showed three distinct peaks throughout the day – hot water storage systems utilising off peak electricity at 1 am, morning peak when people wake and prepare of the day at 8 am, and evening peak around dinner time.

**Energy usage case studies**

The purpose of the case studies is to engage the Healesville community members by improving their understanding of opportunities that can reduce electricity use in their homes. The three homes, Home A, Home B, and Home C, consumed 12 MWh, 4.5 MWh, and 20 MWh respectively. For Home A, hot water, heating, and an energy inefficient dryer were the three main users of electricity. By upgrading the hot water unit, installing floor insulation, and upgrading the dryer, a reduction of 47% on total electricity use is estimated. The residents of Home B use electricity quite frugally and although heating is the highest component of electricity use, there is a much more even distribution of use points compared to the other homes. A 4KW solar array on the unshaded north orientated rooftop is most appropriate for this home, as it will generate more electricity than consumed on site, and it is calculated that 44% of electricity is used during the daytime in the home. Home C consumes the most of the three homes, attributed to a large heating demand. Installation of R2.0 floor insulation is estimated to reduce total electricity use by 38%. Further reductions in electricity can be made by altering heating behaviours.

### What is possible and will it work?

The areas of focus for the next steps on Healesville CoRE's journey towards net zero emissions are summarised below.

## Energy efficiency

- **Insulation**

Heating and cooling account for approximately 40% of household energy use in Australia (Australian Department of Industry, 2013), and insulation is an effective way to reduce this use. 45% and 75% of heat losses flow through walls, floors and ceilings (Keech, 2015). Without insulation, loss in heating and cooling energy could amount to 40% (Department of Environment and Energy, 2018). Insulation is likely to be paid back with the reduction in energy bills, whilst improving the thermal comfort of a home.

- **Heating and hot water systems**

As Healesville experiences near-freezing temperatures during winter, heating and hot water systems are the two largest uses of home energy. Heat pumps are the most efficient appliances used for space and water heating, as they can use up to 4 times less energy than traditional gas or electric heating (Keech, 2015). Solar hot water provides hot water from a renewable source, but is likely to require a gas or electric booster to meet demand. Efficient heating systems and pairing solar panels with electric systems could remove a large proportion of Healesville's $CO_2$ emissions.

- **Behavioural changes**

Although hard to accurately quantify, behavioural changes can have a significant impact on reducing energy demand. For instance, every degree of heating above 20°C in winter can increase running costs by 10%. Also, shifting usage times to correspond with solar power optimises renewable energy generation.

- **Lighting**

While only accounting for 6% of household energy use (Australian Department of Industry, 2013), upgrading lights to energy efficient LEDs and fluorescent lights is a simple and cost-effective way to reduce energy demand.

## Renewable energy generation

- **Solar power generation**

Renewable energy generation is a must for Healesville CoRE to achieve its goal. Solar power is the most appropriate type of renewable energy due to the large potential capacity that can be generated. Solar bulk buy programs are currently in preparation within the Yarra Ranges Council and Healesville. However, large scale generation as well as optimising usage and/or implementing battery storage are necessary for the 2027 target to be met.

- **Battery storage**

The yearly savings from installing a battery system are calculated to be around $324.11 per year, which equates to a payback of 39 years. This payback, although an upper limit, is far beyond the warranty and lifetime of the battery. The cost of a battery, keeping capacity constant, would need to decrease by 75% to provide a less than 10-year payback. This would mean a price of around $230 per kWh of storage. While this seems substantial, technology can progress at an exponential pace and may be a reality in the next 3-5 years. As such, ensuring battery technology can be readily implemented into homes would be beneficial, saving time and money in the future.

- **Wind power generation**

Wind power is a great source of renewable energy generation. Hepburn wind is a community owned renewable energy generator that has two 2.05MW wind turbines that have the capacity to generate 11,000 MWh per year (one quarter of Healesville's usage). However, a 2007 report prepared by Climate Managers concluded the wind speeds in the Yarra Ranges Shire were not suitable for the operation of large scale wind turbines.

## Electrification and renewable wood resources

- **Transitioning away from gas**

Gas end uses are common in residential homes in the form of cooking stoves, heating appliances, and hot water systems. Gas emits 0.22kg of $CO_2$ for every kWh of energy consumed, and gas appliances are much less efficient that heat pumps for heating and for hot water systems. In addition, the extraction of natural gas can contaminate water resources, be detrimental to human health for residents near to extraction sites, and changes the local environment and landscape characteristics (Meng, 2014). Therefore, efforts should be made to switch to emissions free renewable electricity that powers efficient heat pumps.

- **Renewable wood resources**

Ideally, 100% of heating demands would be sourced from electrical heat pumps. Given the context of Healesville, where a large proportion of residents may use wood fire heaters, it is important to consider that the impact of an unplanned transition of all electrical heating onto the local network. Uralla faces a similar situation, with 49% of energy consumption from the residents being wood. The Uralla Z-NET blueprint has outlined possible strategies to address this issue, such as importing certified wood from a nearby region, improving existing collection practices, or funding reforestation programs.

## Addressing other $CO_2$ emitting factors

- **Waste and Transport**

The city of Moreland found that transport and waste accounted for 40% of $CO_2$ emissions per year. Initiatives that tackle waste and transportation emissions may be just as effective and can be more behaviourally focused, making it accessible and reducing the cost of abatement.

## Strategies

- **Bulk buy**

A bulk buy program is the purchase of a large amount of goods and services that typically lower the unit cost of the individual items, resulting in discounts on the original prices. Bulk buys can be set up for renewable energy generation (i.e., solar panels), and energy efficient appliances such as LED lighting, insulation, and heat pumps for hot water services and space heating. They constitute a short term win and low risk strategy that can engage the community and make a considerable start on the transition to net zero emissions.

- **Power purchase agreement**

A Power Purchase Agreement (PPA) is essentially a financial instrument to procure off-site renewable energy through a long-term contract between an energy generator and energy buyer. Healesville could partner with an electricity retailer to enable investment in renewable energy generation to produce renewable electricity for the town of Healesville. This would require extensive community coordination and PPA expertise to set up.

- **Social enterprise**

Central to Healesville CoRE's social drivers, a social enterprise in charge of managing the transition to net zero emissions could provide greater control over energy generation, while building a stronger sense of community, a sense of responsibility, an opportunity to educate and for the benefits to flow back to the community. Although the benefits are long-lasting, it must be acknowledged that setting up a social enterprise requires countless hours of work and expertise. Partnering with one whose vision aligns with that of Healesville CoRE may be more sustainable.

- **Healesville Mini-grid**

A mini-grid is the procedure of setting up large capacity of on-site renewable generation, battery storage, together with the knowledge associated with managing the energy demand and response. It is not the intention of Healesville CoRE to be self-sustaining and to disconnect from the grid. However, a mini-grid would reduce reliance on grid energy, and the volatility of energy prices that comes with it. Healesville does not necessarily need to build a mini-grid to the capacity that will make the town completely independent from the grid, but a mini grid of any size will help alleviate dependence on grid energy, and also facilitates smart and cost-effective energy demand and response.

## Acknowledgements

Luke Barry and Nicholas Seymour were assisted by Dr Yasmina Dkhissi (Monash's Net Zero Strategy Manager), Dr Roger Dargaville (Senior Lecturer in Renewable Energy at Monash University) and Tim Hoban (Monash's Net Zero Project Engineer), and also spoke with other Industry experts in the field of renewable energy and net zero emission transitions.

Collaboration and knowledge sharing were central to the preparation of this report. The intention was not to repeat existing work but rather to learn from experts from the field and provide practical solutions for Healesville. Consultation with Industry experts was key to the value of this report, and the authors thank Taryn Lane and Kate Nicolazzo for their insight on the net zero journeys for the Hepburn Shire and Moreland.

# Contents

# 1 Background

## 1.1 Project Drivers

Several drivers have seen the adoption of net zero energy strategies across various organisations, councils and states across Australia. Motivation has come from the continual improvement and innovation of renewable technologies, the lowering of costs and protection against risk, as well as enormous environmental benefits. Healesville CoRE approach their net zero target with two main drivers.

**Primary Driver - Environmental outcomes**

The main motivator for transitioning the Healesville community toward net-zero is the environmental benefits it will provide. Healesville CoRE seeks to facilitate the development of sustainable energy projects to reduce the amount of carbon emissions, with the aim of Healesville becoming net-zero by 2027.

**Secondary Driver - Community engagement and benefits**

A strong focus of this project is to begin mobilising the community, and ensuring that the benefits flow back to the community. Starting the conversation within the town about the benefits of renewable energy is an important aspect of the project. Inducing community involvement in accessible and exciting initiatives will greatly affect the success and overall positive impact of the project on the Healesville community. Furthermore, minimising cost and ensuring accessibility are two other key elements that ensure a wide range of beneficiaries.

## 1.2 Healesville CoRE and Yarra Ranges Council

### 1.2.1 Healesville CoRE

"Healesville Community Renewable Energy Inc is a group of motivated community volunteers working towards transforming Healesville into a renewable energy town" (Healesville CoRE, 2017).

Healesville CoRE is a small community group run by dedicated volunteers who are looking to influence how the community view and utilise renewable energy. With a strong focus on solar power, Healesville CoRE have run a variety of professional and technical development sessions and public information events, and have begun the process of developing initiatives that can be implemented in Healesville. Healesville CoRE has explored and formed various partnerships, both with the public and private sector, including a strong working relationship with Yarra Ranges Council.

### 1.2.2 Yarra Ranges Council

The town of Healesville lies within the Yarra Ranges Shire, and the Yarra Ranges Council have offered support for Healesville CoRE. It has assisted Healesville CoRE in its establishment, and has offered expert advice and support on grant funding applications. The sustainability team at the Yarra Ranges council supports other projects that will increase the generation of renewable energy in the shire. This strong relationship with the Council is key enabler to the success of Healesville CoRE's vision.

# 2 Demographics and Climate

## 2.1 Demographics

Full details of the demographics of Healesville can be found in Appendix A. Details have not been included in the body of the report, as the information does not impact the energy consumption patterns of the Healesville community.

However, the Healesville area does have a smaller percentage of residents in the upper income bracket and a larger percentage of residents in the lower income brackets compared to Greater Melbourne. This could hinder the community's ability to access projects and invest in assets for their own homes. Furthermore, Healesville's population is ageing, meaning that they are vulnerable to increases in energy prices and would benefit from more reliable power.

## 2.2 Climate

The Coldstream weather station is 12km south-east of Healesville, and provides the most recent and comprehensive weather observations.

### 2.2.1 Temperature

Based on the 23 years data available, Healesville experiences four distinct seasons, with hot maximum daily temperatures from December through to March and cold minimum daily temperatures below 5°C from June to September. Extreme weather conditions are not uncommon during these months, with 112 days 37°C or higher and 489 days 0°C or lower over the course of the 23 years of data. The autumn and spring months in between are relatively mild, and extreme conditions are unlikely, although nights are still frequently below 10°C.

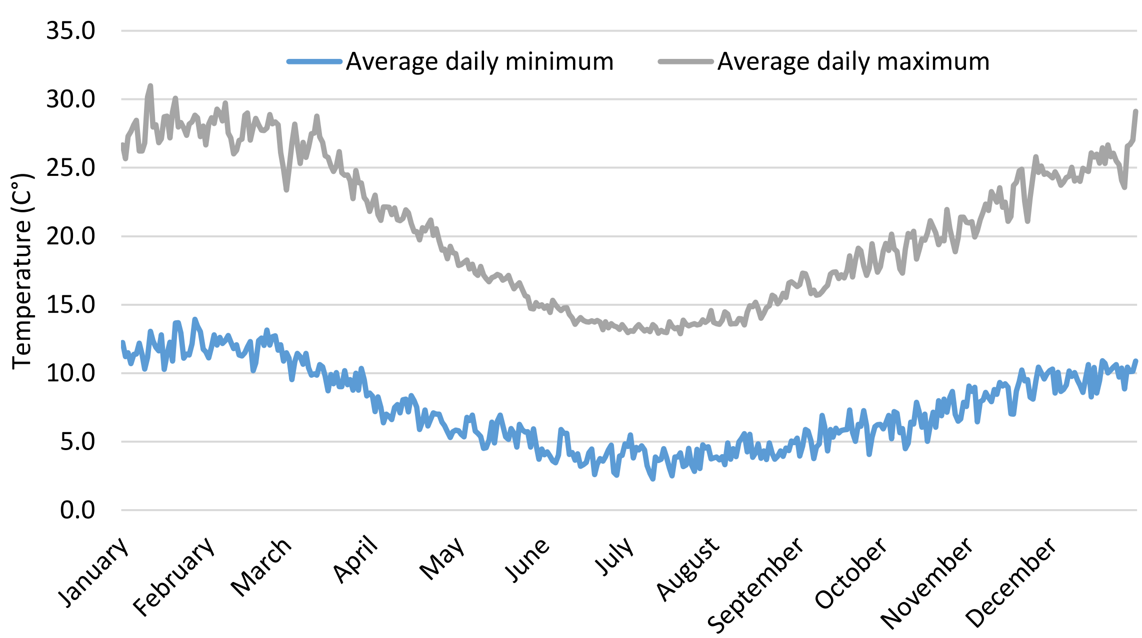


*Figure 2-1: Average daily maximum and minimum temperatures as recorded from Coldstream for the past 23 years (Bureau of Meteorology)*

### 2.2.2 Solar Exposure

There is a distinct seasonal variation in available solar exposure within the Healesville region. Past reports on renewable energy in Healesville have stated an average solar exposure of 16MJ/m$^2$, but variation throughout the year must be taken into consideration, as the capacity of solar is five times more in summer than winter.

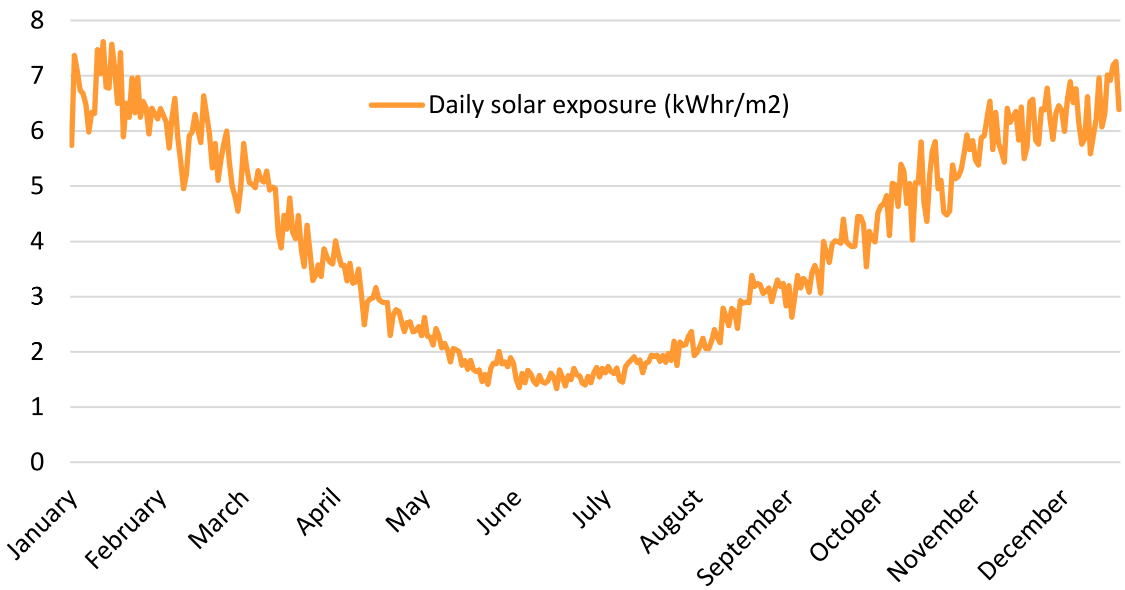


*Figure 2-2: Average daily solar exposure as recorded from Coldstream for the past 23 years (Bureau of Meteorology)*

The solar exposure around Healesville has a large capacity that can meet the demand of current electricity use in the town. However, the seasonal variation across the year (Figure 2-2) will pose challenges as generation has the potential to put strain on the network in summer but not meet demand for heating and hot water in winter (Figure 2-3).

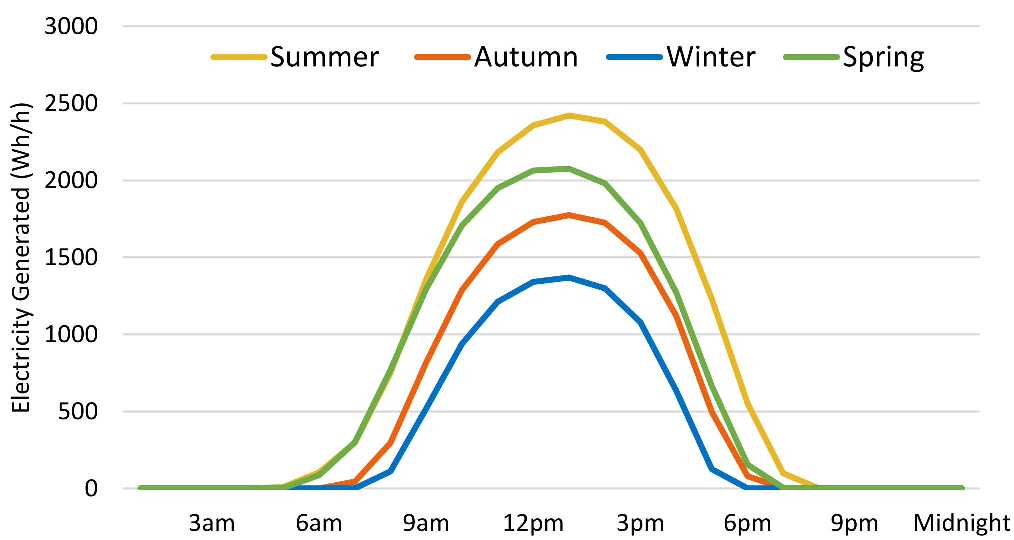


*Figure 2-3: Seasonal daily generation of a 4kW solar array*

# 3 Town Electricity Use

## 3.1 Electricity Baseline

The electricity baseline seeks to identify the characteristics of electricity consumption in Healesville. Residents of Healesville consumed over 43,000 MWh of electricity in 2017, with just over 5000 customer accounts. The data was compiled by AusNet, Healesville's electricity provider, and consists of aggregated smart meter data measured every 30 minutes for the entirety of 2017.

### 3.1.1 Electricity Use Profile

The profile is an important tool in recognising the trends in electricity use and how its consumption contributes to $CO_2$ emissions. With data available for the entire year, the electricity profile can identify peak loads (the maximum amount of power required), trends throughout the day, over a month or between seasons. This section will analyse the electricity profile, identifying key characteristics of Healesville's electricity consumption over several different time steps.

#### *3.1.1.1 Seasonal Electricity Use Trends*

The seasonal variation in electricity consumption for Healesville is quite distinct. There is an obvious difference between the summer and winter profiles. This section will look at each season, identifying the key elements of each. Table 3-1 below shows the key statistics for each season.

*Table 3-1: Electricity Use Key Statistics*

| | *Summer* | *Autumn* | *Winter* | *Spring* |
|---|---|---|---|---|
| *Total Energy Use* | 10,529 MWh | 11,425 MWh | **13,068 MWh** | 10,841 MWh |
| *Average Energy Use per day* | 117 MWh | 124 MWh | **142 MWh** | 119 MWh |
| *Peak Load* | **11.13 MW** | 8.68 MW | 8.44 MW | 9.95 MW |

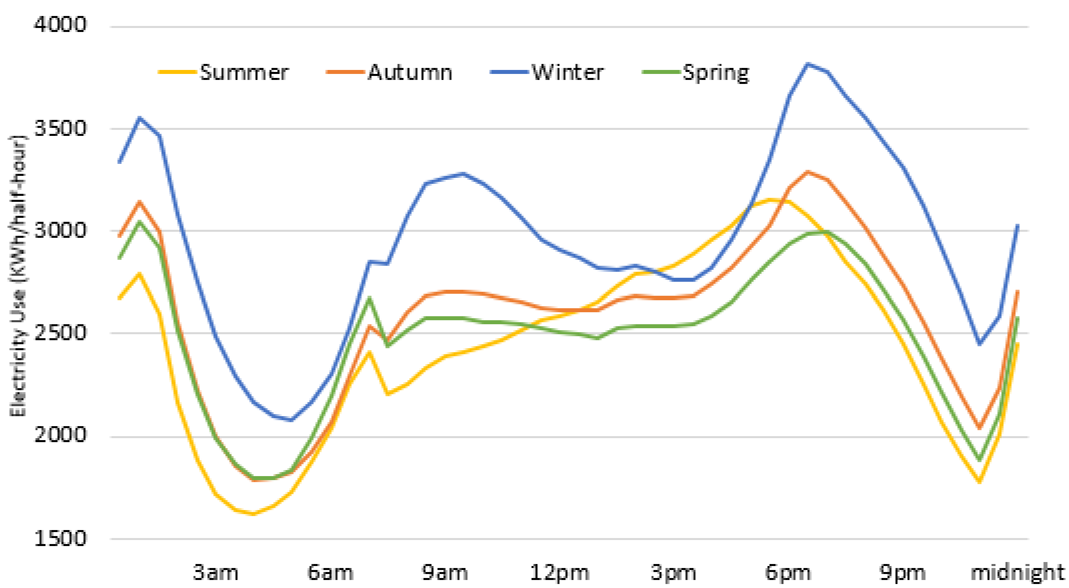


*Figure 3-1: Diurnal Electricity Profile for the Four Seasons*

### Winter

There are three distinct peaks in the winter profile. Predictably, two of the peaks represent when activity in the home is the highest. This occurs as people wake up, and when they arrive home from work. The peak in the morning begins at around 7:30 and is the highest at 9:00. The evening peak starts at around 17:30 with a maximum at 18:30. The evening peak is significantly larger than the morning peak, using 17% more power.

The first peak in the winter graph peaks at 1:30, which is caused by water heaters kicking in at and using off-peak electricity to heat the water (MEFL 2015). The magnitude of the spike suggests that a significant number of households heat their water at this time.

Given the colder climate, heating dominates energy use for Healesville. As such, winter has the highest energy use out of the four seasons. The winter energy demand is relatively consistent, with the lowest peak demand out of the four seasons.

### Summer

The summer profile has different characteristics from the winter profile. It shows a gradual increase in electricity use during daylight hours. The profile represents the house beginning to heat as the external temperature and sun warm it. This results in the air conditioners working harder as the day progresses, and the house warms more and more. Summer and winter share a similar spike at the end of the day, although less pronounced in summer, disguised by the energy use in the late afternoon for cooling. Summer also has the same 1:30 peak in energy from water heater use.

Summer's energy demand is the lowest of all the seasons, but it produces the highest peaks in energy. These energy peaks occur on extremely hot days when many people remain inside, with air-conditioners on, and using appliances such as the fridge and TV more frequently than they would on a regular day.

### Spring and Autumn

Spring and Autumn act like an average of the summer and winter graphs, with spring using 5 MWh less electricity on average per day and sees a slightly higher peak demand at 9.95 MW. Despite these slight differences, the shapes of the graphs are quite similar. From the start of the day until 16:00, electricity use remains relatively stable until the evening peak, with the same peak at 1:30 for water heating.

#### 3.1.1.2 Yearly Electricity Use Profile

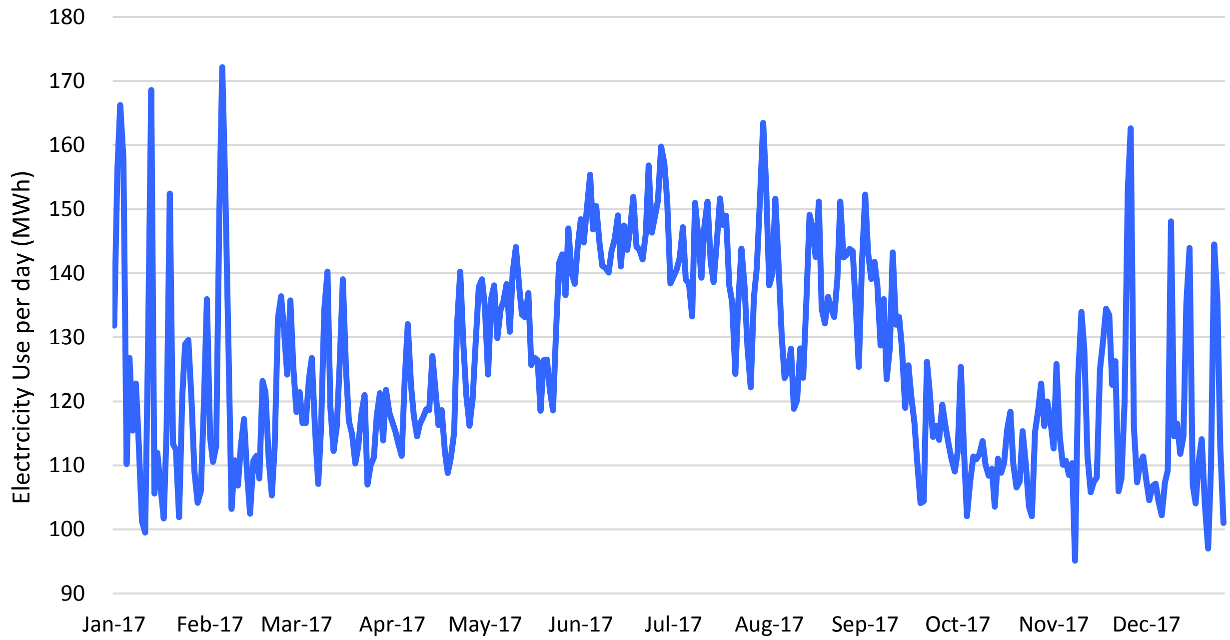


*Figure 3-2: Yearly Electricity Profile – Daily totals*

Figure 3-2 above shows Healesville's electricity use over 2017. As discussed in Section 3.1.1.1, the summer months are considerably more volatile than the other seasons, but average less electricity consumption than other months.

The daily use ranges between 172 and 95 MWh, with the average sitting around 126 MWh. The average electricity use per household (5034 connected households / customers) is 25 kWh per day.

### 3.1.2 Impact of gas use

Given the limited timeframe, electricity use was the focus of this report. However, gas use for space and water heating, as well as stoves, contributes a significant fraction of $CO_2$ emissions. Therefore, the $CO_2$ emissions estimated relates to electricity generation only. There are also emissions associated with other activities such as transport and waste that are not considered in this report.

### 3.1.3 $CO_2$ emissions

The $CO_2$ emissions associated with the electricity generation of the town is approximately **53,602 tonnes of $CO_2$**. If Healesville is to become Net Zero, it cannot emit any $CO_2$ at all. Thus, the emission of 53,602 must be entirely avoided, or significantly reduced and residual emissions offset.

### 3.1.4 Future trends

Energy use in Healesville is likely to increase in the future due to the increase in population, and change in heating arrangements. As the population and number of households in Healesville increase, more and more electricity will be demanded. With little thought to renewable energy, Healesville would see an increase in $CO_2$ emissions as more people use electricity associated with non-renewable sources. Similarly, as the cost and effort of heating homes with firewood increases, many households will switch to gas or electricity for more reliable space heating. Both these factors suggest that electricity use and $CO_2$ emissions will increase into the future. This has not been factored into this analysis, but should be taken into consideration when analysing electricity use and planning future initiatives.

# 4 Home Energy Audits: A Case Study of Three Healesville Homes

## 4.1 Purpose

Healesville CoRE aim to transition their community to a zero-carbon town by 2027, and, as outlined by ClimateWorks Australia, the first step towards this goal is to reduce energy demand through an improvement of energy efficiency. In this regard, homes are a great starting point as residents can have a significant impact on their energy use. Upgrading lighting and appliances, heating and cooling smarter, and changing behaviours are just some of the ways residents can cut into their energy use and thus reduce the $2,400 spent each year on energy bills by the average Australian (Keech, 2015).

## 4.2 What is a Home Energy Audit?

The home energy audits undertaken as a part of this study assess the energy consumption patterns of a home with the objective of reducing total usage. They identify the areas where most energy is consumed and areas for improvement, and thus play a crucial role in improving the energy efficiency of a home.

Interval data of gas was not obtained during the short project time frame. Therefore, 30-minute interval data of only electricity was collected and analysed. Although gas data will not be critically analysed in this paper, all gas end uses in the houses are recommended to be switched over to electricity at the end of their lifetime. This advice is made with the aim of eventually sourcing all energy in the home from renewable sources and is in line with current recommendations from ClimateWorks, which focuses on electrification as one of the four pillars that help achieve decarbonisation (ClimateWorks, 2014).

## 4.3 How Were the Home Energy Audits Done?

### 4.3.1 Data collection

First, electricity consumption data was collected to analyse a yearly pattern for each audited home. AusNet is the energy distributor for the region and allows its customers to access 30-minute interval data online for their electricity meter. The homeowners of the three homes logged into their AusNet accounts and collected the data. This data was communicated with the authors of this report via Healesville CoRE for analysis.

Data from 2017 was used, as it gives a full yearly profile and considers the whole seasonal variations associated with electricity consumption. This was used to find a total amount of electricity and the daily variations and peaks across the four different seasons.

Site visits to the three homes were conducted to collect information surrounding electricity use in the home. A plug load reader meter was used to record the electricity consumption of household appliances such as televisions, computer chargers, microwaves, kettles, etc. When the power point of the appliance was out of reach, the model number and brand was noted and later searched online to find energy ratings through the Australian government star rating program. The number and type of lights was also noted during these site visits.

The home owners were interviewed during these visits to obtain time usage for all the electrical appliances. As there are no precise recordings of the time used for each appliance in the year 2017, estimates were made for each of the appliances, i.e., dishwashers used once a day, or washing machine used three times a week, as well as the settings they were used on, such as cold wash.

### 4.3.2 Interpreting the data

With all the information collected, the electrical data was subdivided into eight main use points

| Electricity use point |
|---|
| Heating |
| Cooling |
| Hot water |
| Kitchen appliances |
| Washing machine |
| Dryer |
| Television/computers/phones |
| Lighting |

Quantifying the kitchen appliances, washing machine, dryer, televisions/computers/laptops and lighting was done through information found during the site visits and interviews with the homeowners as mentioned above. An "energy balance tool" was supplied by Monash University for the estimations of heating, cooling, and hot water. The tool is a spreadsheet where a range of inputs relating to the house are entered. The inputs include, but are not limited to: the building form of the home – ceiling height, wall, roof, and floor dimensions, percentage of facades that are windows, R-values[3] of walls, roof and floors, etc. – the hot water system information and usage, occupancy rates, heating and cooling mechanical information and use times. The tool works by estimating heating and cooling, and hot water demands with the information supplied.

NOTE: The values that come from quantification of data into the eight use points are estimates and are not the exact true value of electricity use points in 2017. However, the values obtained will give a good indication of where the largest portions of energy use are being used.

## 4.4 The Homes

The home energy audits were conducted on three homes for homeowners who volunteered for the audit through Healesville CoRE. The homeowners agreed that all data and information of the energy audits would be de-personalised i.e., no names, addresses, photos, etc. would be used in this paper. Therefore, the three homes will be referenced as Home A, Home B, and Home C in this report.

[3] R-value is a measure of the resistance of heat flow through a material. The higher the R-value, the higher the resistance and the better the insulation

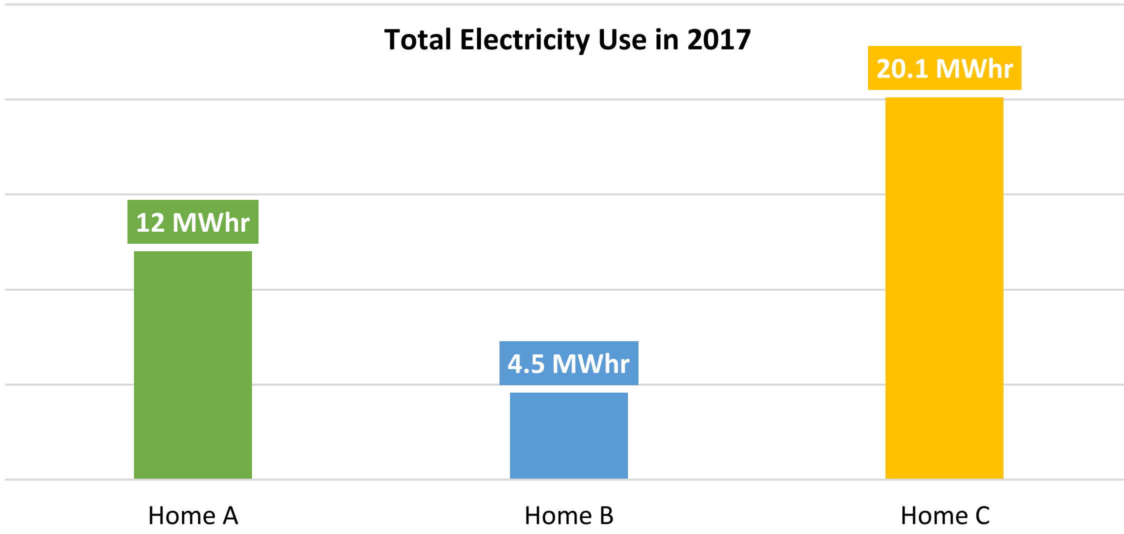


*Figure 4-1: A comparison between the three homes' total electricity Use in 2017*

Full details and calculations of the electricity savings for each home can be found in Appendix B. Below is a summary of all the savings each home can make.

*Table 4-1: Summary of electricity savings for each home*

| | *Home A* | *Home B* | *Home C* |
|---|---|---|---|
| Electricity use (2017) | 12 MWhr | 4.5 MWhr | 20.1 MWhr |
| Potential saving points | ▪ Upgrading hot water system to a heat pump<br>▪ Installing floor insulation<br>▪ Upgrading old, inefficient dryer | ▪ Installing a 4kW solar array on unshaded north orientated roof | ▪ Installing floor insulation |
| % Reduction from saving points | 47% | 111% of electricity generated by solar. Roughly 35-40% used on site | 38% |
| Electricity bills saving per year | $1750 | $980 | $2350 |
| Reduction in $CO_2$ emissions per year | 6.4 tonnes | 2.9 tonnes | 8.3 tonnes |

## 4.5 Simple ways to make a difference

**Lighting**

All the homes in this study mostly had modern LED lights installed throughout. This is reflective on the small amount of total electricity being used for lighting. Compared to old halogen or incandescent lights, LED lights last much longer, give off better quality light, and most importantly are much more energy efficient.

**Hot water**

In Australia, about one quarter of household energy is used to provide hot water (Keech, 2015). Reducing hot water demand – low flow shower heads, using cold wash settings on washing machines etc., and improving efficiency of generation – heat pump or solar hot water – are ways of reducing energy in providing hot water.

**Heating**


**Cooling**

Heating and cooling consume 38% of household energy across Australia (Keech, 2015). Insulating and draught proofing are techniques to keep wanted heat in and unwanted heat out. Heat pumps are the most efficient appliance available, but most importantly, heating/cooling appliances should be appropriately sized.

**Appliances**

When buying a new appliance, consider energy efficiency. Use the online energy rating calculator to compare appliances http://www.energyrating.gov.au/calculator. Appliances that use less energy will be cheaper to run and emit less carbon dioxide. Only upgrade to energy efficient appliances when old ones are at the end of their lifetime. Needlessly exchanging appliances impacts the environment adversely, even if they are energy efficient.

**Solar**

Rooftop solar generation is renewable, does not result in carbon emissions, and makes economic sense. Over the course of their lifetime, the cost of solar PV systems will be covered by savings on the electricity bill. Adequate solar system supplier, solar panel orientation, and shading issues should be considered. If solar cannot be installed, consider switching to an energy retailer that invests in renewable energy.

**Choosing a retailer**

If none of the above strategies is feasible for your home but you still want to contribute to the lowering of energy associate emissions, then consider switching to an energy retailer that invests in renewable energy. “When you buy a GreenPower product from your electricity retailer, you're paying for electricity produced by renewable power sources that meet a strict set of criteria for accreditation.” (Article ref). AGL, EnergyAustralia, and Origin supply about 75% of Australian households but are not the three greenest energy retailers. A full list of Victorian retailers and their green score is shown on the following page.

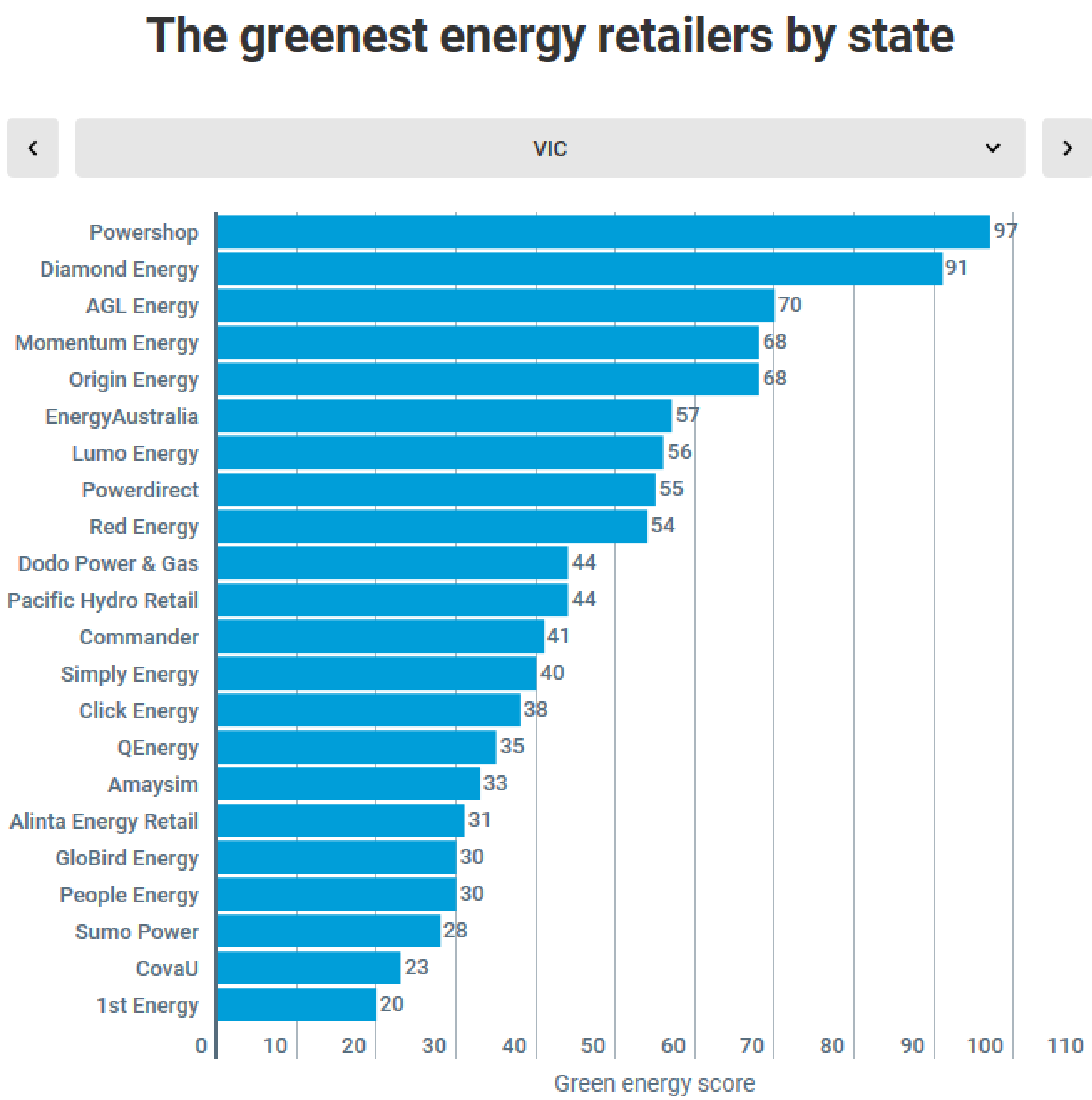


*Figure 4-2 Comparison of retailers for green rating scores in Victoria (Uta Mihm. 2018)*

# 5 Challenges

## 5.1 Cost and Access

A strong focus of Healesville CoRE is to ensure equity of energy access. However, given the often capital-heavy investments that need to be made to install small-scale energy generation systems, improve building fabric and replace energy inefficient appliances, many of those who are willing to participate are unable to because of financial limitations.

The ageing and below average income households identified in Section 2 fall into this bracket. With a 5kWh solar systems costing over $6380 (Solar Choice, 2018), double glazed windows costing $200 per $m^2$ plus installation (Hi pages, 2017) and insulating to an R value of 4 for a 150$m^2$ roof costing $1,170 (Insulation Australia, 2018), it is easy to see how middle to low income earners could not afford to easily participate in the renewable energy transition.

It is essential for the initiatives to be inclusive and involve the wider community, as well as to provide sufficient alternative funding options to invest in renewable technologies and energy efficiency upgrades. This will result in a  greater community participation and support, ultimately leading to a larger reduction in $CO_2$ emissions.

## 5.2 Timeframe and Resources

The goal of reaching net zero by 2027 is very ambitious. It requires significant change in a short amount of time. Furthermore, the Healesville CoRE team, while passionate and hard-working, consists of mainly environmental enthusiasts with little to no technical experience. The team is also limited in terms of the availability of time.

Ensuring that programs are well supported, leveraging outside resources and utilising the Healesville CoRE team and the wider community is necessary if the 2027 goal is to be achieved.

## 5.3 Network Impact

The impact of energy use changes and on-site energy generation on the electricity supply network should be considered. Important considerations must be made in terms of how a high penetration of solar power may impact the grid. An extremely sunny day may see an extraordinary amount of solar energy flowing away from houses back to substations. Without adequate distribution infrastructure, solar power may cause serious issues and impact the reliability of energy supply in Healesville and surrounds.

While excess solar can be an issue for networks, reducing electricity demand through on-site renewables, energy efficiency appliances and behavioural changes reduce demand and can be of great benefit to distribution companies. With the population growing, AusNet may be required to increase the capacity, or build a new substation to facilitate Healesville’s growing electricity demand. However, with the programs being introduced, this demand should reduce and may eliminate the need for such upgrades, saving millions in infrastructure upgrades, maintenance, and the building of extra capacity.

# 6 Opportunities

## 6.1 Energy Efficiency

Energy efficiency is often cited as the first step in the journey towards net zero emissions. Uralla and Moreland employ a variety of energy efficient initiatives in their net zero strategies.

Energy efficiency can involve large upfront costs through the purchase of appliances such as heating systems and insulation, but these costs are generally recuperated from savings on energy bills, and in some cases, save residents money over the course of the appliance's lifetime. However, energy efficiency isn't limited to installing the most efficient appliances. It includes a variety of behavioural and smaller DIY changes that can impact on household energy use. This could form part of the wider community engagement and improving the residents' energy literacy. This section provides a list of the first areas where energy efficiency could be improved in Healesville.

### 6.1.1 Insulation

As discussed in section 2, and seen in the winter energy profile, Healesville's energy use is dominated by heating. Healesville is subject to relatively cold weather, 2°C cooler in winter on average than Melbourne. With an ageing population, significant town-wide heating demand and rising energy costs, improvements to the ability of households to retain heat would produce significant benefit. This would not only see benefits in the environmental and financial outcomes, but also improve comfort and health.

Anywhere between 45% and 75% of heat losses flow through walls, floors and ceilings (Keech, 2015). Without roof insulation, up to 40% of heating and cooling energy could be lost (Department of Environment and Energy, 2018). A simple calculation suggests that insulation could reduce household energy use by over 900 kWh per year, saving over $200 per year, a payback of around 5 years. Insulation also provides households greater flexibility on when to heat their homes.

### 6.1.2 Heating and Hot Water Systems

Heating and hot water systems also provide opportunities to reduce energy demand. Heat pumps used for space and water heating can use up to 4 times less energy than tradition gas heating (Keech, 2015). However, this does not exactly translate to monetary saving, as the high price of electricity negates the efficiency gains (although, in recent times, gas prices have been extremely volatile).

Given the low emissions associated with gas usage, switching to electricity seems counter-intuitive. However, there are strategic advantages to doing so. Unlike gas, electricity has the capacity to be renewably sourced, whether that be through retailer packages, power-purchase agreements or solar panels (discussed later). With renewable power driving heating systems, space and water heating has the potential to emit zero carbon emissions.

Given the cold climate and significant heating load, especially during the winter months, efficient heating systems and pairing solar panels with electric systems could remove a large proportion of Healesville's $CO_2$ emissions.

### 6.1.3 Lighting

Lighting, while only accounting for 6% of household energy use (Australian Department of Industry, 2013), is an extremely accessible and cost-effective way to reduce energy use and associated carbon emissions.

LED lights are almost 4 times more efficient than old, energy-intensive halogen globes, while also lasting 15 times longer. Assuming a house has 20 halogen globes, running for 4 hours per day on average, replacing all halogen globes with LED results in a saving of over $100 dollars a year, paying back in under 3 years. In fact, given the much longer lifetime of LED globes, they make financial sense regardless of energy savings.

### 6.1.4 Behavioural Changes

Simple behavioural changes can make a substantial impact on energy use within the home. Using the qualitative data from the energy audits undertaken by Healesville CoRE, there are some simple, no cost measures that could be implemented and promoted within the community. These are shown in Table 6-1 below. These measures should be promoted and part of Healesville CoRE's community engagement strategy.

*Table 6-1 Effort and savings associated with behavioural changes impacting energy use*

| *Measure* | *Effort* | *Savings* |
|---|---|---|
| *Keep thermostat at 20°C in winter (every degree increase running costs by 10%)* | • | **$$** |
| *Turn off second fridge if/when it's not needed* | • | **$$$** |
| *Avoid using the dryer* | • | **$$** |
| *In summer, open doors and windows to ventilate house at night / when it's colder* | • | **$$** |
| *Take shorter showers* | • | **$$** |
| *Wash clothes with cold water whenever possible* | • | **$$** |

## 6.2 Electrification and Firewood

While gas is a lower $CO_2$ emitter when compared to coal, it cannot be used by a net-zero town, as it still produces 0.22kg of $CO_2$ per kWh or energy used. Gas is used extensively for cooking, space heating and water heating. Moving away from gas to electrified systems means that households and industry can utilise renewable electricity generation (like solar power), which does not emit $CO_2$. While there is still gas as a part of the energy mix, there will still be $CO_2$ produced. Thus, a movement toward electrical systems is essential to reach net-zero.

While no data was sourced as to the number of Healesville residents who utilise firewood to heat their homes, information was collected anecdotally. Healesville still has many woodfired heating systems. This practice can be net-zero when sourced from forests that are quickly regenerating and provide good quality firewood. If trees are being lost due to this practice, it is most likely a $CO_2$ emitting activity. Sourcing firewood in a renewable manner will improve the environmental outcomes of its use and ensure that it emits a negligible amount of $CO_2$.

In the long term, many may find firewood an expensive and unhealthy way to heat their homes. Firewood has already become expensive and may remain that way. It can also cause local pollution issues impacting on the health of residents and the local environment. Heating with modern space heating systems requires a lot less effort, can be more cost effective in the medium to long term, and has no associated local pollution issues. Depending on how cost effective and reliable a renewable firewood source in Healesville can be, and whether pollution effects remain negligible with an increasing population, many may switch to modern systems that offer more comfort, ease of use and less pollution. The transition from firewood to electric, or gas, systems could mean a significant increase in the energy demanded by Healesville. Considering how firewood is and will remain part of Healesville's energy mix may determine certain actions, like a transition away from its use, or incorporating it with a sustainably source that encourages its use.

## 6.3 Renewable Energy Generation

### 6.3.1 Solar power

Healesville CoRE has a strong commitment to the promotion and utilisation of solar power. It is estimated that 18.7% of Healesville homes have solar installations, with a total capacity of 2805 kW (Australian PV Institute, 2018). This is slightly higher than the Yarra Ranges with 16.2%. Estimates for Victoria vary slightly, with an estimate of 15% (Climate Council, 2017). However, this varies considerably in the state with areas neighbouring Yarra Ranges such as the Murrindindi shire and Baw Baw reaching 24.9% and 23.1% respectively.

The deployment of rooftop solar PV is a major opportunity for Healesville to generate a significant amount of its own energy, and is considered by Healesville as a key step in the net zero journey. Aware of this, Healesville CoRE have run a variety of workshops and have recently announced a solar bulk buy partnership with the Yarra Ranges Council following on research conducted into possible bulk buy options.

The potential for solar power will be discussed in this section through the use of the aggregated meter data provided by AusNet, and hourly solar panel output retrieved from PV Watts. Detailed modelling was used for the average household. This allowed the calculation of how much solar was produced, how much was used in the household and how much was exported to the grid. Utilising electricity prices for different times of the day, an accurate payback for solar panels was established for the average house in Healesville.

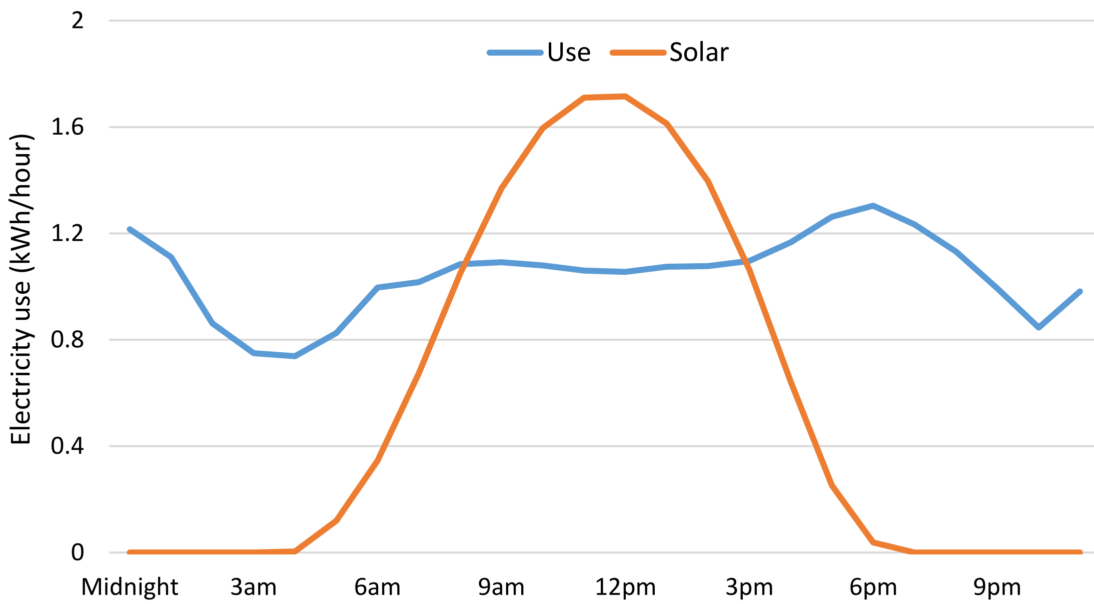


*Figure 6-1 Average energy use per customer and solar generation from a 5kW system over a 24-hour period in Healesville*

Figure 6-1 above demonstrates the ability of solar to create an excess of energy during the day. This 5kW system produces just under 5000 kWh per year, ~54% of total energy demand. The savings associated, applying a dynamic cost of electricity depending on time of day (Origin, 2017) and the solar export tariff, works out to be $1215 per year. With 5kW systems costing around $6,380, the payback on solar panels is around **5.25 years**.

A sensitivity test was undertaken, as 25kWh per day may be considerably more, or less, than what certain households use in a day. This test shows how the payback of solar varies with electricity demanded by households, using 75% of the average or 18.75kWh per day, and those who use more, with a payback for households using 31.25kWh per day. The results are summarised in Table 6-2 below.

*Table 6-2 Sensitivity analysis on solar paybacks with differing electricity demand*

| Electricity demanded | Payback | % Solar exported | Amount exported | % Demand met |
|---|---|---|---|---|
| 25kWh per day | 5.2 years | 36% | 1775kWh per year | 35% |
| 18.75kWh per day | 5.8 years | 47% | 2322kWh per year | 38% |
| 31.25kWh per day | 4.9 years | 27% | 1334kWh per year | 32% |

Both Uralla and Moreland's net zero strategies identify solar power as an opportunity and key action to reduce carbon emissions and help move toward renewable energy. Solar power is the best small-scale onsite energy generator, and tapping into the present demand could provide Healesville CoRE and Yarra Ranges Council with the building blocks for a net-zero town.

### 6.3.2 Optimising for Solar

Putting solar panels on your roof does not mean that your energy use becomes immediately efficient. Looking back at Figure 6-1, and Figure 6-2 below, we can see that there is excess solar during the day and more demanded electricity during hours where solar panels are not producing electricity.

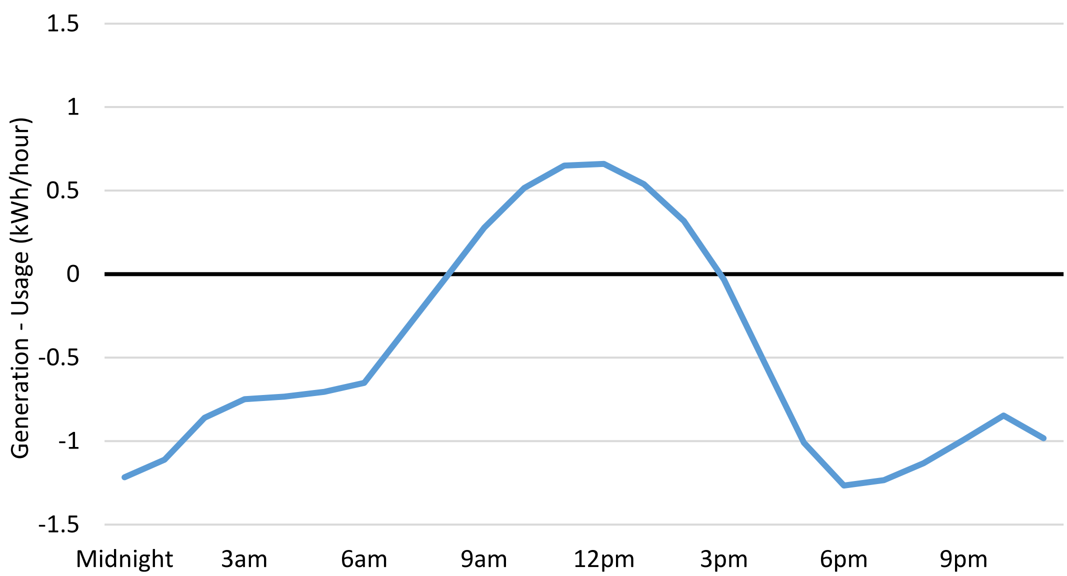


*Figure 6-2 Energy production excess and shortfall from solar production over a 24-hour period*

Being smarter about energy use, in particular, using energy when it is being created, will save even more money and energy. Given the tariff received and price of electricity differs at times by 30c, shifting energy use patterns to solar producing hours can improve the payback of solar systems.

This can be achieved in a variety of ways. Using the delay mechanisms on dishwashers and clothes washers, heating the home throughout the day rather than at night, and instead of water heaters going off at 1am, putting them on at 12pm. To simulate this, loads were shifted for water heating and 7.5% of loads from peak use (5pm, 6pm,7 pm), which resulted in a cost saving of around 4-5% just from rescheduling water heating and using the timer feature on the dishwasher and washing machine. This is only a small shift in behaviour, with room to take a more in-depth approach and really making an effort to shift energy use to times when solar arrays are generating energy. The ability to shift heating loads depends on the ability of the building to hold in heat. If the building is an effective insulator, heating systems can function for set period when solar is producing, with the house remaining warm for the period when the sun is not shining.

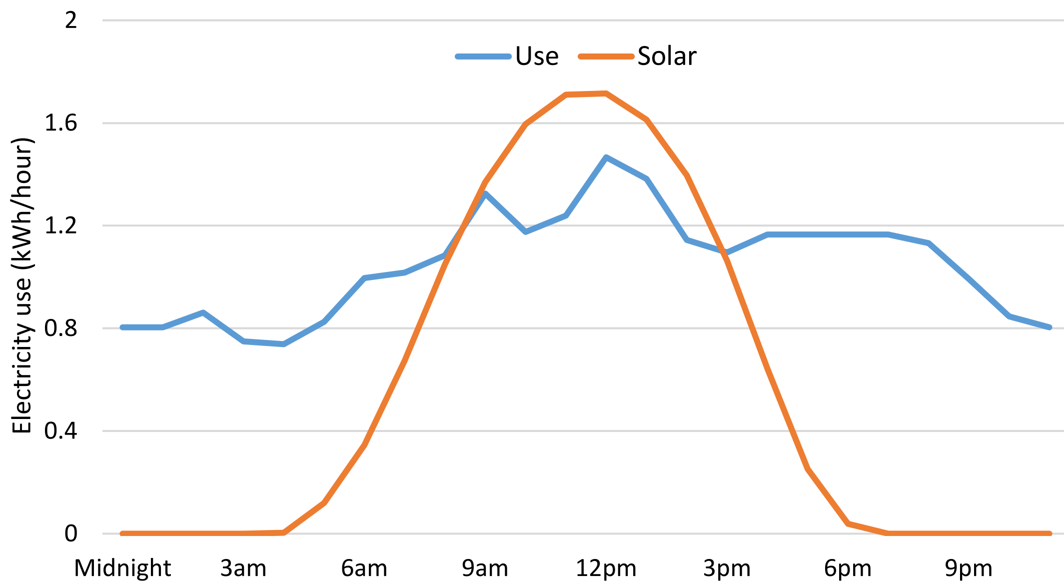


*Figure 6-3 Average energy use per customer and solar generation from a 5kW system over a 24-hour period in Healesville*

The ability to load shift water and space heating depend on these systems being electrified. While gas systems can be more cost-effective (although this may change), when solar panels are installed, electric hot water and space heating can help the household save money, and if scheduled, reach net zero emissions for the home.

As part of the Yarra Ranges Bulk Buy initiative, Healesville CoRE could work with residents and industry to help them optimise their systems, ensuring that buyers achieve the best financial and environmental return on their investment.

### 6.3.3 Battery Opportunities

Batteries are, in their present state, expensive, and probably do not provide a return on investment. This section looks to quantify the payback on a battery system in its current form, and provides a cost reduction value that would signal a payback of less than 10 years, where battery technology should be seriously considered throughout Healesville. This analysis will be undertaken using the average household and a 5kW system as in previous sections. The Tesla Powerwall 2 has a 13.5kWh storage capacity and a 10-year warranty. The behaviour of batteries can be complex, so various simplifying assumptions were made to provide this estimate.

- Assume that the battery is in use during peak times when the cost of electricity is, on average, 35c per kWh
- Assume battery is charged via the solar panels
- The battery discharges electricity as soon as the household begins to use more power than is generated, i.e. no complex optimisation behaviour
- Price of the Tesla Powerwall 2 - $12,749 (Origin Energy, 2018)

This produced a saving of around $324.11 per year. The payback for such a system was calculated to be 39 years, far beyond the warranty of the battery. However, this is not a precise calculation and may be conservative on the ability of the battery to do more than just store solar. As such, the 39-year payback should be seen as an upper limit, with the real value being lower than this. Furthermore, households who use less energy than 25kWh per day would see this payback decrease. Because lower energy households have more energy exported on a 5kW system, the battery can capture this extra energy and use it, rather than exporting at the low rate of 11.3c per kWh. This 13.5kWh battery may not be the most ideal battery for the electricity use of this home. As such the payback may be less if an optimised smaller system was installed.

While batteries remain too expensive to provide real financial benefit, the technology itself has progressed at a rapid rate. Future battery technologies may provide more storage capacity and, more importantly, significantly reduce in cost.

The cost of a battery, keeping capacity constant, would need to decrease by 75% to provide a less than 10-year payback. This would mean a price of around $230 per kWh of storage. While this seems substantial, technology can progress at an exponential pace and may be a reality in the next 3-5 years. As such, ensuring battery technology can be readily implemented into homes would be beneficial, saving time and money in the future.

## 6.4 Community-wide opportunities

### 6.4.1 Healesville mini-grid

The traditional electricity grid is changing to one that is more decentralised and will have a high penetration of embedded generation and more demand side control. A mini-grid (or Microgrid) is a small local network that allows its members to share electricity generation and storage (MEFL, 2017).

Mini-grids are usually comprised of a mix of small scale renewable energy generators, such as solar panels, and energy storage resources, such as batteries. Local generation and storage, combined with an intelligent control system, enables energy assets to be orchestrated to maximise Mini-grid energy management and value for Mini-grid participants.  Mini-grids can either islandable (self-sustaining) or grid-connected, benefitting from and providing support to the broader grid.

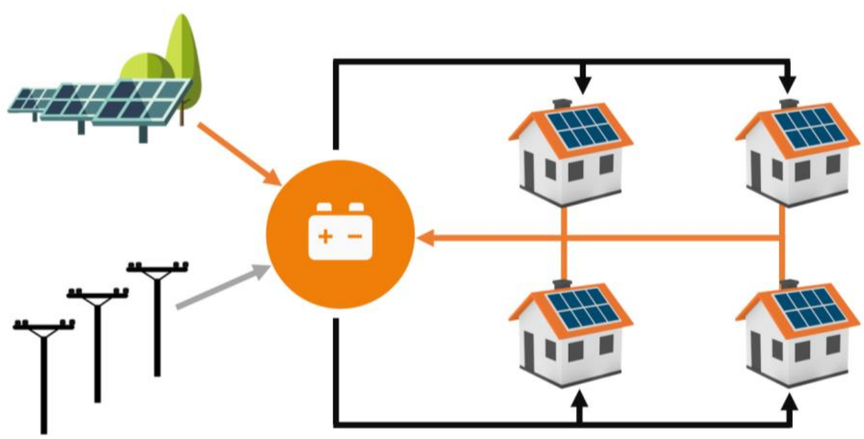

*Figure 6-4 Mini-grid diagram*

Benefiting from increased independence from the grid, households become less subject to volatile prices and unreliable supply. While these systems can prove complex and costly to set up, long-term benefits financially, socially and environmentally can outweigh the costs.

The Western Australian town of Marble Bar has a mini-grid, which supplies 65% of its daily energy requirements through solar panels and a flywheel storage system with diesel generation backup (Australian Trade and Investment Commission, 2017). This has greatly improved reliability, lowered costs and cut down significantly on the emissions of the town.

While Healesville may not face the same challenges as Marble Bar, there is no reason why a mini-grid could not operate successfully. As more and more people begin to install solar, and battery technologies become affordable, connecting households together may provide added coordination of and value from renewable energy systems. The pooling of resources and collection of energy from the wider community would allow access to a more secure supply. Possibilities include linking individual domestic solar systems together, or providing a singular system that serves several households, or even a combination of both.

Healesville could begin by trialling a small mini-grid, formed from a collection of willing households, perhaps focusing on the most isolated in the community, where a mix of renewable energy generation and storage meet the majority of energy demand. Ensuring the test is scalable, such a mini-grid would provide a valuable test to whether such a system could be applied town-wide.

Adequate partnership locally would be key to the success of a mini-grid implementation for Healesville. Initial conversations have begun with Mondo Power, currently running the Yackandandah Mini-grid trial.

### 6.4.2 Social Enterprise

A social enterprise is usually defined as an independent, autonomous organisation that engages in economic activity to achieve a social objective. A social enterprise can be a powerful way to provide investment in renewable energy while also offering value for money and financial benefits. There are various examples of social enterprises, including Hepburn Wind, and a variety of international examples. Hepburn Wind produces over 10,000 MWh on average per year, and has paid back its $3.1 million loan from Bendigo bank in 2017, 10 years earlier than expected (Hepburn Wind Annual Report, 2017). Hepburn Wind will also provide its first return to its members. Denmark, using a similar model, has numerous ‘local partnerships’ that own over 5,600 wind turbines producing 14% of the country’s total energy demand (Doyle, 2015).

Social enterprises provide an opportunity for Healesville to enter the renewable energy market, generate income and reduce a significant amount of $CO_2$ emissions. Third party support and partnerships may be necessary to realise a social enterprise in Healesville; however, Hepburn Wind provide a great example of what can be achieved.

Social enterprises provide greater control of energy generation, while building a stronger sense of community, a sense of responsibility and an opportunity to educate. While it must be acknowledged that setting up a social enterprise is a big task, the benefits will be lasting.

### 6.4.3 Power Purchase Agreements

Healesville could also procure cost-effective off-site renewable energy through a power purchase agreement (PPA).

A PPA is a contract between two parties where one (the developer) sells both electricity and renewable energy certificates (RECs) to another party (the buyer). The developer arranges all aspects of the design and construction of the large-scale off-site renewable energy project, and it can have either a physical connection to the buyer's site, or a 'virtual' connection.

A physical PPA relies on geographical proximity to support a connection to the large-scale renewable energy project.

A virtual PPA is essentially a financial instrument whereby the buyer guarantees the developer of the renewable energy project a certain fixed price for the RECs and electricity output which the developer sells to the grid.  If the electricity sells to the energy market for less than the fixed price, the buyer pays the difference.  If it sells to the grid for more than the fixed price, the buyer will make money. This is known as a contract for difference model (see Figure 6-5 below) and essentially is a financial hedge.

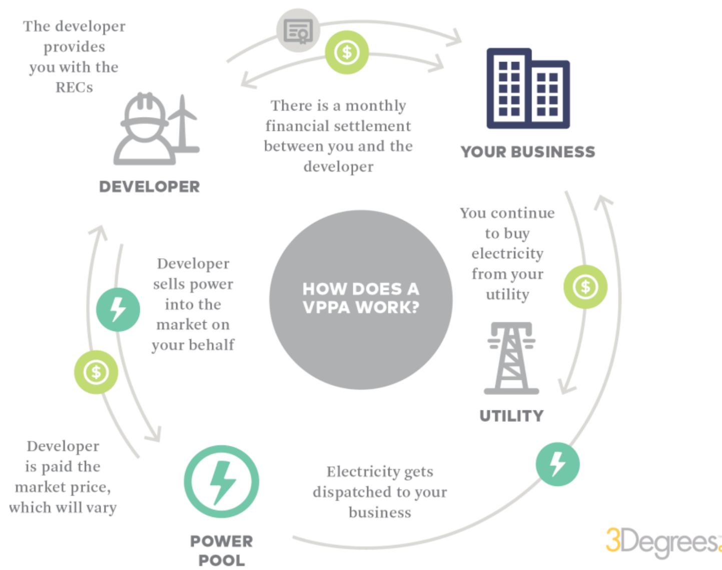


*Figure 6-5: Outline of a virtual PPA*

In the case of Healesville, this would mean Healesville's residents and businesses signing into a long-term contract with an electricity retailer. This would enable fast track of Healesville's transition to net zero emissions electricity, but would require extensive community engagement and buy-in, and the assistance of PPA contract experts.

## 6.5 Other $CO_2$ Emitting Activities

Given the focus of Healesville CoRE on electricity generation, some other $CO_2$ contributing activities were not considered. Transport and waste account for 20% of Australia's total carbon emissions (ClimateWorks, 2014). Local figures can be even higher than 20%. For example, the city of Moreland found that transport and waste accounted for 40% of $CO_2$ emissions per year. Initiatives that tackle waste and transportation emissions may be just as effective and can be more behaviourally focused, making it accessible and reducing the cost of abatement.

While data on firewood use in Healesville is lacking, qualitative discussions suggest that there is a significant amount of firewood used to heat homes in the community. Uralla had a similar situation, where firewood accounted for 45% of energy used (Moreland Energy Foundation, 2015). Ensuring that firewood resources are managed effectively, and adequately replaced, can ensure the renewable use of firewood, and limit $CO_2$ emissions.

Taryn Lane of Hepburn Wind suggested that Healesville CoRE could take a more holistic approach to the net zero target, encompassing these other emission areas (Appendix C). Promoting areas such as waste and transport would be in line with other municipalities and communities and really target $CO_2$ emissions in general, rather than just those associated with electricity use.

# 7 Recommendations

## 7.1 Short-term recommendations

Over the next few years, the focus of Healesville CoRE should be on increasing the participation of Healesville's community residents. It is suggested a variety of Bulk Buy and education programs to begin the process of reducing $CO_2$ emissions, building up a name and furthering current levels of community engagement. With the upcoming bulk buy program, Healesville should focus efforts on ensuring its success as well as providing residents with advice and changes that can be made to optimise their systems as described in Section 6.2. Other opportunities discussed in Section 6. may form part of programs that follow the Solar Panel Bulk Buy.

This section summarises how the various initiatives may come together and contribute to the net zero target over the next 18 months. Table 7-1 describes the energy savings associated and the uptake from households and businesses with each initiative.

*Table 7-1 Initiatives list and assumed uptake and savings per household*

| *Measure* | *Household uptake* | *Household energy savings* |
|---|---|---|
| *Solar panel bulk buy* | 12% | 34% |
| *Solar-optimisation* | 15% | 3% |
| *Light-globe replacement* | 15% | 5% |
| *General education* | 15% | 5% |
| *Insulation bulk buy* | 5% | 25% |
| *Heat pump bulk buy* | 5% | Varies |

If the household uptake in the following initiatives is achieved, the total electricity demand would reduce by an estimated 7.1%, or 3,261 MWh, over 18 months. Approximately 60% of the $CO_2$ emissions abated come from the solar panel bulk buy. This is one of the most critical activities that will be undertaken in Healesville over the next 18 months. Ensuring significant uptake within the Healesville community will help drive strong reductions in energy use and $CO_2$ emissions.

Maintaining the same rate of reduction per year of around 4.7% from 2017 levels, the net zero goal for stationary energy emissions would be met by 2040. This is still 13 years past the goal of 2027.

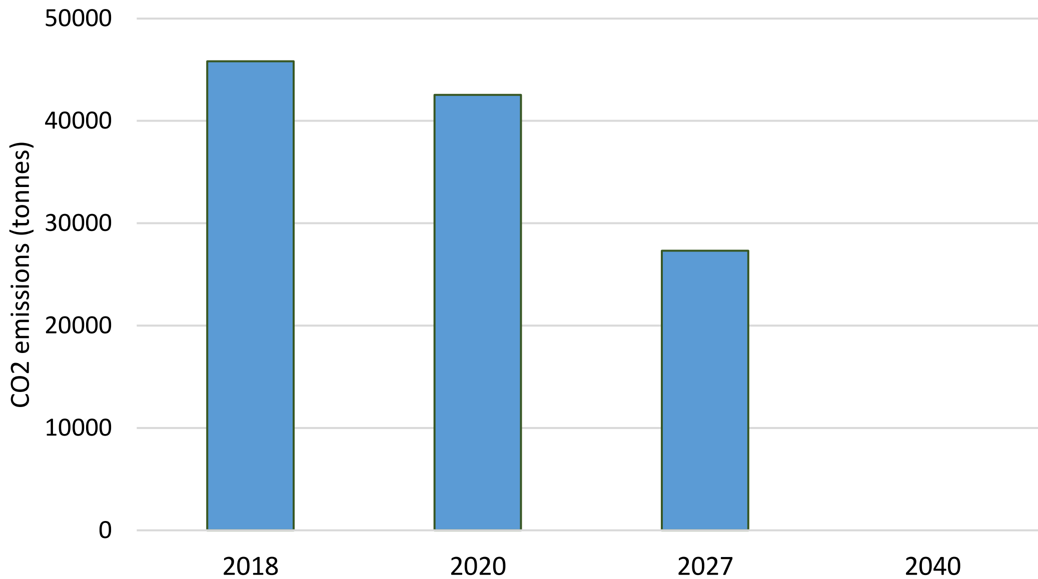


*Figure 7-1 Possible reduction in carbon emissions for Healesville – Short and Long term*

## 7.2 Long-term recommendations

As shown in Section 7.1, bulk buys and education programs cannot reduce carbon emissions to zero on their own. Larger, more town-wide measures will be required. As shown above, a significant amount of $CO_2$ emissions still need to be addressed in order to meet the 2027 target.

Healesville CoRE should explore all three of the community-wide opportunities described in Section 6.3. By using one or a combination of these options, Healesville could realise its goal to become net-zero. Healesville CoRE should look to partner with third parties, learning from the experience of other communities, and consider sustainable longer-term models that provide Healesville with energy that is affordable, sustainable and reliable.

## 7.3 Getting started

Immediate action is paramount as the target for reaching net-zero is fast approaching. Starting to implement initiatives will help establish the Healesville CoRE vision, engage residents and give Healesville's net-zero movement momentum. The upcoming Solar Panel Bulk Buy run in conjunction with the Yarra Ranges Council is the perfect opportunity to begin the journey. Ensuring this initiative is run efficiently while promoting the benefits that residents obtain will create a sense of hope and motivation in the town.

While initiatives targeting households are rolled out, Healesville CoRE and Yarra Ranges Council should in parallel start investing their time and effort on enabling the long term vision. Partnerships should be forged, exploring various opportunities for the town to be involved in different programs that could form Healesville's energy model.

## 7.4 Feasibility Study

While this report has shown a variety of options that Healesville CoRE could take, it is not a detailed report on the possibilities for Healesville. It should be noted that a full feasibility study is required, digging deeper into which initiatives would be most effective and how they could be implemented to transition to net-zero. This report should form the base for further investigation and development of the Healesville CoRE mission.

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# 9 Appendix A: Demographics

## 9.1 Community Profile

The community profile compiles various demographic data to present a snapshot of the Healesville community, both for further analysis in the report, as well as providing context. There are various ways the Healesville area can be defined. This section defines Healesville as the area bound by Murrindindi Shire to the north, Warburton to the east, stretching as far south as Mt Toolebewong, following the Yarra River to the West. This area will be referred to as Healesville and Surrounds and is shown shaded grey in Figure 9-1 below.

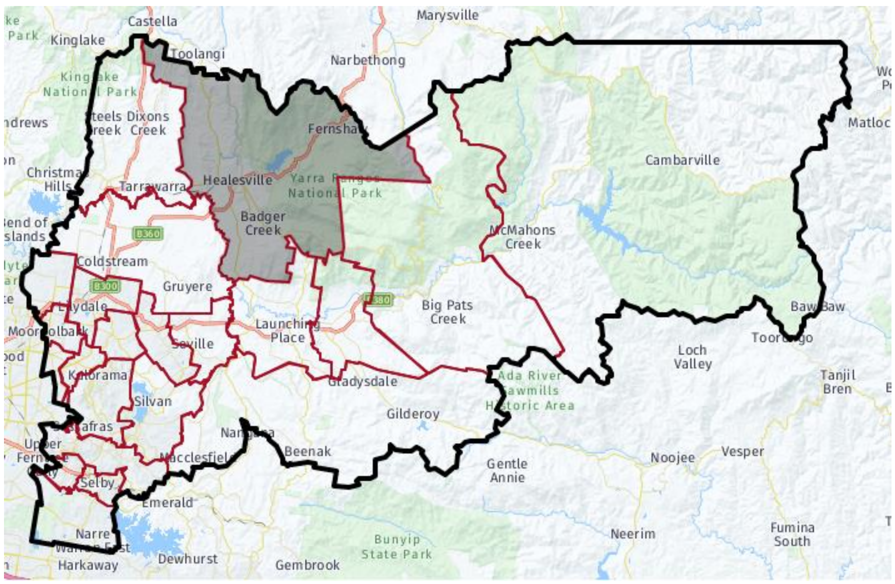



*Figure 9-1: Map of the Healesville and Surrounds area as defined by .id*

The data used in the following sections is taken from a demographic resource known as .id, which compiles data from Australian Bureau of Statistics, including census data, to create community profiles.

### 9.1.1 Population

From the 2016 census, Healesville had an estimated population of 10,551, which was an increase of 5.5% on the previous census five years prior. The current population is estimated to be 10,695, to be increased by 8.82% by 2036 for a total projected population of 11,638 (.id, 2018). The population has increased, on average, by 34 people per year between 2012 and 2016. Based on population forecasts, this rate is set to slow by half, averaging an increase of 60 people per year from 2018 to 2036.

In Healesville and surrounds, there were 4,316 dwellings in 2016, including 3,880 separate houses, 381 medium density dwellings and 47 cabins or other dwellings[1]. 156 dwellings were built between 2011 and 2016, with 372 private dwellings being unoccupied in 2016, decreasing from 392 in 2011 (.id, 2016). The number of dwellings is forecast to continue to increase with 4,739 dwellings Healesville by 2036. The average houehold size in Healesville is currently 2.44, forecast to slowly decline to 2.38 by 2036.

[1] 8 dwellings were unspecified

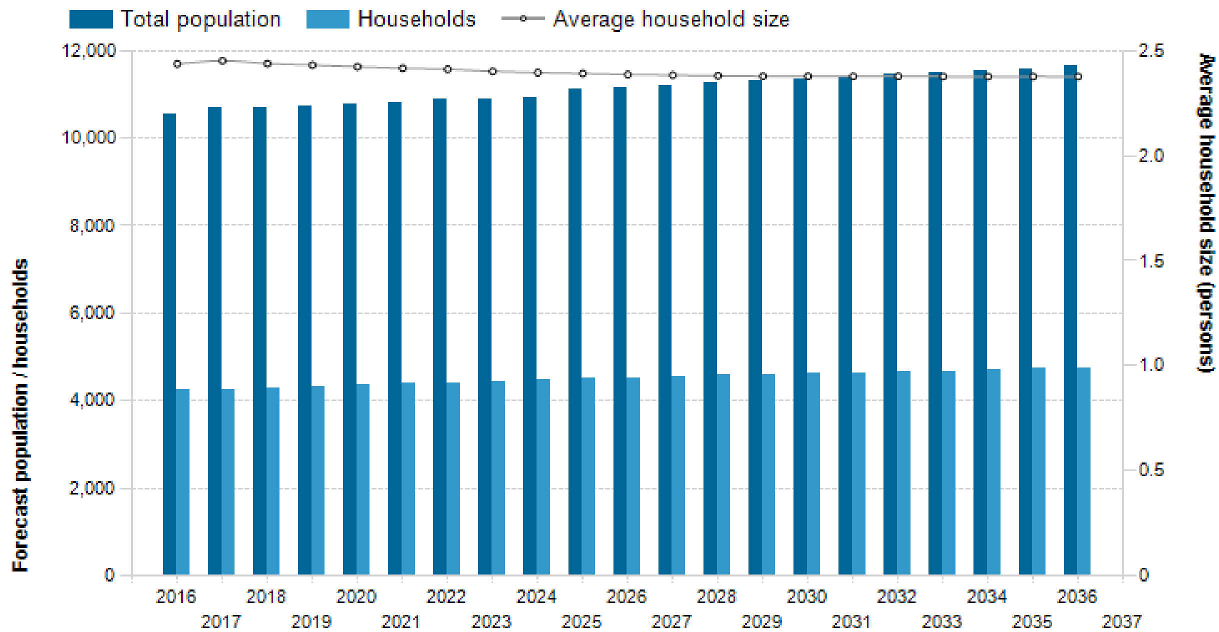



*Figure 9-2: Forecast population, households and average household size – 2018 to 2036 (.id, 2018)*

The population is 52% female, 48% male, with approximately 342 Aboriginal residents in the area. The age-sex pyramid in Figure 9-2 below shows a slight ageing of the population in Healesville, with 41.8% of the population over the age of 50 and 34% of the population under 30 (.id, 2016). The ageing of the Healesville population over the last two decades is evident in the 2006 and 1996 Age-sex pyramids. There has also been a gradual balancing of the population, with 2016 showing less pronounced slender and wider sections than are present in both 2006 and 1996.

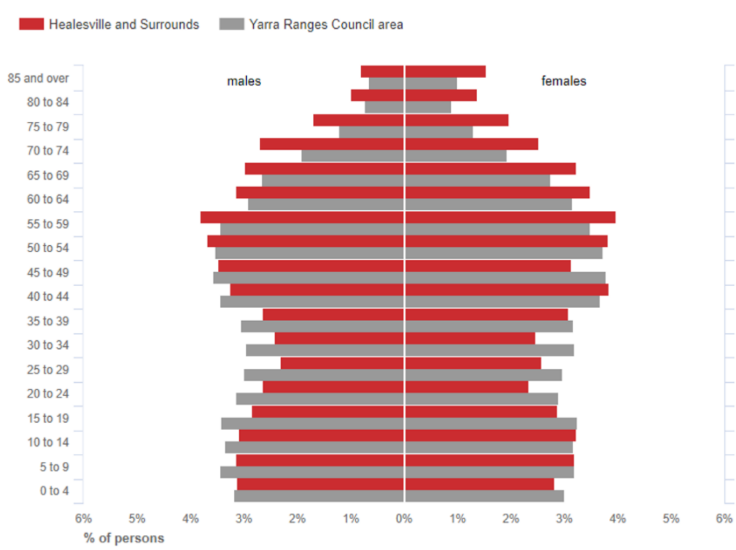
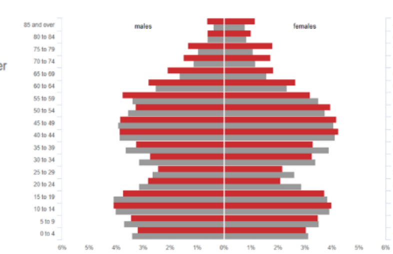
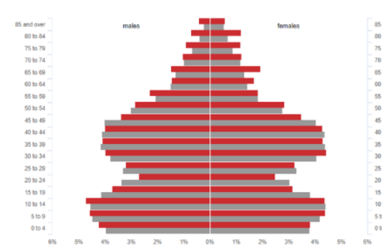



*Figure 9-3: Age-sex pyramid – 2016 (.id, 2016)*



*Age-sex pyramid – 2006*



*Age-sex pyramid – 1996*

### 9.1.2 Employment and Income

At the time of the 2016 census, the unemployment rate sat at 4.9%, with 231 residents actively seeking work unable to find it. While Healesville's unemployment rate has increased from 3.5% in 2011, it compares favourably to Greater Melbourne, which sat at 6.8% in 2016 and 5.5% in 2011.

The labour force consists of 4,758 people, of which 4,527 are currently working. The top three industries by total employees of Healesville residents are construction, health care and social assistance, and manufacturing (.id, 2016). These three industries account for over one third of the total labour force. Between the 2011 and 2016 censuses, there has been considerable movement in where Healesville residents are employed as shown in Figure 9-4. The strongest growing industries included health care and social assistance (+64 employees, +14.2%), education and training (+49 employees, +15.3%), and arts and recreational services (+43 employees, +42.1%). The industries that saw the biggest decline in employees included retail trade (-77 employees, -16.9%), manufacturing (-69 employees, -12.0%) and wholesale trade (-49 employees, -34.5%).

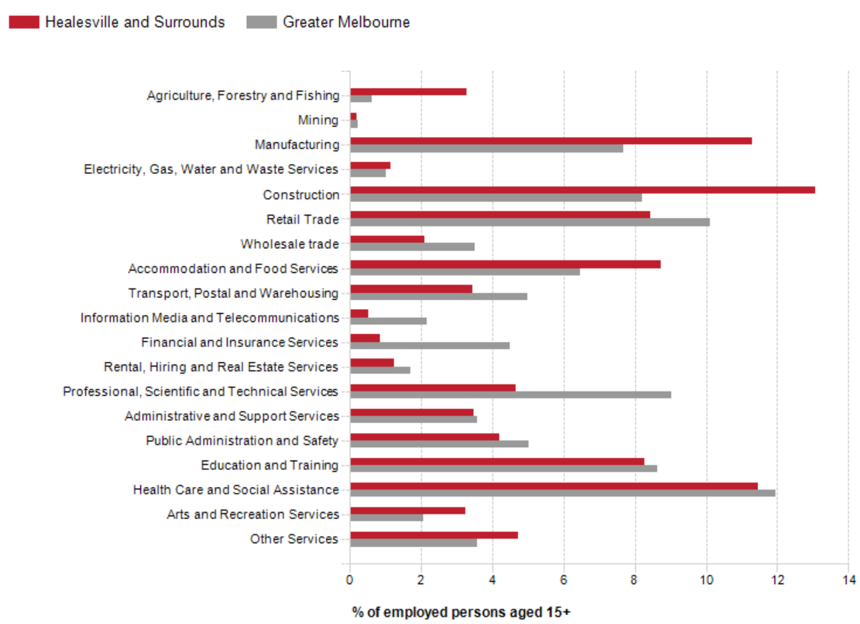



*Figure 9-4: Employment by industry for Healesville and Surrounds (Red) compared to Greater Melbourne (grey) (.id, 2016)*

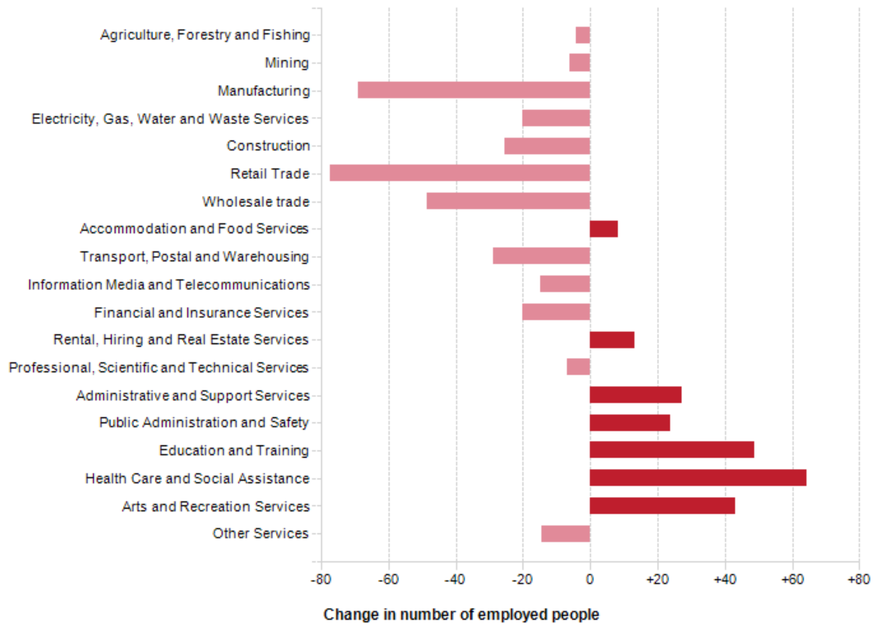



*Figure 9-5: Change in employment by industry 2011 to 2016 (.id, 2016)*

In 2016, 13.4% of households were considered high income (whose weekly earnings exceed $2,500) and 20% were considered low income (whose weekly incomes were $650 or less). When compared to Greater Melbourne, Healesville and surrounds has less percentage of its earners in the high-income bracket and higher percentage of its oncome earners in the low-income bracket, as shown in Figure 9-6 below. However, low income earners in Healesville are far more likely to be earning closer to $650 per week than those in Melbourne.

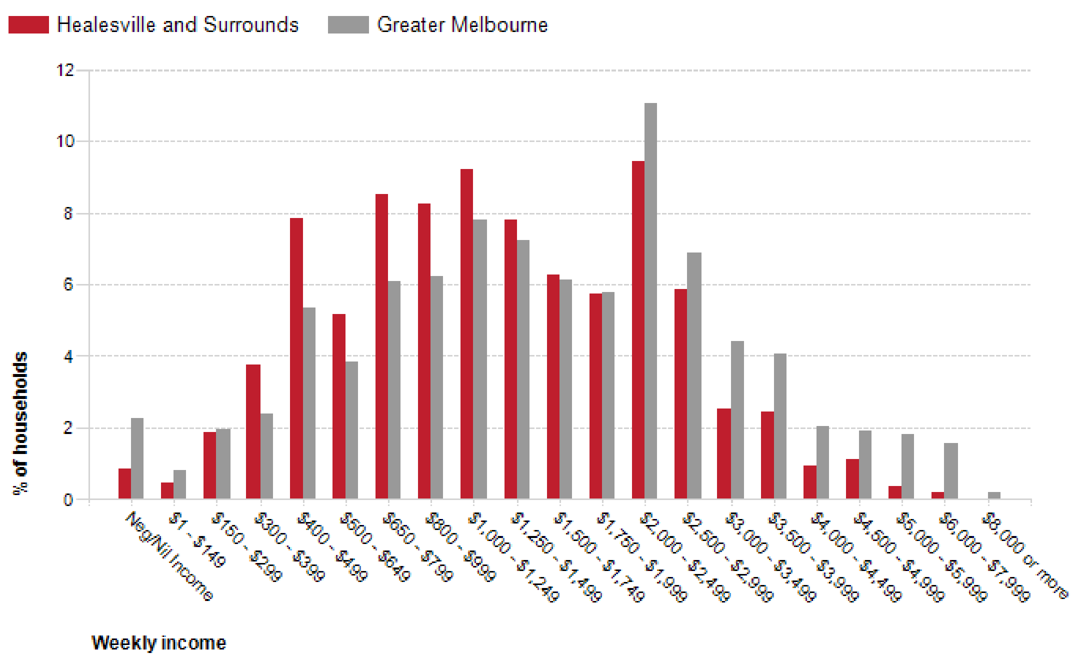



*Figure 9-6: Percentage of households at each weekly income bracket for Healesville (red) and Greater Melbourne (Grey)*

There were approximately 1,780 volunteers in Healesville in 2016, an increase of 128 from 2011. This equates to around 23% of those above the age of 15 being involved in some kind of volunteer work in the community[2].

[2] 714 people did not specify whether they were involved in volunteer work or not in the 2016 census

# 10 Appendix B: Home Energy Audits

## 10.1 Home A

The residents of Home A are a family of four, with two children at primary school age and two adults. The home is a double fronted brick veneer home built in the 1960s with three bedrooms, one bathroom, and a large kitchen/living space covering 162m$^2$. The floors are suspended roughly 30cm above the ground. The homeowners moved into the home in 2016. Twelve pre-existing solar panels (6 facing east and 6 facing north) were on the roof, and their true age and output is uncertain, but it is estimated to be a 1.5kW system that generated ≈2000kWh in 2017. In 2017, the residents of Home A consumed 10421kWh of electricity from the grid and it is estimated 1970kWh of Solar was produced from the 1.5kW system. The total energy use is therefore estimated at 12391kWh, the second highest of the three homes.

*Table 10-1: Outline of main use points of Home A*

| | |
|---|---|
| Heating | Frequent use of a heat bank system located in a central position between the kitchen/living space and the bedrooms and bathrooms. Occasional use of a gas fire place in the living area.<br>A ducted heat pump system was installed at the beginning of 2018 |
| Cooling | No Cooling in 2017. Future cooling will be done by the heat pump system |
| Hot water | 315L storage: heated with electric element |
| Kitchen appliances | Renovations were completed in 2016 to modernise the kitchen space. All kitchen appliances are new and energy efficient |
| Washing machine | 4 star energy rated 8.5kg front loader |
| Dryer | 2 star energy rated Westinghouse dryer |
| Television/ Computers/Phones | One television in the living space, one in the parents' bedroom. Two laptops in use. Electricity consumed from these devices is minimal in comparison with other uses |
| Lighting | Most of the lights have been upgraded to LED efficient lighting |

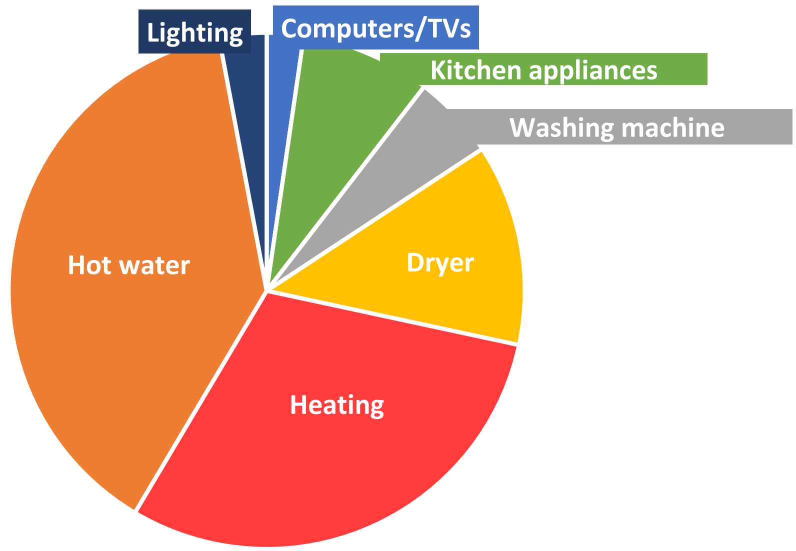



*Figure 10-1: Breakdown of electricity end uses for Home A*

### 10.1.1 Electricity Usage Profile and Seasonal Variation

Home A's electricity usage experiences three distinct peak periods (Figure 3-1). These peaks can be attributed to the heating of the electric element 315L hot water storage unit (at 1am), when all four occupants are home and using appliances/heating to prepare for the day (at 7am-8am), and when all four occupants arrive home from work/school (6pm-7pm). The peaks are less pronounced during summer, autumn, and spring due to generation from the rooftop solar, and less reliance on heating and hot water.

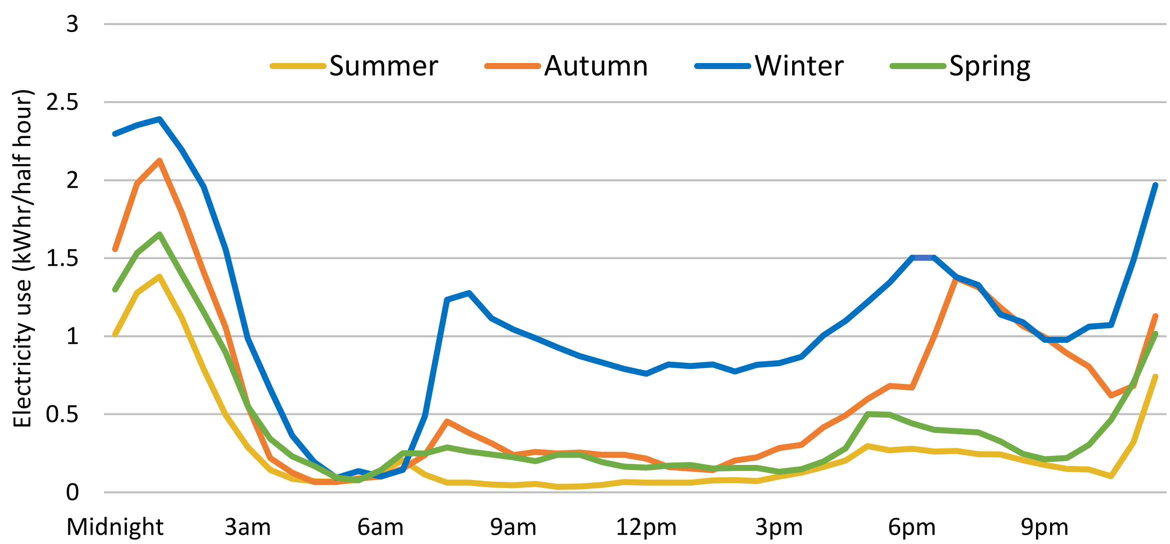



*Figure 10-2: Seasonal daily electricity usage profile for Home A*

*Table 10-2: Seasonal variation of total electricity use*

| | *Summer* | *Autumn* | *Winter* | *Spring* |
|---|---|---|---|---|
| *Consumption* | 10.7% | 26.3% | **45.6%** | 17.4% |

### 10.1.2 Electricity Efficiency Opportunities

1. Replacing the old electric element 315L hot water storage system with a heat pump 315L hot water storage system. **Saving an estimated 3200 kWh/year**

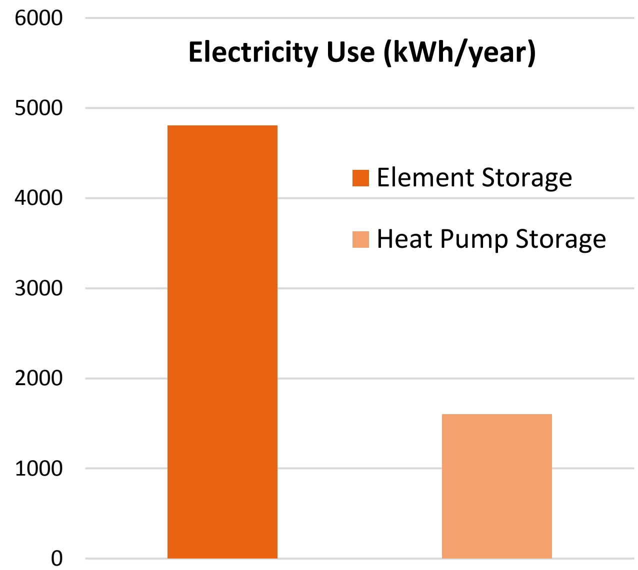



*Figure 10-3: Estimated electricity savings by upgrading hot water storage system*

*Table 10-3: Capital investment and expected payback on hot water storage upgrade*

| Capital Cost | Energy Savings | Saving on electricity bill per year | Payback Period | Avoided carbon emissions |
|---|---|---|---|---|
| $3,793 | 3200 kWh | ≈ $950 | ≈ 5 years | ≈ 3.5 tonnes |

2. Installing R2.0 underfloor insulation. **Saving an estimated 1650 kWh/year**

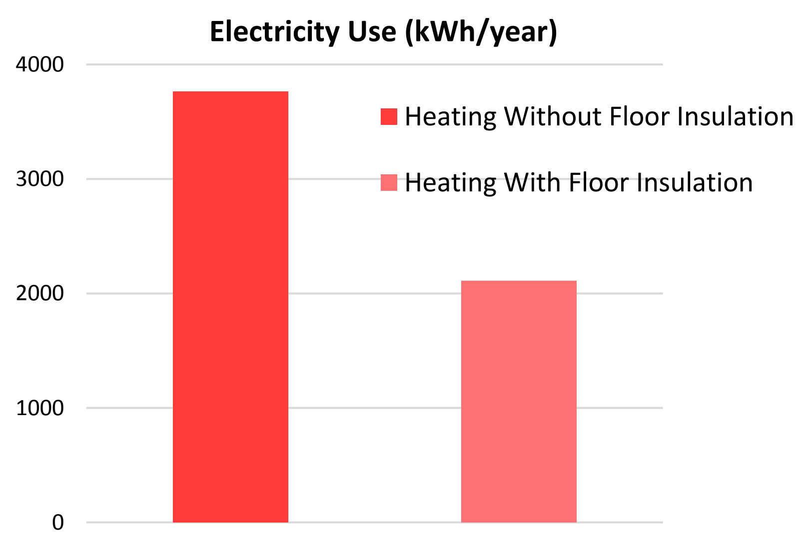



*Figure 10-4: Estimated electricity savings by installing floor insulation*

*Table 10-4: Capital investment and expected payback on floor insulation*

| Capital Cost | Energy Savings | Saving on electricity bill per year | Payback Period | Avoided carbon emissions |
|---|---|---|---|---|
| $3,630 | 1650 kWh | ≈ $500 | ≈ 7.5 years | ≈ 1.7 tonnes |

*NOTE: Home A may have difficulty with installing flooring insulation or incur extra costs for installation as they suspended floor is only 30cm above ground*

3. Upgrading an old dryer with a 2-star energy rating to a 10-star rated dryer. **Saving an estimated 1100 kWh/year**

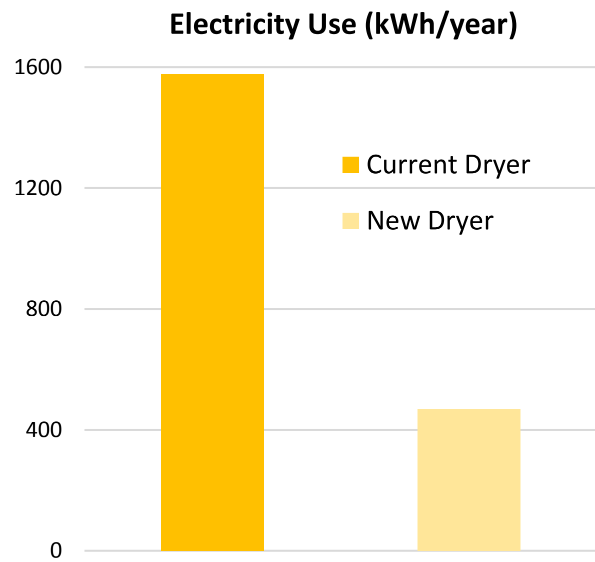



*Figure 10-5 Estimated electricity saving by upgrading inefficient dryer*

*Table 10-5: Capital investment and expected payback on upgrading dryer*

| Capital Cost | Energy Savings | Saving on electricity bill per year | Payback Period | Avoided carbon emissions |
|---|---|---|---|---|
| $2500 | 1100 kWh | ≈ $300 | ≈ 8.5 years | ≈ 1.2 tonnes |

### 10.1.3 Recommendations

It is recommended to the residents of Home A that they install all the upgrades detailed above. These upgrades will make significant reductions in electricity use in the home and reasonable payback periods can be expected. The hot water and dryer upgrades are particularly viable for the residents as these two appliances are nearing their end of life. Flooring insulation may be difficult to install or an extra fee may be incurred. However, if installation is possible, it is highly recommended as it will reduce demand on heating and cooling and improve thermal comfort in the home. Further changes to behaviour such as setting the washing machine to cold wash occasionally and air-drying clothes rather than using a dryer are minor changes that will see reductions in electricity use.

## 10.2 Home B

The residents of Home B are an elderly retired couple. It is a large north-facing 1882 heritage listed home with four bedrooms, two bathrooms, two living areas and one kitchen area. The building has 295m$^2$ of floor area and the ground below the house is slanted downwards towards the north. The floor is suspended roughly 2.5 metres above the ground at the highest point on the north side and suspended roughly 30cm at the south end. The house is well shaded with an awning above a wide veranda that follows the east, north and west facades. A new kitchen with modern appliances and induction cooking has been installed recently, and most of the lights throughout the house are efficient LED lights. In 2017, the residents of Home B consumed 4566 kWh of electricity from the grid, the least of the three homes.

*Table 10-6: Outline of main use points of Home B*

| | |
|---|---|
| Heating | Wall mounted heat pump air conditioner. Occupants prefer to heat their living space with a wood fireplace |
| Cooling | Wall mounted heat pump air conditioner |
| Hot water | 315L storage: heated with a heat pump |
| Kitchen appliances | Modern kitchen appliances from new kitchen renovations |
| Washing machine | Only used weekly |
| Dryer | Rarely used |
| Television/ Computers/Phones | Rarely used |
| Lighting | Most of the lights have been upgraded to LED efficient lighting |

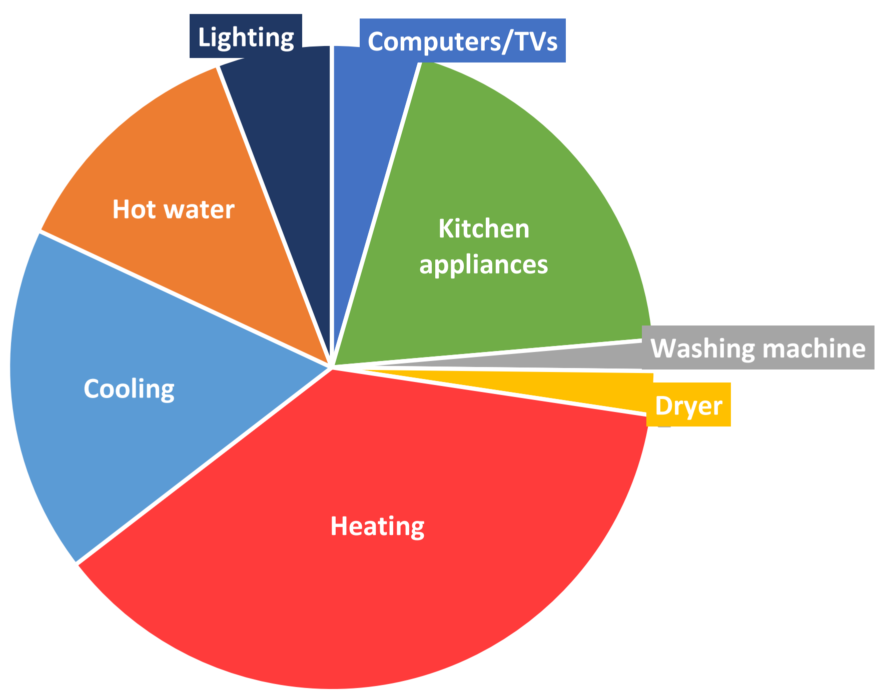



*Figure 10-6: Breakdown of electricity end uses for Home B*

### 10.2.1 Electricity Usage Profile and Seasonal Variation

Home B's electricity usage experiences two distinct peak periods (Figure 3-6). These two peaks can be attributed to the heating of the heat pump 315L hot water storage unit (at 1am) and when the cooking appliances, lights, and heating turns on (6pm-7pm). There are only minor seasonal variations throughout the year. During interviews with the two elderly occupants of the home, they stated that they preferred to use the woodfire heating in place of the heat pump. This is evident in the electricity profile as the winter usage is only slightly more than the other seasons. Spring usage is the least, which shows that time of year would be most thermally comfortable, therefore no heating or cooling is required.

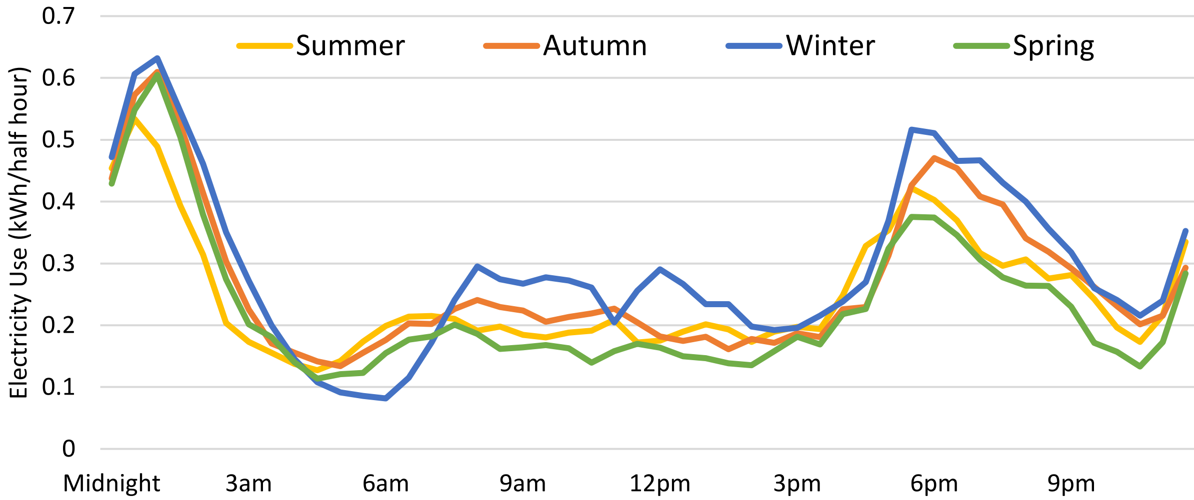



*Figure 10-7: Seasonal daily electricity usage profile for Home B*

*Table 10-7: Seasonal variation of total electricity use*

| | *Summer* | *Autumn* | *Winter* | *Spring* |
|---|---|---|---|---|
| *Consumption* | 23.5% | 26.0% | **28.5%** | 21.9% |

### 10.2.2 Renewable Energy Generation Opportunity

1. Installing a 4kW solar array along the north facing rooftop. There is sufficient space along the appropriately orientated and non-shaded rooftop that could generate ≈ **5000 kWh**

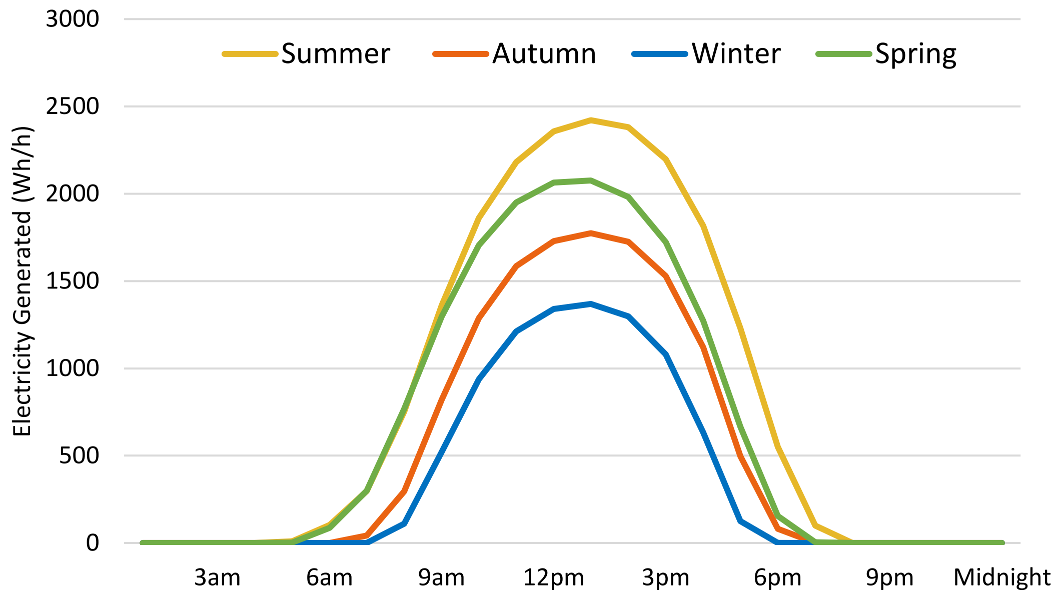



*Figure 10-8: Seasonal daily generation of a 4kW solar array*

*Table 10-8: Capital investment and expected payback on a 4KW solar array*

| Capital Cost | Energy Savings | Saving on electricity bill per year | Payback Period | Avoided carbon emissions |
|---|---|---|---|---|
| $6,700 | 4566 kWh | ≈ $950 | ≈ 7 years | ≈ 5400 tonnes |

### 10.2.3 Behavioural changes

The current electricity use of the home is efficient and the 4kW solar array is the only upgrade recommendation for the residents. To improve the effectiveness of the solar array, more electricity should be used when the 4kW array is generating. A significant behavioural change in this regard would be to set the time of use of the hot water storage to daytime when the sun is shining instead of 1am as it is now (Figure 13-7).

## 10.3 Home C

The residents of Home C are a middle-aged couple, one of whom works full time outside of home. Together they were running a Bed and Breakfast / Day Spa business in their home until the end of 2017. The building has four bedrooms, three bathrooms, a kitchen/dining space, a study space, and living space that cover a total of 316m$^2$. The ceilings are 3.8m high with R2.7 m$^2$K/W insulation that covers 80% of the ceiling space. The floors are suspended, except for a single bedroom which is a concrete slab on ground below the main level of the house.

*Table 10-9: Outline of main use points of Home C*

| | |
|---|---|
| Heating | Ducted split cycle system and hydronic heating, two wall mounted split cycle systems in bedrooms, five water heater columns throughout the house, and firewood heating in the living space |
| Cooling | Ducted split cycle system and two wall mounted split cycle systems in bedrooms |
| Hot water | Instantaneous gas |
| Kitchen appliances | Modern large refrigerator, industrial dish washer |
| Washing machine | Standard domestic washing machine |
| Dryer | One small domestic dryer and one large commercial dryer |
| Television/ Computers/ Phones | One small television in the kitchen/dining space, one television in the living space, one laptop and one computer in use. Electricity consumed from these devices is minimal in comparison with heating |
| Lighting | Most of the lights have been upgraded to LED efficient lighting |

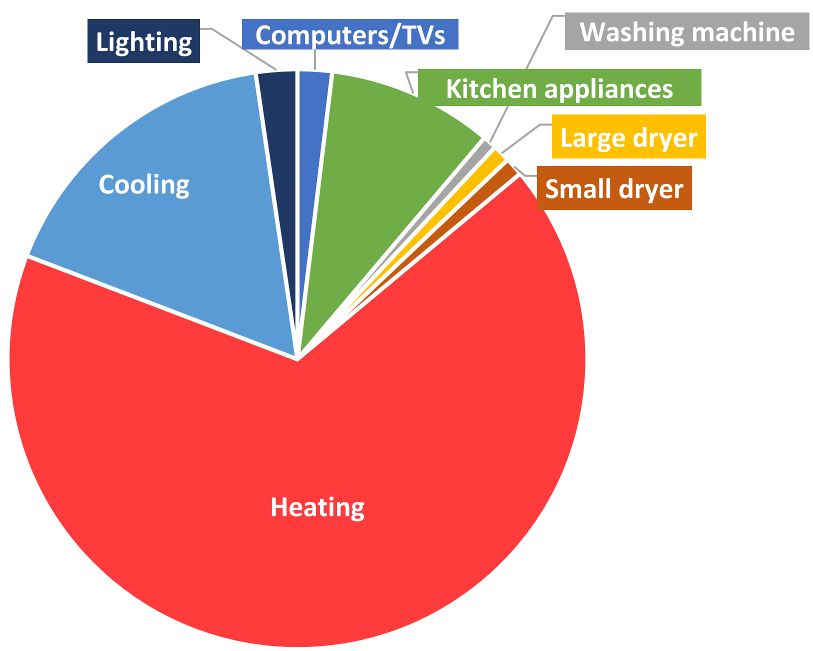



*Figure 10-9: Breakdown of electricity end uses for Home C*

### 10.3.1 Electricity Usage Profile and Seasonal Variation

Unlike Home A and Home B, Home C's electricity usage experiences no 1am peak load. This is due to Home C sourcing their hot water energy from an instantaneous gas system. The electricity profile of Home C is less typical than expected, with flat peaks that are at their maximum for multiple hours. The electricity profile indicates heavy usage for heating and cooling across the year. The use of electricity throughout summer steadily increases across the day before experiencing a singular peak around 6pm. This is indicative of the split systems continually working to maintain the house at a cool temperature. During winter, the split systems are continually working to maintain the home at a warm temperature. As Healesville continually experiences cold weather throughout winter, the split systems consume significant amounts of electricity throughout winter.

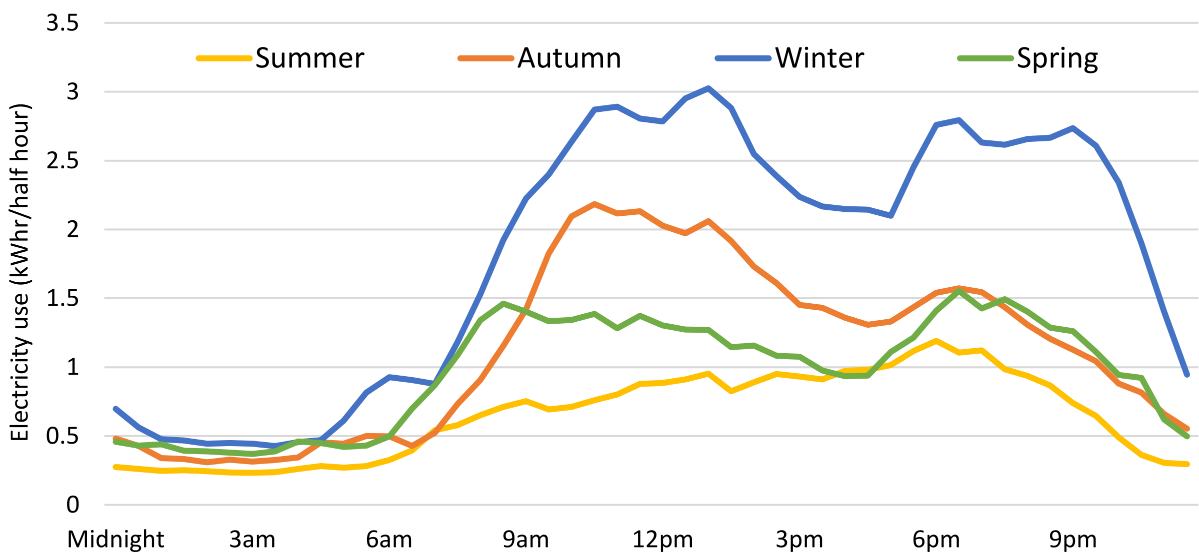



*Figure 10-10: Seasonal daily electricity usage profile for Home C*

*Table 10-10: Seasonal variation of total electricity use*

| | *Summer* | *Autumn* | *Winter* | *Spring* |
|---|---|---|---|---|
| *Consumption* | 14.0% | 24.8% | **40.1%** | 21.1% |

### 10.3.2 Electricity Efficiency Opportunity

1. Installing R2.0 underfloor insulation. **Saving an estimated 7600 kWh/year**

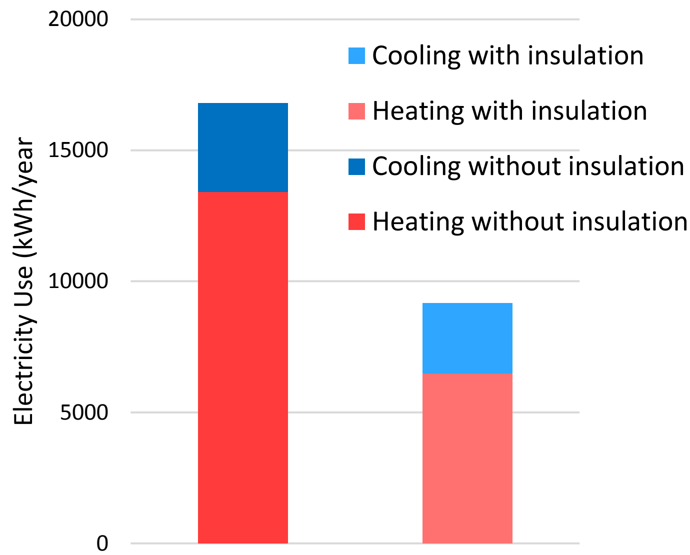



*Figure 10-11: Estimated electricity saving by upgrading inefficient dryer*

| Capital Cost | Energy Savings | Saving on electricity bill per year | Payback Period | Avoided carbon emissions |
|---|---|---|---|---|
| $4,400 | 7600 kWh | ≈ $2350 | ≈ 2 years | ≈ 8.2 tonnes |

### 10.3.3 Behavioural changes

It has been identified that the main issue with the electricity use by the residents of Home C is the heating. This can only be partially reduced with flooring insulation, but behavioural changes must be made to see further reductions. Currently, the ducted split-system air conditioner is heating a significant volume of space in the home – large floor area and tall ceilings. This means unnecessary heating is done through the house that doesn't improve the thermal comfort of the residents. At the beginning of 2018, the residents of Home C installed a gas furnace heating for the kitchen space. It is recommended that the residence rely on the gas furnace and the wood fire place in the lounge space for heating instead of the ducted system.

# 11 Appendix C: Case Studies

## 11.1 Hepburn

Hepburn is home to Australia's first community-owned wind farm. The wind farm consists of two 2.05MW turbines, jovially named Gale and Gusto, that produce enough clean energy for over 2000 homes - The wind farm has a predicted capacity factor of 34%. ~ 11,000 MWh per year. Hepburn Wind is the trading name of the wind turbine operator that was established in 2007 by the Hepburn Renewable Energy Association, now known as SHARE.

*"The Hepburn Wind co-operative is entering an exciting time as we work to transition the Hepburn Shire to zero-net energy by 2025. To meet this target, we are working on projects that will help our community reap the benefits of 100% renewables."*

### 11.1.1 Wind Farm Finances

The capital required to finance the construction of the two wind turbines came from a range of sources, but was predominately sourced from community members and applicants.

- Capital from members and applicants $9,900,000
- Sustainability Victoria RESF grant $975,000
- Regional Development Victoria RIDF grant $750,000
- Bendigo and Adelaide Bank loan (10 years, not fully drawn) $3,100,000
- A debt guarantee from Embark Australia $1,000,000

At the time of the wind farm's inception, Hepburn Wind determined that the best course of action for the sale of the generated energy was to sell at market price. This was chosen over entering into a long-term Power Purchase Agreement with a retailer as the prices on offer were not reasonable. This choice exposes Hepburn Wind to the associated price risks of the market. Market prices in the National Electricity Market are set in the form of auction every 30 minutes throughout the day and can be as high as $1000 per MWh and can be as low as a negative value.

### 11.1.2 Partnerships

- **Coalition for Community Energy (C4CE)**
- **TAKE2 –** A government organised pledge run by sustainability Victoria that aims to have Victoria net zero emissions by 2050. A range of grants for sustainability projects are offered through take2, i.e., energy assessment for businesses using $20,000 of energy/year.
- **Powershop/Meridian energy***
  - How does the Hepburn Wind & Powershop partnership work?
    1. Meridian's Shaun and Gus will take care of our turbines Gale and Gusto
    2. Meridian will manage the output of our wind farm
    3. We get a financial contribution from Powershop for every new customer and for customer loyalty
    4. We get to sell our Community Green Renewable Energy Certificate Product on their platform

*bullet points as stated on the website

### 11.1.3 Ongoing Projects

- Hepburn Solar Bulk-buy
- Daylesford Lake micro hydro
- Grid-connected solar
- Behind the meter solar.
- Solar on neighbourhood centres

### 11.1.4 Discussion with Taryn Lane

Taryn Lane works for Hepburn wind, owner and operator of Australia's first community-owner wind farm, and has extensive community program development experience both locally and internationally. She has a wealth of knowledge in relation to political engagements that impact community energy programs, the development of community based masterplans, community group governance and ownership, and more.

**Building a project vs. Community-based masterplan**

Taryn cautioned the idea of being fixated on the idea of developing the next 'big' project that will make a considerable reduction in carbon emissions. In reality, carbon emissions are sourced from a number of areas, e.g. energy, waste and transport, and they require a number of small strategies that accumulatively reduce emissions. In terms of energy, talking about what strategies are viable and then prioritising these helps identify what strategies are the easiest to implement. By beginning with easy targets, subsequent strategies can follow on. This program creates a community-based masterplan that builds a narrative and brand, which benefits community engagement and trust.

**Political engagements**

Government policies that impact the viability of sustainable programs are volatile with the upcoming state elections. Taryn mentioned two programs that can be of importance for the Healesville community net zero emissions target.

- New energy jobs fund – Provides businesses with funding of up to $1 million to support projects that improve access to renewable energy and reduce greenhouse gas emissions.
- Sustainability Victoria: Hepburn Pilot – The Hepburn Shire is the Z-NET pilot for Victoria (similarly to Uralla for NSW). The program will study the feasibility on projects identified to help reach 100% renewable energy.

**Community group governance and ownership**

Once a community group is established and implements the initial programs, the size of group and the responsibility that inevitably comes with the programs can grow rapidly. Taryn recommends establishing a plan for the future that expects growth, and builds a resilient community group that can withstand the growth in responsibilities.

**Comments on bulk buy**

Taryn supports a bulk buy program for Healesville CoRE. However, she recommends branding the program as Healesville CoRE/Yarra Ranges Council and not overworking the Healesville CoRE volunteers involved.

**Climate council - City power partnership**

The City power partnership has been established as a knowledge sharing network for local council groups who want to reduce emissions and boost clean energy production. Mutually beneficial relationships are established between local councils through a City Power Partnership, which catalyses the knowledge growth for actions against climate change. As of 18th April 2018, Yarra Ranges Council are not yet a member of City Power Partnership.

## 11.2 Uralla

Uralla is a rural town in North-East New South Wales and is the first Australian town to have the Zero Net (Z-NET) Energy Town blueprint applied to it. A Z-NET town supplies all its energy needs from renewable energy, thus emitting no $CO_2$ emissions. The blueprint outlines a logical approach to achieving the goal of 100% renewables.

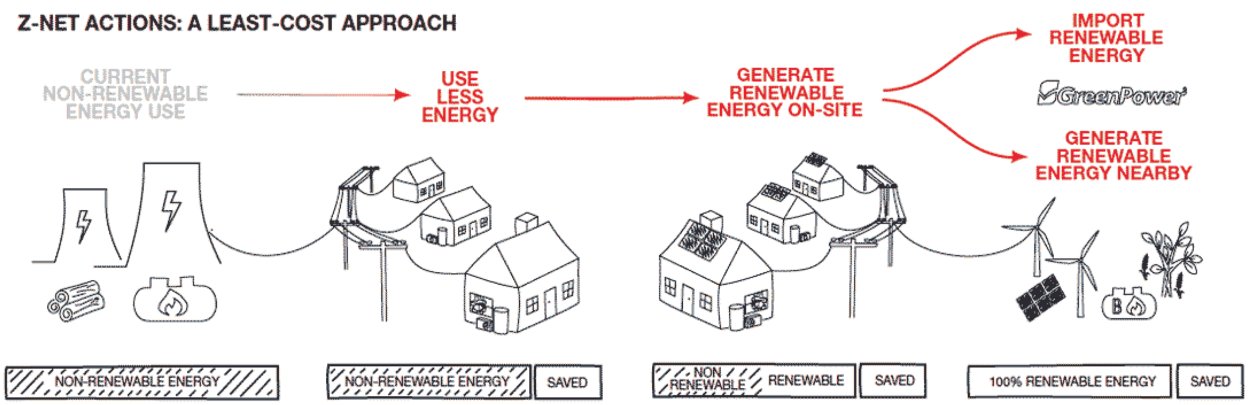



*Figure 11-1: Zero Net Energy Town blueprint*

At the beginning of the project, Uralla's energy consumption was made up of electricity (49%), gas (6%), and firewood (45%). The first stage of the project – "use less energy" – would see a 15.7% reduction in total energy use and 20% of total energy use would be sourced from on-site solar PV generation and purchasing of GreenPower. The second stage would incorporate further reductions in energy from energy efficient practices, but renewable energy from off-site generation would have to be imported or more on-site renewable energy generation would have to happen for the town to reach Z-NET (Figure 11-2). In addition, further research needs to be done to understand the changes needed to collect wood from a renewable source. Possible options include importing certified wood from a nearby region, improving existing collection practices, or funding reforestation programs.

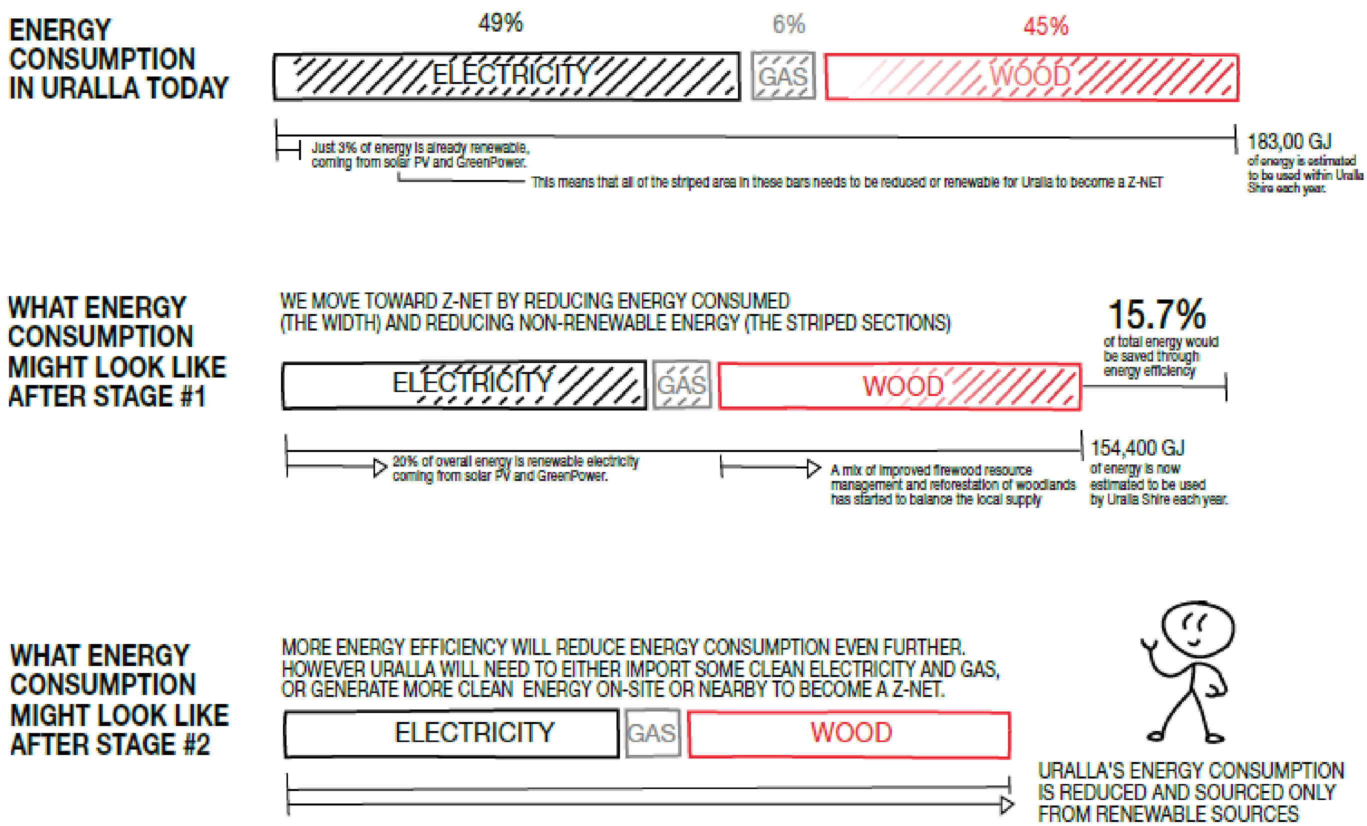



*Figure 11-2: Summary of the changes made from stage 1 and 2 of the Uralla Z-NET project.*