CLEAN TECH IN CITIES

A STUDY OF STRATEGIES AND LOCATIONS FOR RAPID DECARBONIZATION IN AUSTRALIA'S URBAN AREAS

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CLEAN TECH IN CITIES:
DESIGNING GUIDELINES FOR RAPID DECARBONIZATION IN AUSTRALIA'S URBAN AREAS

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AUTHORSHIP

The introduction, background, methodology, and findings of this report were written collaboratively by all team members and edited by Professor Stephen McCauley and Professor Sara Saberi. Each section was broken up and assigned to group members to work on individually. Zarrin Rahman was a primary writer and lead in ArcGIS use and analysis. Hannah Edlund was a primary editor for the final report. Nolan Warner, Ryan Fischer, and Hannah Edlund were the primary researchers for the case studies. Peer review was done throughout each section. The authorship, references, appendices, table of contents, and other sections were also written by each team member and edited by the team, Professor Stephen McCauley and Professor Sara Saberi.

ABSTRACT

The goal of this project was to identify promising strategies and locations for decarbonizing urban areas in Australia rapidly and equitably. We identified and analyzed international case studies, with different policies or technologies to reduce carbon emissions in urban areas. Then, we performed multi-criteria analysis, utilizing ArcGIS software, to identify Local Government Areas (LGAs) across Australia that would be appropriate locations for the policies and technologies examined in the case studies.

EXECUTIVE SUMMARY

At the global level, the need for rapid decarbonization is urgent. For instance, in 2015, many international governments “agreed to keep global average warming to well below 2˚C, and ideally lower than 1.5˚C”, as a sustained level of increased temperature can be irrevocably damaging (De Kruijff, 2023). As a country, Australia is a leader internationally in fossil fuel consumption, using 7% more fossil fuels to generate electricity than the international average (Bakhtiari, 2016). Specifically, the building (residential and commercial) and transportation sectors account for a significant percentage of Australia’s total greenhouse gas emissions, which is approximately 39%. This is an issue due to the constant energy requirements from these sectors.

We collaborated with Beyond Zero Emissions (BZE) to address the need for rapid decarbonization in Australia. BZE is an independent think tank that engages with industries to establish change throughout Australia. They proposed a plan titled “The Deploy Report” to use readily available clean technology to reduce Australia’s emissions 81% by 2030 (Beyond Zero Emissions [BZE], 2022b). Additionally, BZE has proposed a strategy called “Renewable Energy Industrial Precincts (REIPS)” which works to support industries and secure jobs while promoting and installing clean technologies (BZE, 2023). Already having extensive knowledge of the precinct model for industrial areas, BZE is interested in exploring a similar model for the building and transportation sectors in metro, suburban, and regional town areas across Australia.

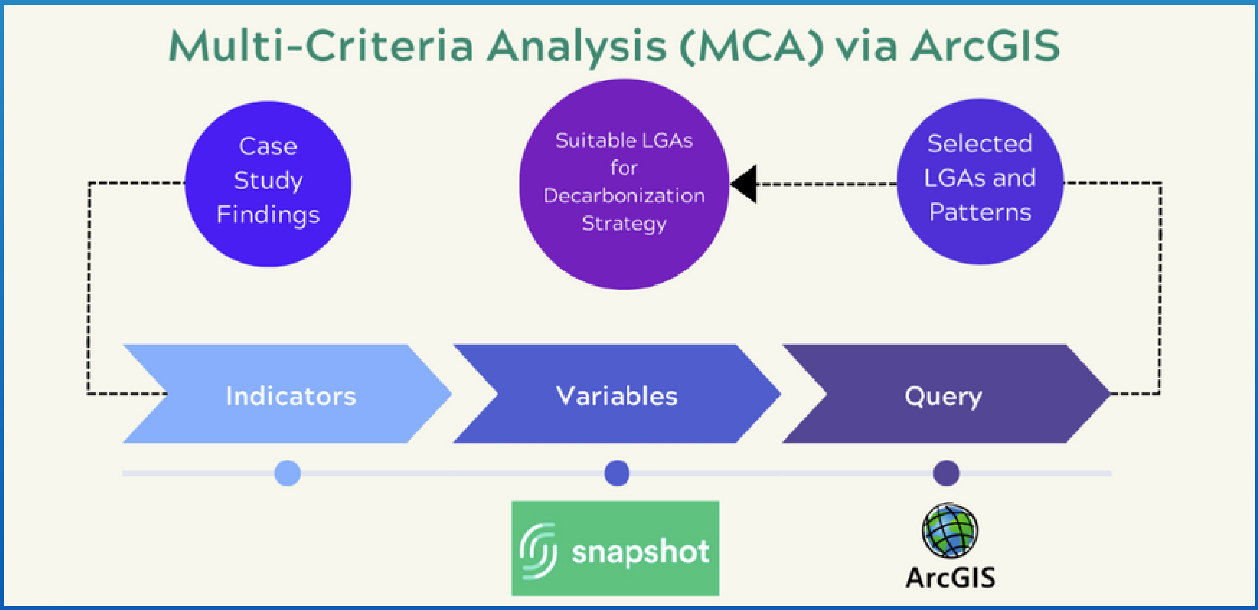
The goal of this project was to identify strategies and locations where rapid and equitable decarbonization can be implemented in Australian metro, suburban, and regional town areas, specifically within the building and transportation sectors. We identified specific case studies that have implemented clean technology within the building and transportation sectors. This information was used to suggest urban areas throughout Australia where similar technologies could be deployed. We achieved this goal by (a) utilizing archival research and contacts of Beyond Zero Emissions (BZE) to enhance our understanding of rapid decarbonization methods; (b) identifying and analyzing global communities that have successfully implemented clean-tech solutions; and (c) recognizing appropriate local government areas (LGAs) for urban-scale decarbonization.

In total, we identified five case studies each with varying decarbonization strategies. The first case study is Energiesprong whom BZE had written about previously in their Million Jobs Plan (BZE, 2020). The main work done through Energiesprong takes place in the Netherlands. The decarbonization strategy Energiesprong utilizes is a retrofit approach, where houses are upgraded with technology such as solar panels, insulation, and prefabricated facades that reduce the amount of carbon emissions from households. Energiesprong’s method involves working with housing associations where homes have a similar design to streamline the retrofitting process for homes (Energiesprong, n.d.). The second case study is SolShare which is a technology developed by Allume. SolShare works by providing solar energy to multi-dwelling buildings and social housing to allow tenants to have access to renewable energy (Allume Energy, 2023b). The third case study is New York City Local Law 97. Local Law 97 is legislation affecting New York City (NYC) aiming to reduce carbon emissions produced by buildings over

25,000 square feet in the city by putting acap on their emissions (Urban Green, n.d.). These caps become more stringent over time, culminating in achieving net zero emissions by 2050 (Urban Green, n.d.). The fourth case study is Plug in BC, an organization working with the Province of British Columbia to provide 50-75% rebates on the purchasing and installment of electric vehicle (EV) chargers (Plug in BC, 2024). This increases the amount of infrastructure supporting EVs, leading to more sustainable on-road transport. The final case study is Totally Renewable Yackandandah (TRY), an initiative by a volunteer organization to transition the entire town of Yackandandah, Australia to 100% renewable energy. Solar and batteries in each home will assist in creating a virtual power plant— a network of distributed energy resources—to share power between Yackandandah residents and create a self-sufficient community (Totally Renewable Yackandandah [TRY], 2022). After analyzing the case studies, we performed multi-criteria analysis to map the LGAs in which each case study would be most effective. A multi-criteria analysis involves conducting a query with multiple variables to determine cases that each meet a set of criteria determined to be important as shown in Figure ES-1. The variables in each MCA differed from each other, as the strategies are each suited to different places and contexts. Variables were determined from a list of indicators that best represented the findings for each case study. Snapshot Data was the source for all variables involving emissions in tons of carbon dioxide for all LGAs for the 2021/2022 fiscal year.

Figure ES-1

Pathway of Multi-Criteria Analysis to connect case study findings to identifying suitable LGAs and recognizing its patterns.

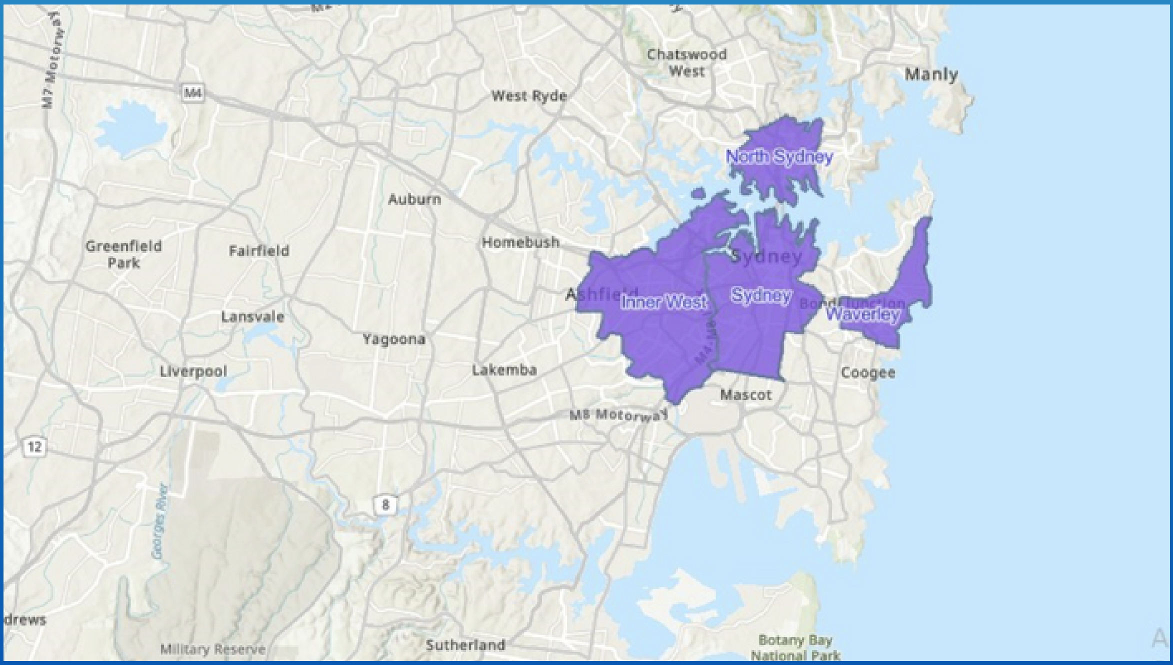


The decarbonization strategy represented by New York City (NYC) Local Law 97 focuses on large building emissions limits. The indicators chosen were high residential emissions, high commercial emissions, and population density to align with New York City's characteristics, directly related to its selected variables from Snapshot. The criteria for Local Law 97 encompassed are: electric residential emissions above average (90,306 t CO2), gas residential emissions above average (17,717 t CO2), electric commercial emissions above average (79,990 t CO2), gas commercial emissions above average (4331 t CO2) and population density above the third natural quartile (4,704). Figure ES-2 shows the LGAs selected as suitable for this decarbonization strategy.

The second decarbonization strategy is Allume's SolShare technology, which targets providing accessible solar power for renters. The social justice aspect the strategy focuses on is the renter versus homeowner power dynamic. Residential emissions and renter percentage, from the Australian Bureau of Statistics (ABS), were both indicators and variables for this strategy as it encompassed the core audience of SolShare. Sustainability engagement served as a third indicator and was represented binarily by active sustainability teams in LGAs. Active sustainability team information was provided by Allume, however, is only representative of LGAs in South Australia (SA), New South Wales (NSW), and Victoria (VIC) from their current research. The criteria included the following: electric residential emissions above average (90,306 t CO2), gas residential emissions above average (17,717 t CO2), presence of an

Figure ES-2

Local Government Areas (LGA) Identified as Suitable For the Policy Approach Used in the New York Local Law 97 Case Study.



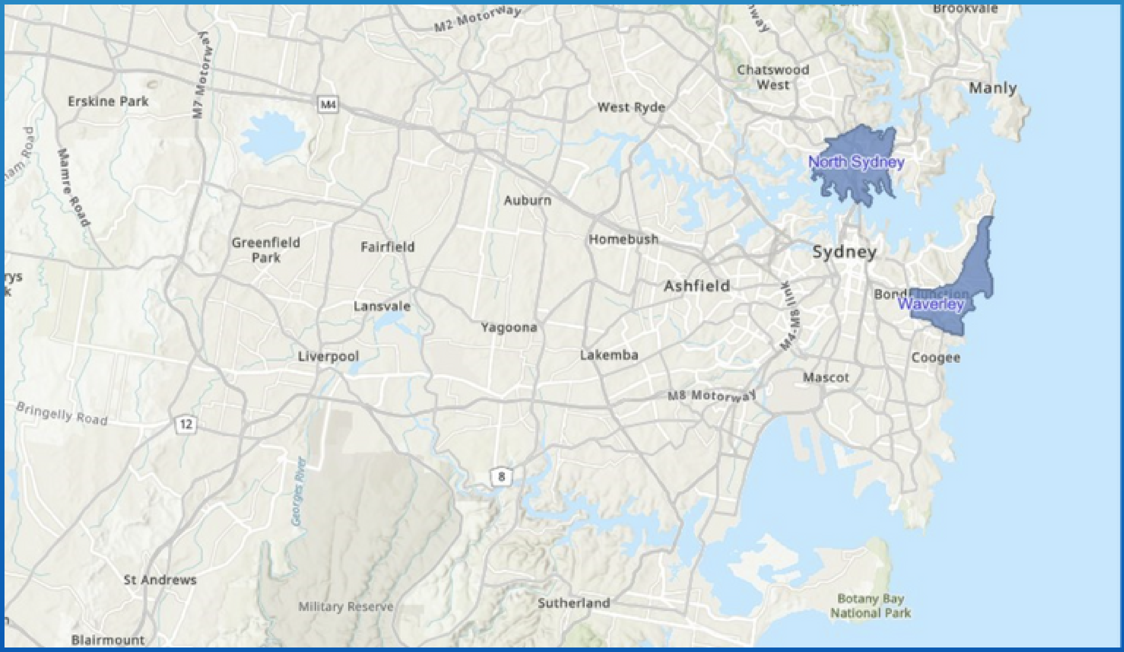
active sustainability team, renter percentage above national average (30.6%), and LGA populations below 100,000 people. Figure ES-3 shows the LGAs selected as suitable for the Allume decarbonization strategy.

This project is integral to the continued understanding of strategies to rapidly decarbonize Australia and the planet. By looking at success stories from around the world, we can find the characteristics that directly influence the successful implementation of policy or technology. Using these characteristics, we can continue to explore datasets and use this information to determine areas around Australia where the same technology or policy may be most effective. Overall, this project can provide a blueprint to the rapid decarbonization of the residential and transport sectors, assisting in a net zero-emission future for Australia.

Following this shallow dive, we recommend that Beyond Zero Emissions continues to further explore rapid decarbonization in the building and transportation sectors. For Local Law 97, we recommend implementation in larger cities within Australia such as Melbourne and Sydney. In addition, we recommend that the size of buildings affected are reduced from 25,000 square feet to 20,000 square feet as New York City is larger than any city in Australia. We also believe that combining Local Law 97 with Allume's Solshare technology could lead to an effective combined product. In conclusion, there are a lot of opportunities to reduce emissions in an equitable and rapid manner in Australia.

Figure ES-3

Australian LGAs through a multi-criteria analysis from the findings of Allume's SolShare program via ArcGIS. The LGAs shown are: North Sydney (NSW) and Waverley (NSW).



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1.0 INTRODUCTION

At the global level, the need for rapid decarbonization is increasingly apparent. In 2015, many international governments “agreed to keep global average warming to well below 2˚C, and ideally lower than 1.5˚C”, as a sustained level of increased temperature can be irrevocably damaging (De Kruijff, 2023). The planet is already 1.1˚C warmer than during the 1800s; keeping that temperature from increasing further is paramount to the safety of the planet. Analysis shows that even a 1.5˚C increase in temperature in Australia will cause “8% of plants [to] lose ½ of their habitable area, 6% of insects [to] lose ½ of their habitable area, a 70%-90% decline in coral reefs, and a 14% chance that the global population [will] be exposed to severe heat every 1-5 years.”(Climate Council, 2019). The UN Net Zero Coalition states that for the temperature to never increase more than 1.5˚C, there needs to be an emission reduction of “45% by 2030 and reach net zero by 2050” (United Nations, n.d.). With only six years until emissions need to be reduced to 45%, there is urgency to rapidly and effectively decarbonize.

As a country, Australia is a leader internationally in fossil fuel consumption, using 7% more fossil fuels to generate electricity than the international average (Bakhtiari, 2016). Specifically, the building (residential and commercial) and transportation sectors account for a significant percentage of Australia’s total greenhouse gas emissions, which is approximately 39%. This is a significant problem due to the constant energy requirements from these sectors.

We are working with Beyond Zero Emissions (BZE), an independent think tank that engages with industries, governments, and policymakers to establish change throughout Australia. They have proposed a plan, titled “Deploy,” to use readily available clean technology to reduce Australia’s emissions 81% by 2030. BZE’s plan is based on a strategy called “Renewable Energy Industrial Precincts (REIPS),” which works to support industries and secure jobs in a focused regional area, through the promotion and installation of clean technologies (Beyond Zero Emissions [BZE], 2023). Already having extensive knowledge of the precinct model for industrial areas, BZE is interested in exploring a similar model for the building and transportation sectors in metro, suburban, and regional town areas across Australia. This knowledge will help BZE to address the need for rapid decarbonization across Australia.

The goal of this project was to perform a shallow dive analysis for BZE of the potential impact of a policy strategy focused on urban and residential areas in Australia. This analysis focused on determining effective strategies and locations to decarbonize urban areas rapidly and equitably in Australia. We accomplished this goal by completing three objectives. First, we analyzed the process and intricacies of decarbonization through different methods by use of internal and external expert interviews. Second, we established an understanding of existing decarbonization strategies through thorough case study analysis. Third, we determined the most viable locations for the implementation of each strategy. This information will help BZE decide whether to pursue rapid decarbonization in the building and transportation sectors across Australia.

2.0 BACKGROUND

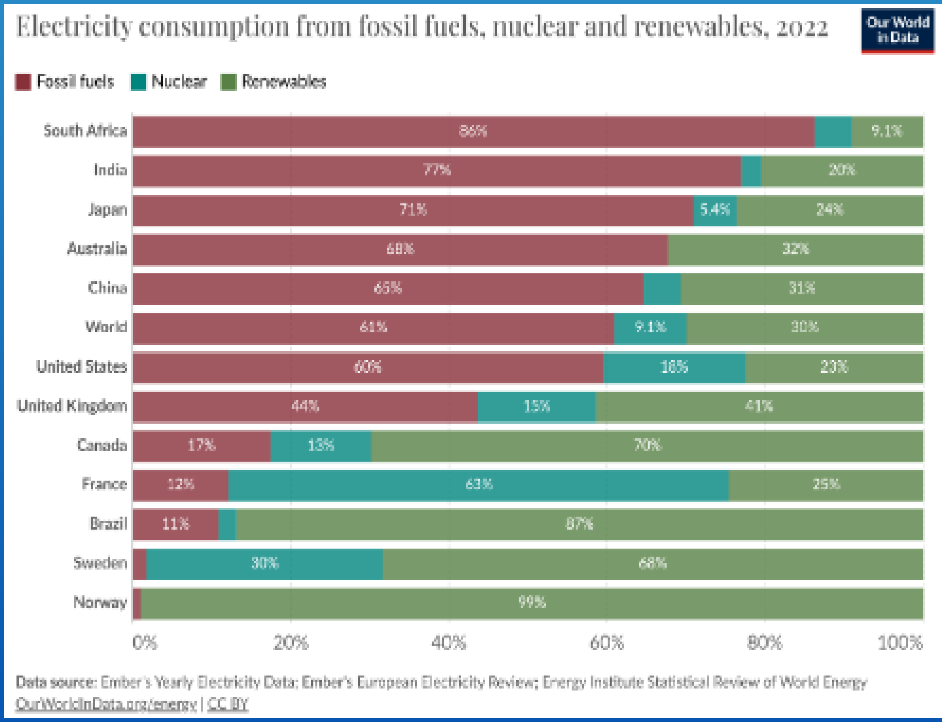
This chapter presents the impact of clean technology on Australia's energy landscape. It reviews emissions generated from the building (residential and commercial) and the transportation sectors in LGAs (local government areas), along with current clean technology solutions to highlight significant insights and emerging trends within the Australia energy framework.

2.1 Australian Energy Use in the Building and Transportation Sectors

Australia significantly contributes to global fossil fuel consumption due to the exportation of coal, other fossil fuels, and uranium (Geoscience Australia, 2023). As observed in Figure 1, Australia's usage of fossil fuels for electricity generation is 7% greater than the world average (Bakhtiari, 2016). Coal is the largest export from Australia, grossing over 40 billion dollars AUD annually (Geoscience Australia, 2023). The coal reserves in Australia can be broken into two major categories: black and brown coal. Brown coal has a higher moisture and lower carbon content than black coal, making it the most polluting type of coal when considering carbon dioxide emitted per unit of electricity generated (Diesendorf, 2003). Due to its composition, brown coal is not exported from Australia and is instead utilized to generate electricity within the country (Environment Victoria, 2022). The largest percentage of brown coal is found in Gippsland Basin in Victoria 200 kilometers (about 124.27 mi) east of Melbourne (Geoscience Australia, 2023). Due to its proximity, coal accounts for a massive portion of Victoria's electricity generation

Figure 1

Electricity consumption from fossil fuels, nuclear, and renewable sources of various countries (Our World in Data, 2023).



(Geoscience Australia, 2023). For instance, in 2021-2022, brown coal accounted for 34.2% of electricity generated in Victoria whereas electricity from renewable sources only generated 6.3% of electricity (Department of Climate Change, Energy, the Environment and Water [DCCEEW], 2023c).

The residential and commercial building sectors significantly impact electricity usage and emissions in Australia (DCCEEW, 2023b). Consistently, residential buildings account for 24% of electricity usage and more than 10% of carbon emissions in Australia (DCCEEW, 2023b). Additionally, commercial buildings account for 25% of overall electricity usage and 10% of total carbon emissions in Australia (DCCEEW, 2023e). According to the Australian government, energy waste is partially due to the inefficiency of homes built before energy building standards were introduced. As an effort to combat energy waste, the Australian government established the Household Energy Upgrades Fund to provide low-interest loans and fund upgrades for low-income housing (Commonwealth of Australia, 2023). Beyond Zero Emissions (BZE) has developed a comprehensive outline, referred to as the Deploy plan, that uses readily available clean technology to speed up decarbonization in Australia (Beyond Zero Emissions [BZE], 2022b). According to the Deploy plan, BZE predicts that Australia can reduce emissions in the residential and commercial building sectors by 75% by implementing technology like induction heat pumps, induction stovetops, and insulation (BZE, 2022b).

As Australia attempts to generate 82% of electricity with renewable energy by 2030, it is important to consider the current impacts of the transportation sector (DCCEEW, 2023d). In 2022, the transportation sector accounted for 19% of total emissions in Australia (DCCEEW, 2023d). Within this emissions category, passenger cars and commercial vehicles were responsible for 60% of transportation emissions (DCCEEW, 2023d). Although the transition to electric vehicles appears to be a straightforward solution for decarbonizing the transportation sector, Australia is below other countries' averages in electric vehicle sales. For instance, in 2022, electric vehicles accounted for 4% of new car sales in Australia whereas in other countries such as Norway, electric vehicles accounted for 80% of passenger vehicle sales in 2022 (Jaeger, 2023). To increase the market share for electric vehicles, the Australian government has created the National Electric Vehicle Strategy which provides discounts on electric vehicles and aims to increase the electric vehicle charging infrastructure across Australia (DCCEEW, 2023d). According to Deploy, BZE has determined that Australia must deploy 3.8 million electric vehicles to reach 82% of electricity generated with renewable energy by 2030 (BZE, 2022).

2.2 Beyond Zero Emissions Precinct Approach to Rapid Decarbonization

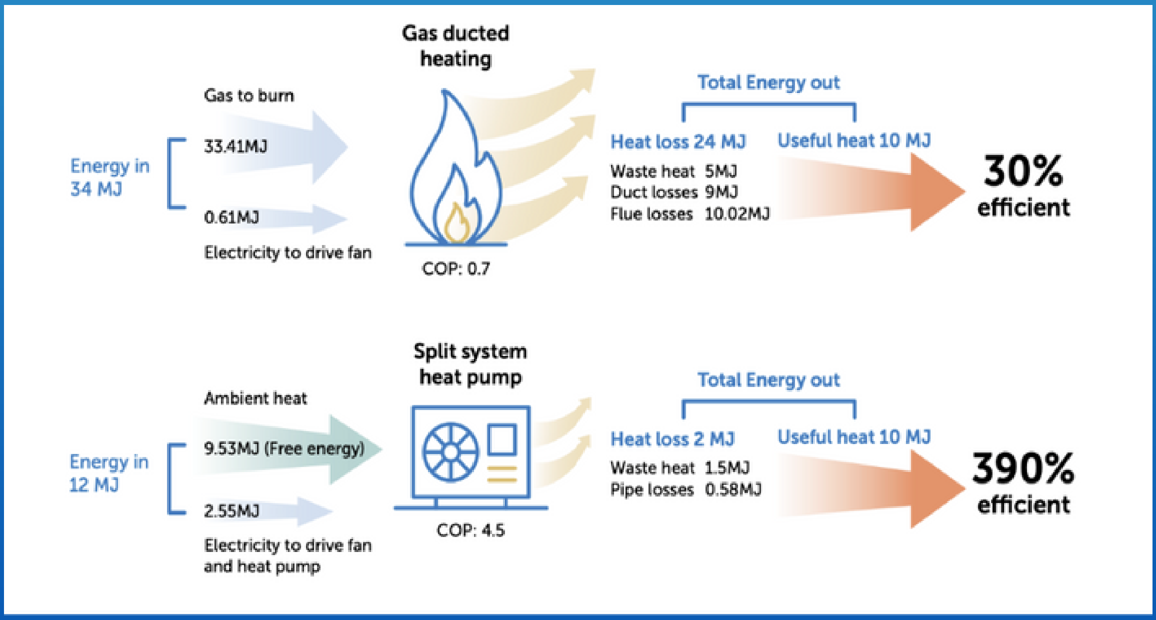
BZE has conducted extensive research on the Renewable Energy Industrial Precinct (REIP) model and additional models that propose rapid decarbonization solutions. The reports include case study research highlighting feasible locations and technologies for the precinct-based design and descriptions of time-efficient retrofits and required infrastructure to decarbonize Australia. The two reports most applicable to this research project are the Renewable Energy Industrial Precincts report and the Deploy report.

Renewable Energy Industrial Precincts (REIPS) are defined as renewable energy clusters with access to affordable renewable energy (Dandanay, 2023). The purpose of REIPS is to decarbonize existing industries in Australia by connecting industrial centers with hydrogen hubs and renewable energy zones (BZE, 2021). Currently, BZE has identified 14 locations for potential implementation of REIPS in Australia, two of which are the Hunter Valley and Gladstone regions (Mella et al., 2022). Both locations have been known historically as regional industrial centers. BZE selected these locations based on their skilled workforces, existing industrial bases, deep water ports, transport networks, and close access to rich renewable energy resources (BZE, 2021). In addition to the criteria above, when choosing REIPS locations, the BZE's research team performed emissions calculations to target areas producing high amounts of emissions.

The Deploy report highlights six technologies that can help reduce national emissions by 81% (BZE, 2022b). These technologies include solar panels, wind turbines, heat pumps, batteries and storage, electrolysers, and electric vehicles. When considering the buildings and transportation sectors, certain technologies are more applicable than others when implementing retrofits. These retrofits include heat pumps, energy efficient technologies like induction cooktops and insulation, electric vehicles, and using solar panels to generate and store electricity (BZE, 2022b). Upgrading commercial and residential buildings will improve their efficiency which subsequently reduces emissions and energy waste.

Figure 2

Comparision of the efficiency of gas ducted heating vs split system heat pump (BZE, 2022b).



As depicted in Figure 2, replacing gas ducted heating with split system heat pumps is proven to be 360% more efficient (BZE, 2022b). Split system heat pumps are more efficient because they use electricity to extract heat from the air whereas gas ducted heating uses fossil fuels to generate energy (BZE, 2022b). For perspective, gas ducted heaters generate less than one unit of energy for each unit of gas burnt whereas split system heat pumps generate between three and six units of heating and cooling energy (BZE, 2022b). As mentioned in 2.1, to support the addition of 3.8 million electric vehicles, 1.4 million public and residential charging units must be implemented. Implementing retrofits similar to the suggestions in the Deploy Report could provide a path for rapid decarbonization within Australian urban areas. However, the large number of stakeholders in residential areas adds to the complexity of this issue, as the increased diversity of power and interest levels makes designing solutions challenging.

2.3 Promising Policy Approaches for Decarbonization in Australia

The Australian government has implemented several schemes to regulate, disclose, and decrease the number of emissions produced. In 2007, the National Greenhouse and Energy Reporting Scheme Act (NGERS) was introduced by the Australian Government. This act both fills Australia's international obligations towards clean energy and helps to collect data for designing policies that target emission reduction and climate change (Clean Energy Regulator, 2023). NGERS requires firms to record and report their energy consumption and equivalent carbon dioxide emissions (Clean Energy Regulator, 2023). This is a metric utilized to compare the emissions of various greenhouse gases based on their global warming potential. In 2012, Australia introduced the Clean Technology Investment Program (CTIP), an initiative to assist Australian manufacturing businesses in maintaining competitiveness in both domestic and international markets while reducing their carbon emissions. This is accomplished by providing grants that can supply up to half the proceeds needed for manufacturers to switch to efficient equipment and technologies. Since the CTIP was introduced, there has been a steady flow of projects that were completed within four years (Bakhtiari, 2016). After carbon-pricing was introduced in Australia, there was a drop in emissions by 9.7% in the four-year period, due to the sector-wide technology shift whereas in prior years the technological shift had been an average of 0.8%. This is compelling evidence that the introduction of the NGERS and the CTIP had a direct influence on the reduction of carbon-based emissions (Bakhtiari, 2016).

Established in 1993, the Nationwide House Energy Rating Scheme (NatHERS) aids in providing energy ratings for new residences (DCCEEW, 2022). NatHERS works by ranking a home on a scale from 1 to 10 stars based on its thermal performance (heating and cooling needs). Stars are assigned based on the "home's design, construction materials, and the climate where it is built" (DCCEEW, 2022). When building new dwellings, homeowners must abide by the National Construction Code (NCC) which is updated every three years. For instance, starting in October of 2023, all new homes must have at least a 7-star rating as opposed to a 6-star rating.

By increasing the energy efficiency standard from 6-star to 7-star, it is projected to cut thermal energy use by 20-27% (Hassen, 2023). This implies that energy inefficiency is a significant factor in energy consumption.

Australia leads the world in per capita deployment of rooftop solar with 30% of homes having installed rooftop solar (Australia Trade and Investment Commission, n.d). Solar power is categorized into behind the meter or in front of the meter depending on where it was generated. Behind the meter refers to energy generated or managed on the customers end of the utility meter. This typically refers to systems such as rooftop solar, battery storage, and electric vehicles and chargers (Australia Renewable Energy Agency, 2024). In front of the meter refer to systems on the utility end, including large-scale energy generation and storage facilities such as solar farms (Australia Renewable Energy Agency, 2024). In 2018, there was a significant increase observed in rooftop solar with 1.55 gigawatts installed in residential areas across Australia, compared to only 1.1 gigawatts installed in 2017. The increase can be attributed to the savings on energy bills. Solar panels specifically have become cheaper, and adoption of that technology has increased at a substantial level (Nijsse et al., 2023). On average, households that have incorporated these systems save $540 AUD annually on energy bills which has been attributed to their popularity. Furthermore, Australia has shown an increase in size of solar panel systems, with the average system now being 7.13 kW. This change in data is a significant increase when compared to 1.34 kW per system in 2009 (Council, 2019).

2.4 Local Government Areas and the Reporting and Classifications of Emissions

Australia's political jurisdiction includes states, municipalities, local government areas (LGAs), and electorates. LGAs are of higher importance due to their role in direct community engagement, and there are 566 LGAs currently in Australia. Environmental impact is tracked in these areas by way of urban emissions. Urban emissions are described as substances (typically harmful) released into the air and measured in concentration. They primarily involve gas and electrical emissions from residential, commercial, industrial, and transportation sectors of cities and towns. Communities use urban emissions from such areas to determine energy usage and form conclusions and opinions on climate change. Urban emissions are categorized by the source of emissions, which is divided into gas or electricity. Looking at other data such as population density, land size, volunteer hours, and political views can be further useful in determining why an LGA's residential area could be fit for potential rapid decarbonization solutions.

There are three scopes used to categorize emissions, labeled as Scope 1, Scope 2, and Scope 3, as seen in Figure 3. These scopes are based on the emissions source. Scope 1 encompasses emissions that an organization directly controls or owns such as the emissions utilized by fossil fuels powering company vehicles. Scope 2 describes emissions that an organization is indirectly responsible for generating, which includes emissions caused by generating electricity to power company buildings.

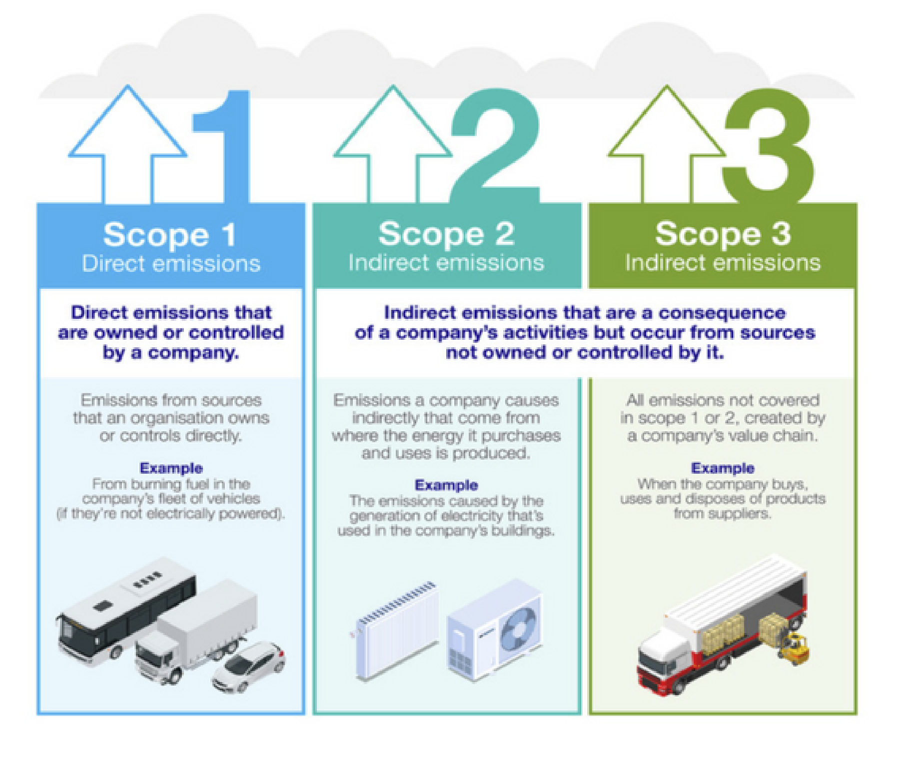
Although not as applicable in urban settings, Scope 3 accounts for indirect emissions that are not represented in Scope 2, which are the emissions generated in the wider economy such as when companies purchase, use, and dispose of products from suppliers (National Grid, 2024). Scope 1 and Scope 2 are mandated to be reported under the National Greenhouse and Energy Reporting (NGER) Scheme by the Clean Energy Regulator (Clean Energy Regulator, 2023). Scope 3 is applicable to the Australian National Greenhouse Accounts (Clean Energy Regulator, 2023). Scope 3 is not used when determining major emissions in urban areas, so the emphasis is predominantly put onto reducing Scope 1 and 2 emissions. Scope 3 emissions are harder to analyze, as companies do not have direct control over their production and instead need to track them through their value chain.

2.5 Significance of Environmental Justice

Understanding the needs of vulnerable individuals and communities can be an integral part of identifying barriers in implementing rapid decarbonization. Environmental justice is universally interpreted as equitable access to both positive and negative environmental consequences (Wolch et al., 2014). For example, as population density increases within urban areas, there is competitive demand for any land. This leads to a need for green spaces to compensate for such and for a balanced ecosystem (Abercrombie et al., 2014). The consequences from more spaces can include both healthier neighborhoods and rising property values, possibly leading to

Figure 3

Depiction and Comparison of the Scopes of Emissions (National Grid, 2024)



gentrification. This brief example shows the complexity in environmental justice which increases with mandates and policies. A focused perspective for such policymaking comes from a principle of environmental justice as it emphasizes to advocate for ecological policies in urban and rural areas to restore balance with nature, preserving cultural integrity, and ensuring equitable resources for all (Ramirez-Andreotta, 2019).

Distributive, Procedural, and Restorative justice are three main concepts of implementing environmental justice through policy (McCauley & Heffron, 2018). Such types of justice involve community resistance, analysis of climate justice literature, and job restoration, respectively. Equitable resources and accessibility within both environmental and social justice have a direct correlation with economic benefits such as job restoration. The 'just transition' framework describes the mobilization of green jobs as a critical component in withdrawing from fossil fuel usage (McCauley & Heffron, 2018). The 'just transition' is modeled by the Paris Agreement, as it marked a significant advance towards decarbonization on an international scale. Australia is a party to the accord in which their government leads negotiations inclusive of domestic policies, greenhouse gas inventories and emission projections (DCEEW, 2023a).

While there are economic dimensions of environmental justice, another important dimension is community empowerment as a combination of Distributive and Restorative justice. There is value in acknowledging and understanding the root of environmental research and legislation which is community agency. Indigenous perspectives are the key voices in community agency as they are the traditional owners of the land. They have local and cultural expertise that can guide Australia in achieving decarbonization (DCCEEW, n.d.). The Newport Lakes Reserve is an example of the Indigenous perspective and community agency in collaboration in an urban area. The reserve was a community-led initiative to transform its previous state as a landfill site to an accessible park and green area spearheaded by Friends of Newport Lakes and Maarten Hulzebosch (CityDays, 2023). Indigenous flora and fauna now prosper within the park due to collective effort. Local justice developments such as the Newport Lakes Reserve are crucial for achieving environmental sustainability in urban areas.

A prominent environmental justice issue central to our project and part of the Distributive justice dimension is the issue of renters versus homeowners. Thirty-one percent of people are renters in Australia (Australian Bureau of Statistics, 2019-20) Due to the large portion of Australians renting households, there is less of an incentive to purchase retrofits for their home. In addition, renters in Australia often have short-term leases (6 months), which can dissuade them from purchasing retrofits, as they cannot count on renting long enough to see the cost benefits. When retrofitting apartment buildings in Australia, renters need to approve most changes through their landlords. Although retrofits theoretically benefit landlords and renters, there is little incentive or policy for landlords to implement green technology. As policymakers struggle to engage landlords in making sweeping, drastic changes, it leaves renters subject to rising energy prices because they cannot make energy efficiency improvements (Lang et al., 2022).

3.0 METHODS

The goal of this project was to identify strategies and locations where rapid and equitable decarbonization can be implemented in Australian metro, suburban, and regional town areas, specifically within the building (residential and commercial) and transportation sectors. We identified specific case studies that have implemented clean technology within the building and transportation sectors. This information was used to suggest urban areas throughout Australia where similar technologies could be deployed. We achieved this goal by (a) utilizing archival research and contacts of Beyond Zero Emissions (BZE) to enhance our understanding of rapid decarbonization methods; (b) analyzing global communities that have successfully implemented clean-tech solutions; and (c) recognizing appropriate local government areas (LGAs) for urban-scale decarbonization.

3.1 Understanding Promising Rapid Decarbonization Strategies

The first objective was to conduct archival research and interviews to determine our project's scope. Through this goal, we sought a better understanding of BZE's decarbonization strategies and learned integral dimensions of the decarbonization process. This tailored our research to their interests and made our findings applicable for future use. This was accomplished by performing interviews with employees of BZE and meeting with local experts of different perspectives on renewable energy and its role in environmental justice in Australia.

We interviewed seven people, from six different companies: Dominique Hes (Chair of Greenfleet, City of Melbourne), Peter Hansford (Director of Deakin Energy Networks), Alan Pears (Senior Industry Fellow, RMIT) Gill Armstrong (Building Project Impact Manager, Climateworks), Elizabeth Eacott and William Anstee (Allume), and Matthew Charles-Jones, (President, Total Renewable Yackandandah (TRY)). The first-hand information from experts with knowledge of BZE's approaches aided in determining strategies for further research. These interviews gave us perspective on local legislation and regulations regarding land use and development. Additionally, we met with local experts who provided insight into social justice and decarbonization practices. These interviews helped guide and provide a scope for the next steps of the analysis. The interviews were organized ahead of time by BZE. Interview questions can be found in Appendix A.

3.2 Analyze Relevant Case Studies that Target Urban Areas

The second objective was to identify promising instances of technologies and policies that support rapid decarbonization in international and local urban settings through case study analysis. For each case study, we performed stakeholder mapping to understand which individuals have influence in the implementation of clean technologies.

We researched decarbonization case studies to develop a better understanding of how their respective technologies have been utilized internationally in urban settings. Additionally, we used information from external and internal interviews arranged by BZE to understand the considerations in choosing criteria for potential case studies as BZE had previously conducted research involving a precinct model of decarbonization for an industrial setting, the main criteria for choosing case studies for this project was their effect on the building (residential and commercial) and transportation sectors. Other significant criteria included the extent of emission reduction techniques within clean technologies. Once we identified the case studies, we conducted further background analysis and determined a list of indicators for each of the decarbonization strategies within the case studies.

The case studies we analyzed included: Energiesprong, a global neighborhood-scale retrofit solution that has completed most of its work in The Netherlands; SolShare, a technology from Allume which allows tenants in apartment buildings to use rooftop solar technology; New York City (NYC) Local Law 97, a policy on emission caps for buildings over 25,000 square feet; Plug In British Columbia, a policy that allows for rebates on the purchasing and installment of electric vehicle chargers; and Total Renewable Yackandandah (TRY), a community of volunteers who aim to make their town of Yackandandah run on 100% renewable energy. We performed stakeholder mapping within each case study location. Stakeholder mapping is a beneficial tool to understand how stakeholders can impact decarbonization efforts in their respective locations (GSA Technology Transformation Services, n.d.). We represented the stakeholder map in terms of a flow chart, beginning with the party in power to make that choice, i.e., government body, to ending with the party affected, i.e., homeowners (See Appendix C). We determined who has actionable power to create the change we outlined in addition to the interests and motivations of these groups.

We utilized BZE's research method to assist in stakeholder mapping, which is based around the categories of "Why", "Where", "How", and "Who" (see Appendix B). The "Why" involved researching the benefits of these technologies/methods being used in each area. The "Where" examined the characteristics that help identify applicable urban places. The "How" analyzed the guiding principles and what each specific urban area needs to implement for decarbonization. Lastly, the "Who" section involved researching power dynamics in each area to determine who can put these ideas into action.

3.3 Identifying Suitable LGAs for Urban Scale Decarbonization

The third objective was to identify suitable LGA locations across Australia—metro, suburban and regional town areas—where decarbonization strategies seen in the chosen case studies could be implemented. Each of the five case studies chosen for our analysis represents a different decarbonization strategy. We chose to use LGAs as the unit of analysis due to their direct impact on community engagement when compared to larger jurisdictional areas. We determined variables and datasets for the multi-criteria analysis (MCA) based off the case studies to determine suitable LGAs by conducting geographical analysis.

A multi-criteria analysis involves conducting a query with multiple variables to determine cases that each meet a set of criteria determined to be important. Separate MCAs were run for each of the decarbonization strategies represented by the five case studies. The variables in each MCA differed from each other, as the strategies are each suited to different places and contexts. Variables were determined from a list of indicators that best represented the findings for each case study. Snapshot Data was the source for all variables involving emissions in tons of carbon dioxide for all LGAs for the 2021/2022 fiscal year.

The first decarbonization strategy, Energiesprong's Stroomversnelling program, targets areas with extreme temperatures and high residential emissions (Energiesprong, n.d.). The variables chosen to represent these indicators were maximum and minimum annual temperatures and residential emissions per capita. The criteria were inclusive of maximum annual temperatures above 25 degrees Celsius, minimum annual temperatures below 15 degrees Celsius, electrical residential emissions per capita above average (1.8), and gas residential emissions per capita above average (0.20).

Our second decarbonization strategy, Allume's SolShare, targets providing accessible solar power for renters (Allume Energy, 2023b). The social justice aspect the strategy focuses on is the renter versus homeowner power dynamic. Residential emissions and renter percentage, from the Australian Bureau of Statistics (ABS), were both indicators and variables for this strategy as it encompassed the core audience of SolShare. Sustainability engagement served as a third indicator and was represented binarily by active sustainability teams in LGAs. Active sustainability team information was provided by Allume, however, is only representative of LGAs in South Australia (SA), New South Wales (NSW), and Victoria (VIC) from their current research. The criteria included the following: electric residential emissions above average (90,306 tCO_2), gas residential emissions above average (17,717 tCO_2), presence of an active sustainability team, renter percentage above national average (30.6%), and LGA populations below 100,000 people.

The decarbonization strategy shown by New York City (NYC) Local Law 97 focuses on large building emissions limits (Urban Green, n.d.). The indicators chosen were high residential emissions, high commercial emissions, and population density to align with New York City's characteristics, directly related to its selected variables from Snapshot. The criteria for Local Law 97 encompassed: electric residential emissions above average (90,306 t CO_2), gas residential emissions above average (17,717 t CO_2), electric commercial emissions above average (79,990 t CO_2), gas commercial emissions above average (4,331 t CO_2) and population density above the third natural quartile (4,704).

The fourth decarbonization strategy was Plug in BC in British Columbia. This program places emphasis on rebates for electric vehicle chargers (Plug in BC, 2024). Given that Indigenous communities and businesses can get up to 100% off from their rebates, the indicators chosen were high proportion of Indigenous populations (ABS data), low access to public transport, and high car emissions. Quantitative variables used for the criteria were transport emissions (automotive, bus, rail, tram) and Indigenous renter percentage to align with the targeted multi-level housing. The criteria were determined as such: transport automotive emissions above average (102,573 t CO_2), transport bus emissions below average (2,930 t CO_2), transport rail emissions below average (1,084 t CO_2), transport tram emissions below average (152 t CO_2) and Indigenous renter percentage above 60%.

TRY's program as the fifth and final decarbonization strategy involves the size of Yackandandah as a key factor to its success as a completely renewable energy-run community (TRY, 2022). The indicators chosen from the data available were LGA population, area size and electric grid transmission lines via Digital Atlas of Australia. The variables aligned directly with the indicators as they consisted of LGA population, area in square kilometers and distance from electric transmission lines given Yackandandah's isolation. The criteria for this strategy were determined as: LGA populations less than 2,008 people, areas less than 1,000 square kilometers, and LGAs not within 23 kilometers from an electric transmission line. The specificity in the LGA population and area size criteria was derived from Yackandandah's statistics as of 2021 (TRY, 2022).

4.0 FINDINGS

This chapter compiles the results from our team's research and begins with an outline of the knowledge from different experts we met with. The next section shows the results of the case study research and the main LGA indicators we determined. The final section shows the multi-criteria analysis through use of ArcGIS, which was used to identify LGAs where our outlined case studies could be applicable in urban areas across Australia.

4.1 Expert Views on the Dimensions of Decarbonization

Throughout our time working with BZE, we met with internal and external experts who provided integral information on background and scoping for our case study and multi-decision analysis. We met with employees of BZE who taught us about Snapshot, a data website to assist in carbon dioxide emission analysis, gave us further background on BZE’s prior reports, and how our findings could eventually be framed to match BZE’s message. We learned from Anna Boin, a Senior Project Manager at BZE, about the main issue of designing urban solutions in Australia, the large number of renters. We found solutions that can help renters who have little jurisdiction over retrofitting their homes as possible rapid and equitable decarbonization strategies. In addition, we met with seven different external experts of different backgrounds that were beneficial in giving us perspective in our research. The guidance from these experts was essential in determining case studies and the criteria for our multi-criteria analysis (MCA).

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Within the lens of energy networks, we met with Peter Hansford who works closely with the microgrid project team, located on Deakin University’s campus. We discussed logistical information on how the microgrid works and the integral components allowing or a microgrid to operate functionally. We gathered information on the placement of microgrids and the infrastructure needed to support them, further helping us explore microgrids and other shared energy solutions as a decarbonization strategy.

Alan Pears has decades of experience working in the renewable energy sector. We learned about the complexities of passing policies in Australia on the LGA, state, and national scale. He emphasized the importance of community-based sustainability which further attested to the need for community agency in renewable energy initiatives.

From Climateworks, we met with Gill Armstrong where she explained the process of retrofitting buildings and the concept of a ‘thermal shell’. A thermal shell refers to building renovations that increase insulation. Buildings in Australia are notoriously ‘leaky' which leads to AC and heating units producing more emissions, especially during high and low temperatures. This discussion helped us to establish extreme temperatures as one of our indicators in finding LGAs that would benefit from retrofitting, as those areas will be impacted the most by ‘leakage’.

From Allume, we met with Elizabeth Eacott and William Anstee. Prior to this meeting, we established Allume's SolShare program as one of our case studies. We used this meeting to gain further background and perspectives beyond Allume’s public resources. We obtained a further understanding of the stakeholders involved in Allume's audience, and how they decide which areas to target for the implementation of their technology.

Matthew Charles-Jones provided insight on Totally Renewable Yackandandah ’s (TRY) planned microgrid. We used this meeting as an opportunity to further understand Yackandandah’s 100% renewable energy initiative. Additionally, we discussed stakeholders in the Yackandandah community and the evolution of the project, which aided in framing our analysis of TRY.

4.2 Case Studies with Promising Urban-Scale Decarbonization Strategies

In-depth research was done on five different case studies with decarbonization strategies that span the residential, commercial, and transportation sectors. We researched each case using BZE’s recommended approach, based on the categories; “Why”, “Where ”, “How “, and “Who”. For each case study, a comprehensive summary and a stakeholder map was created. These reports can be found in Appendix C.

4.2.1 Stroomversnelling, Energiesprong, Netherlands - Neighborhood Retrofits

Energiesprong, a global company working to quickly and efficiently retrofit homes to net zero, is primarily focused on their Stroomversnelling project located in the Netherlands. The goal of Stroomversnelling is to increase the amount of Net Zero Energy (NZE) buildings in the Netherlands. The Stroomversnelling project aims to reduce the price of NZE renovations, increase acceptance of NZE renovations with occupants, and increase the momentum and growth of the NZE housing market. Many of the first renovations have been implemented in buildings owned by housing associations, due to their propensity to use a standard design that makes it easier to mass-produce the parts needed for a retrofit. Energiesprong helped set up a system that lets tenants pay an “energy service” bill that covers a fraction of the renovation costs to address costs associated with NZE retrofits. The energy savings from retrofits can also help cover the cost of the installation. The process of the retrofits starts with groups of housing organizations who collaborate to create a first market while simultaneous adjustments are made. These adjustments are important to make scale possible, from one household to a neighborhood simultaneously. At this stage, receiving a set number of properties via the program sets up an initial market for product development amongst solution providers (Energiesprong, n.d.). A 'first market' is described as the time when securities, or initial investments, are created. This initial investment represents the confidence for retrofits to be added efficiently.

The Energiesprong Independent Market Developing Team coordinates all the activities to ensure each of the required market conditions will be fulfilled once the financial institutions evaluate the retrofit approach to provide affordable financing to homeowners. Suppliers are motivated to develop unique solutions within their supply chains by the available investment and specified energy parameters, ultimately lowering the solution costs. (Energiesprong, 2018) This allows companies to invest and develop NZE makeovers that drive performance up and bring costs down (Energiesprong, 2018). Each project starts with a pilot program in the area to determine if the project is feasible before advancing to larger retrofit projects. Technologies used in these retrofits include prefabricated facades, insulated rooftops with solar panels, smart heating, and ventilation and cooling installations (Figure 4). In addition, Energiesprong is building a portfolio of apartment-type buildings to determine which technologies can be used to electrify since rooftop solar is not as influential. In addition to the Netherlands, Energiesprong has projects in the UK, France, Germany, Italy, New York, and California.

4.2.2 SolShare, Allume Energy, Australia - Shared Apartment Solar Panels

Allume Energy is a company that provides solar energy to multi-dwelling

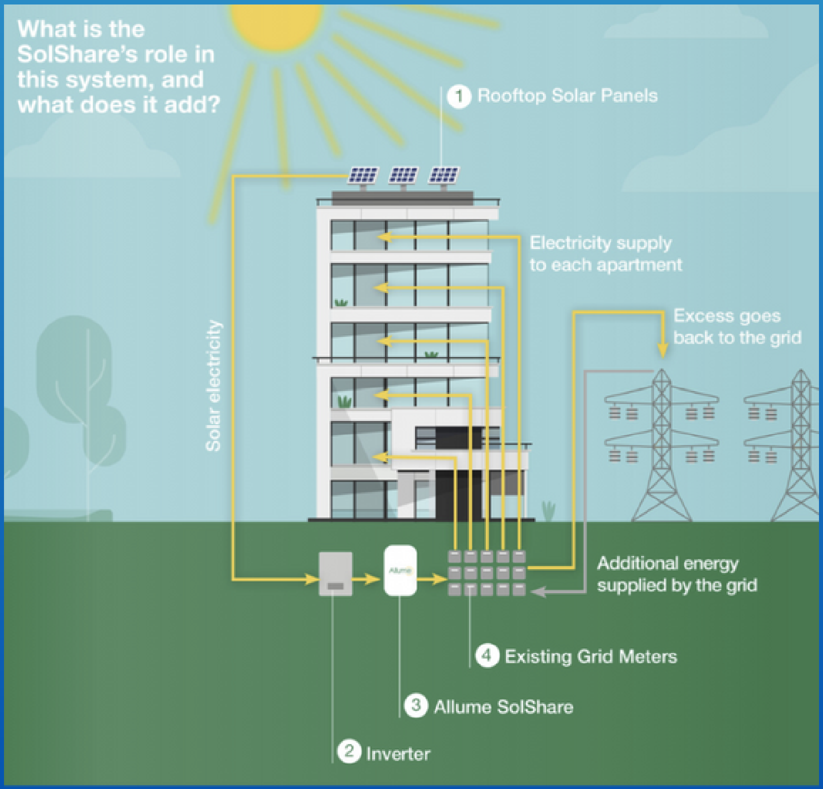
Figure 4

Depiction of Retrofit Technology (Energiesprong, n.d.).

buildings and social housing to allow tenants to have access to renewable energy (Allume Energy, 2023b). This program is known as SolShare. Through their practice, Allume strives for a world where everyone has access to clean and affordable solar technology. One of the main issues of implementing solar in urban areas is renters in Australia have minimal power to make permanent retrofits to their apartments and must consult their landlords before making most changes. Additionally, renters in Australia often have short-term leases. This may discourage renters from purchasing solar retrofits because they might not lease long enough to see the cost benefits. Although short-term leases can provide flexibility for renters, over time they can become more expensive and less secure compared with long-term leases (Kyprianou, 2024). Allume aims to simplify this process for renters who are seeking renewable energy solutions and retrofits by identifying key stakeholders necessary for the implementation of SolShare. For SolShare to be implemented in apartments, tenants should express their interest in the technology to their strata committee—a group that represents and makes decisions on behalf of the Owners Corporation (OC). The OC is composed of owners that live in the building (owner-occupiers) and/or owners that rent out their properties to tenants (landlords). Once it has been brought to the attention of the strata committee, they can schedule a special general meeting to vote on the implementation of SolShare. Depending on which Australian state the vote occurs in affects the quorum needed for SolShare implementation to be passed. For instance, in New South Wales and Victoria, only a 50% quorum is required to pass solar for

Figure 5

Depiction of how SolShare works to generate and distribute solar energy (Suntrix, n.d.).



the entire building whereas in Queensland a 67% quorum is needed (Allume Energy, 2023a).
Allume is based in Melbourne, Victoria, but has spread throughout Australia and to other parts of the globe. Although there is a focus on renters, this technology is applicable to any multi-dwelling buildings, such as office buildings and retail centers. SolShare works by directing power from a rooftop solar system on a shared roof to participating tenants behind the meter. As seen in Figure 5, rooftop solar panels turn sunlight into DC energy, then the inverter converts the energy from DC to AC, which is the energy needed to power home appliances. Next, SolShare distributes the AC energy to participating units via existing grid meters depending on the energy load each apartment requires to maximize efficiency (Suntrix, n.d.). If an apartment energy load exceeds what is distributed from SolShare, additional energy will be supplied by the grid. Conversely, any excess energy not utilized by the apartment will be returned to the grid and the electricity retailer will provide proper compensation.

SolShare can be tailored to work on a wide variety of rooftops, but there are specific situations where installation is more expensive or not feasible. One factor that affects the cost of implementation is roof material. For example, flat concrete roofs and tiled roofs are more expensive, whereas metal roofs are the least expensive for the installation of solar panels. Installation on flat concrete roofs requires additional materials to tilt solar panels for maximum efficiency (Sykes, 2023). Additionally, solar installation on tiled roofs can cause tiles to crack or become loose over time, which increases the chance of leaks (P, 2023). Solar installation on metal roofs is less expensive and more efficient because solar panels can be directly drilled into metal roofs without damaging the roof. The lifespan of a metal roof is longer than that of a solar panel, implying that the roof will require less maintenance over time. Another factor that affects the installation of SolShare is meter boxes. For SolShare to be compatible with a meter box, it must be a smart meter, as opposed to an analog meter. Smart meters, unlike analog meters, can support two-way electricity flows which allows apartments to both purchase and sell energy back to the grid which is a key feature of the SolShare technology. Another factor that affects the compatibility of SolShare is outdated switchboards and wiring. Switchboards aid in safely distributing energy throughout a building. Installing solar without an updated switchboard can lead to issues when there are fluctuations in solar power generation. This can create imbalances in the electrical system and impact the efficiency of solar power generated (TP Electrical, 2023). Local grid stability is another factor that impacts the implementation of SolShare. Grid stability is dependent on the supply and demand of energy. The more the frequency and voltage fluctuate the less stable the grid becomes. As the amount of solar power generated can change daily depending on weather conditions and sunlight, it can impact voltage fluctuations creating instability in the grid (Poddar, 2023). The final factor that can impact the installation of SolShare is the lack of roof space.

4.2.3 New York City Local Law 97, USA - Large Building Emission Limits

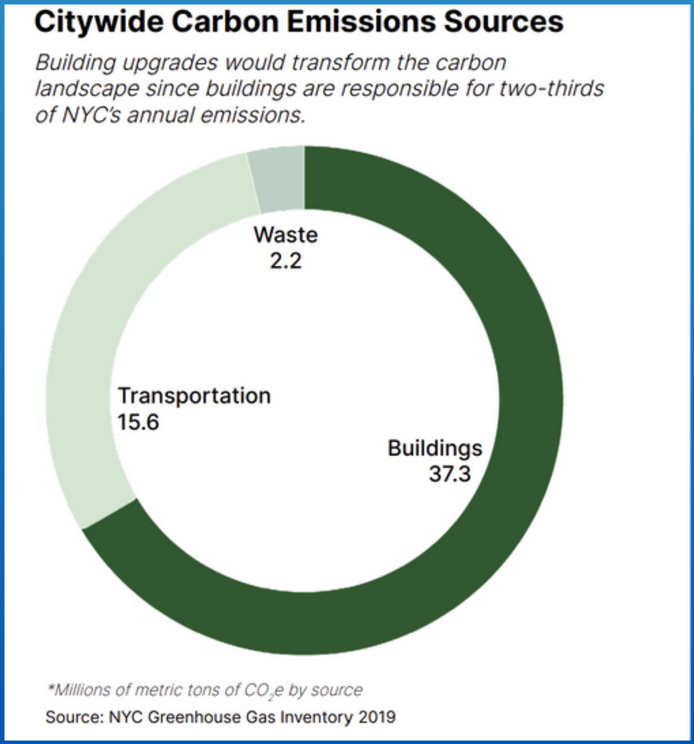
Local Law 97 is legislation affecting New York City (NYC) aiming to reduce carbon emissions produced by buildings over

25,000 square feet in the city through emission caps (Urban Green, n.d.). This law specifically targets buildings since they account for about two-thirds of the carbon emissions in NYC (Figure 6). In total, this law will affect 59% of residential buildings and 41% of commercial buildings exceeding 50,000 separate properties in the city. New York's 80x50 plan acts alongside Local Law 97 as it aims to decrease emissions from every building 80% by 2050. The goal for Local Law 97 is a 40% reduction of carbon emissions by 2030, and a 100% reduction of carbon emissions in applicable buildings by 2050 (Urban Green, n.d.). Starting in 2024, the law on emission caps becomes more stringent, though renewable energy credits or emissions offsets are available for purchase if companies cannot complete the retrofits before the deadline. Additionally, NYC has established penalties to enforce participation in the law.

There are alternative requirements in place for specific types of buildings in NYC. Government buildings are under a stricter timeline as they must reduce 40% of emissions by 2025 and 50% by 2030 (Urban Green, n.d.). There are additional adjustments catered toward hospitals and healthcare facilities that work with a percent reduction framework. Flexibility is key to this program's impact on environmental justice. For example, by 2024 "buildings with more than 35% rent-regulated units, houses of worship and some subsidized housing must either implement prescriptive energy-saving measures or meet their 2030 cap" (Urban Green, n.d.). These energy-saving measures are more affordable than the maximum emission cap costs, assisting those without funds for alternative solutions.

Figure 6

Chart Containing New York City Carbon Emission Data (Urban Green, n.d.).



4.2.4 Plug in BC, British Columbia, Canada - Rebates on Electric Vehicle Chargers

The Province of British Columbia (BC) and Natural Resources Canada (NRCan) are collaborating in the affordable deployment of electric vehicle chargers and infrastructure. Through their CleanBC Go Electric EV Charger Rebate and Fleets programs, BC will increase availability to those who may not have access to EV charging stations at homes, businesses, and municipalities (Zelen et al., 2022). This access will ease the transition and make the switch to EV's more appealing. This program allows for funding of 50-70% of the purchase and installation costs for EV charging stations. These rebates assist in the accessibility of EV parking and charging spaces throughout BC. Additionally, NRCans and BC offer reimbursements for Indigenous communities and businesses for charging equipment. These communities are eligible for up to 100% reimbursement on installation costs, and purchase of Level 2 charging equipment up to 270V under $6,000 per station, up to $50,000 per site (Plug in BC, 2024).

For changes to occur, the government must create rebate plans covering up to 75% of the total cost for local governments, health authorities, school districts, universities, and colleges. For leased buildings, renters must receive approval from their landlords. For these rebates to be approved, the installation must be a permanent, network-integrated Level 2 charger. Driving the permanent transition to EVs will require increasing the accessibility of charging across BC and making charger installation financially feasible for home and business owners (Zelen et al., 2022).

4.2.5 Totally Renewable Yackandandah (TRY), Yackandandah, Australia - Virtual Power Plant

Yackandandah, a small town in Victoria, Australia plans to have 100% renewable energy by 2027. They will be powered by a virtual power plant that will provide renewable energy to Yackandandah. This project aids in reducing carbon emissions and developing greater resilience for the town's electricity supply through weather extremes and natural disasters by providing 100% renewable power to Yackandandah. This project is arranged by Total Renewable Yackandandah (TRY), a volunteer organization composed of members from the Yackandandah community. This project is funded by the Department of Industry, Science, Energy, and Resources. TRY partnered with a local firm, Mach 2 Consulting, to manage the project and undertake the financial feasibility (TRY, 2022). Under its guidance, Yackandandah became powered with 60% renewable energy by generating three smaller operating microgrids, solar and heat pumps, a community virtual power plant, and a 274-kWh community battery (TRY, 2022). TRY recently published its 100% feasibility report as an advance toward its goal. This outlines how they will implement 100% renewable energy via microgrids. TRY settled on a local area footprint determined by the electricity feeder currently supplying all the local properties, as outlined in its feasibility report (TRY, 2022). Establishing electricity facilities within the feeder area means the town could continue to supply its own power. Solar and wind generation are the main contenders for energy generation assessed by Mach2. The results from the technical analyses will feed into a financial analysis identifying the best options, pathways, financials, and operations. In the feasibility study, TRY highlights that 100% clean energy implementation and the completion of the project could occur as soon as 2024 with the proper funding (TRY, 2022).

4.2.6 Case Study Honorable Mentions

Although we decided to focus on the five case studies detailed above, we investigated additional case studies that were useful to our research and provided insight into decarbonization and environmental justice. These "honorable mentions" include the MyTown microgrid, Portugal's mobile transport plan, the UK's building rating scheme, and Australia's NABERS program.

MyTown, located in Heyfield, VIC, was meant to implement a microgrid as it exemplified the importance of involving the community in decisions throughout the decarbonization process (University of Technology Sydney, 2023). After installing energy monitoring devices, it was determined that general electrification and smart energy would better fit the needs of the community. The main draw of this case is the role of community engagement in decision making. When implementing the microgrid plan, "community workshops, programs with the local schools', webinars and on-street engagement" (University of Technology Sydney, 2023) were used to gain an understanding of the communities' wants and needs. Engaging the community through these programs helps to ensure residents are invested in the cause for decarbonization and participate in deciding which solutions should be implemented. This case was discarded as the microgrid failed but provided further insight into community agency.

Portugal established a detailed plan for the decarbonization and electrification of the transport sector. They utilized an integration of EV's, batteries, charging stations, suppliers or energy retailers, operators of the charging network, and a management system model (Ribiero et al., n.d.). The proposed plan expanded and encompassed multiple municipalities in Portugal. However, it was not feasible for a singular LGA as opposed to a wider range. Overall, this case study provoked ideas for later case studies despite not being utilized.

The Energy Performance Certificates (EPC) is a program in the United Kingdom that rates buildings on their efficiency, from most efficient (A) to least efficient (G). This efficiency directly correlates to carbon emissions, as higher efficiency buildings produce lower emissions. Homeowners and landlords must have their buildings achieve an EPC rating of 'E' (Department for Energy Security, 2021). If the rating is an 'F' or 'G', the building owner must immediately upgrade the building and pay a fee (Energy Saving Trust, 2024). This creates a baseline level every building must follow, providing incentives for landlords to increase their ranking and value to provide better appeal towards their properties. This case study was discarded because it only affects the residential sector and decarbonization is not as effective through EPC when compared to retrofitting.

The National Australian Built Environment Rating System (NABERS), in place across Australia, has a similar plan to the EPC. NABERS gives a star rating based on the efficiency of energy, water, waste, and the indoor environment of office buildings, apartments, and hotels (NABERS, n.d.). There are up to 6-stars a building can be classified under, where 6-stars indicates a building with market leading efficiency. The NABERS program also identifies areas for cost savings and future improvements. The benefits of this plan include a strict model indicating where buildings can be compared, an easy and accessible form of communication, and the competitive edge building owners can obtain from having higher ratings (NABERS, n.d.). This plan was not used as a case study as it is already used in Australia and does not affect most residential buildings. However, this could lead to an implementation strategy being applied to homes and apartments in the future we could then perform a query within ArcGIS, a data mapping software, to identify suitable LGAs in Australia for each of our five case studies.

4.3 Multi-Criteria Analysis (MCA) to Identify Suitable Sites in Australia

To perform multi-criteria analysis (MCA), we used characteristics of areas that were present in each case study and turned these characteristics into indicators. From there, we turned these specific indicators from each case study into variables, where

4.3.1 MCA for Stroomversnelling, Energiesprong, Netherlands

Figure 7

Australian LGAs from a multi-criteria analysis from the findings of Energiesprong's Stroomversnelling program via ArcGIS. The LGAs shown are: Cunderdin (WA), Moree Plains (NSW), Western Downs (QLD) and Ipswich (QLD).

In Figure 7, we identified four LGAs that fit our parameters. Three out of the four areas we identified are in Queensland and New South Wales and are close to each other. These locations likely experience similar weather patterns while also producing higher amounts of residential emissions. These locations have characteristics akin to Stroomversnelling, the project by Energiesprong in the Netherlands. Another variable that would be useful for further analysis is temperature range data, which would assist in drawing conclusions towards specific technologies that Stroomversnelling highlights, such as insulation and updated heating and cooling systems.

4.3.2 MCA for SolShare, Allume Energy, Australia

In Figure 8, we identified two specific LGAs that met our parameters of high residential emissions and renters' percentage, and then narrowed our search using a list of active sustainability teams provided to us by Allume Energy. Although this list was not comprehensive of the entirety of Australia it contained data for eastern Australia. These LGAs represent areas that could be targeted by Allume with their SolShare technology. One variable we would suggest for future research is electric grid stability. Electric grid stability would indicate areas where such technology would thrive as SolShare depends on the reliability of the grid for optimal solar energy generation and distribution.

4.3.3 MCA for New York City Local Law 97, USA

In Figures 9-11, we identified five separate LGAs that met our parameters, which were commercial emissions, residential emissions and population

Figure 8

Australian LGAs from a multi-criteria analysis from the findings of Allume's SolShare program via ArcGIS. The LGAs shown are: North Sydney (NSW) and Waverley (NSW).

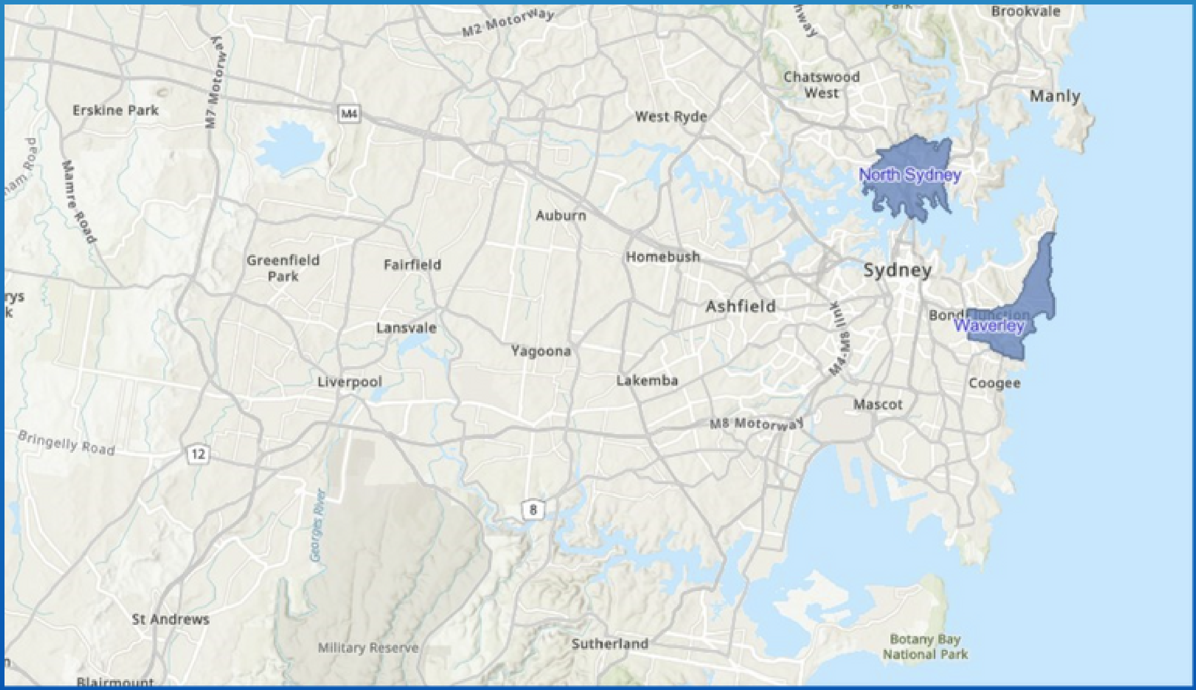


Figure 9

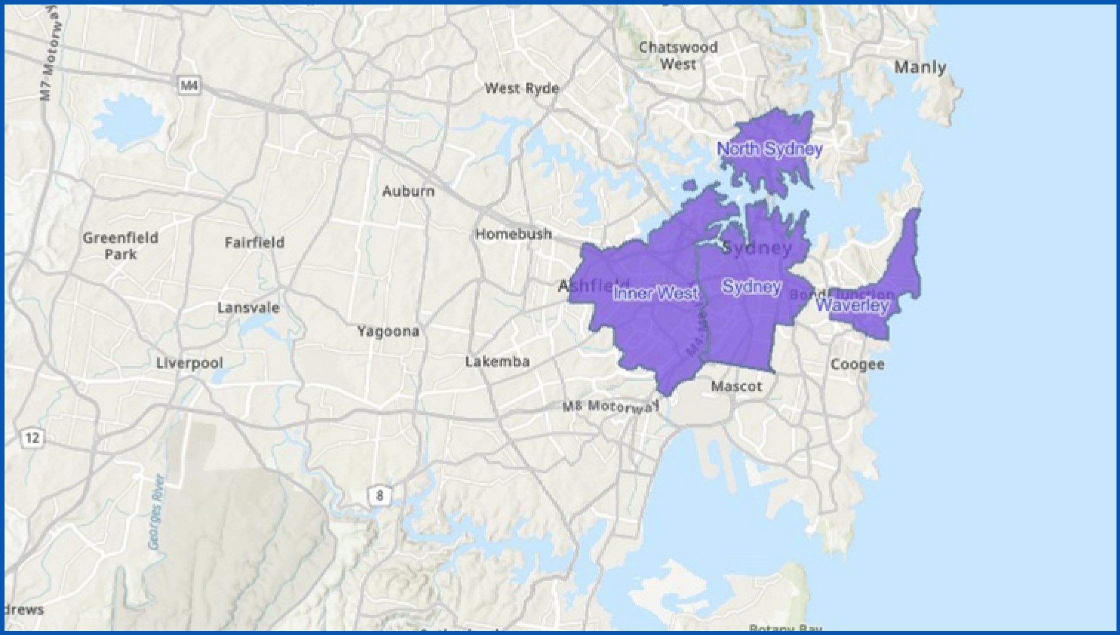
Australian LGAs from a multi-criteria analysis from the findings of New York City Local Law 97 via ArcGIS. The LGAs shown are within New South Wales and Victoria, Australia.

Figure 10

Magnified Australian LGAs from a multi-criteria analysis from the findings of New York City Local Law 97 via ArcGIS. The LGA shown is Port Phillip (NSW).

Figure 11

Magnified Australian LGAs from a multi-criteria analysis from the findings of New York City Local Law 97 via ArcGIS. The LGAs shown are North Sydney, Inner West, Sydney, and Waverley within New South Wales.



density. These locations were indicative of areas with a high concentration of large buildings, where Local Law 97 might be applicable in Australia. However, within this specific query, the data is not what was expected by our team as many central business districts (CBDs) were excluded. CBD proximity to neighboring LGAs and building dimensions would provide greater accuracy as additional datasets to identify suitable LGAs like New York City.

4.3.4 MCA for Plug in BC, British Columbia, Canada

In Figures 12-15, we identified seven LGAs that fit our MCA variables, Indigenous renter percentage, high automotive emissions, and low bus, rail, and tram emissions. These locations are the most likely to need and implement EV charging rebates due to the high number of cars needed along with the increased incentive of rebates for Indigenous communities and businesses. For future research and analysis, access to transportation grid lines would be beneficial in pinpointing areas with low access to public transport.

Figure 12

Australian LGAs from a multi-criteria analysis from the findings of "Plug in BC" program in British Columbia, CA via ArcGIS. The LGAs shown are within Western Australia, Northern Territory, and Queensland.

Figure 13

Magnified Australian LGAs from a multi-criteria analysis from the findings of "Plug in BC" program in British Columbia, CA via ArcGIS. The LGA shown is Belmont (QLD).

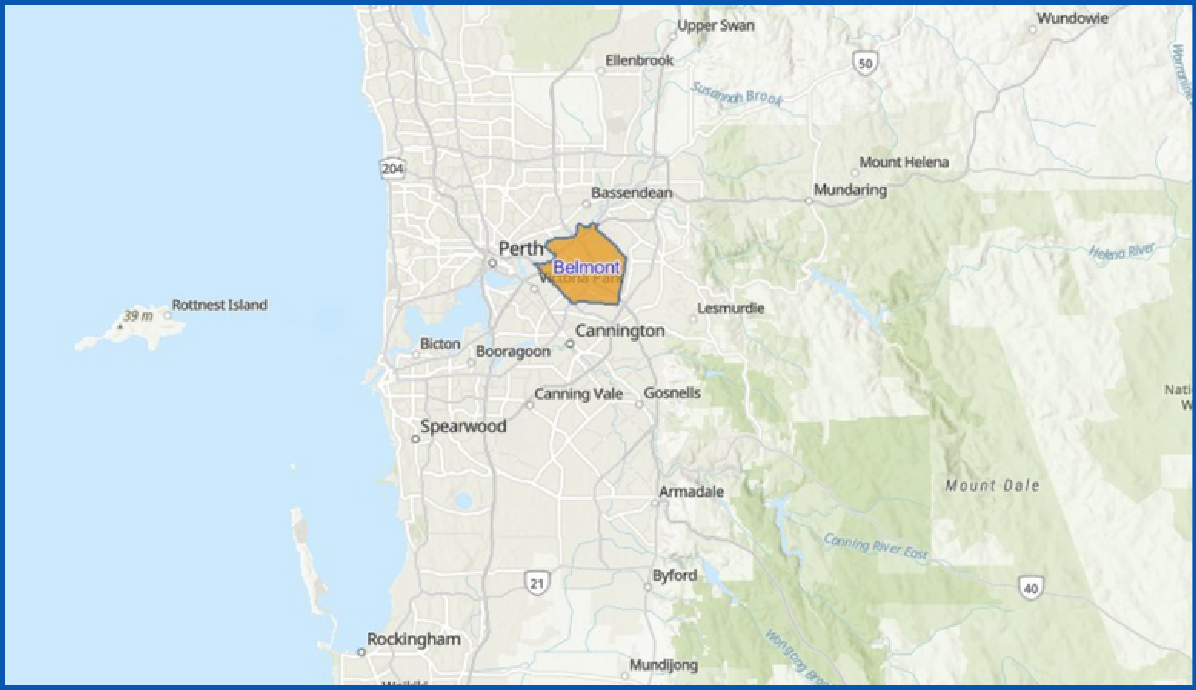


Figure 14

Magnified Australian LGAs from a multi-criteria analysis from the findings of "Plug in BC" program in British Columbia, CA via ArcGIS. The LGA shown is Alice Springs (NT)

Figure 15

Magnified Australian LGAs from a multi-criteria analysis from the findings of "Plug in BC" program in British Columbia, CA via ArcGIS. The LGAs shown are Toowoomba, Gladstone, Rockhampton, Townsville, and Central Highlands within Queensland.

4.3.5 MCA for Totally Renewable Yackandandah (TRY), Yackandandah, Australia

In Figures 16-19, we identified three LGAs that met our parameter variables for MCA. These variables were distance from the electric grid (>23 km), small (< 2,000) LGA population size, and small areas by land size (<1,000 square km). This gave us LGAs that were of similar structure to that of Yackandandah. For further analysis, volunteer hours data would be integral in enhancing our search parameters. Community agency is a critical component in pushing renewable energy initiatives forward. Other resilient communities can be identified through volunteer hour statistics as Yackandandah's community was the core of TRY.

Figure 16

Australian LGAs from a multi-criteria analysis from the findings of TRY in Yackandandah, Victoria via ArcGIS. The LGAs shown are within Queensland and South Australia.

Figure 17

Magnified Australian LGAs from a multi-criteria analysis from the findings of TRY in Yackandandah, Victoria via ArcGIS. The LGAs shown is Coober Pedy within South Australia.

Figure 18

Magnified Australian LGAs from a multi-criteria analysis from the findings of TRY in Yackandandah, Victoria via ArcGIS. The LGA shown is Cherbourg within Queensland.

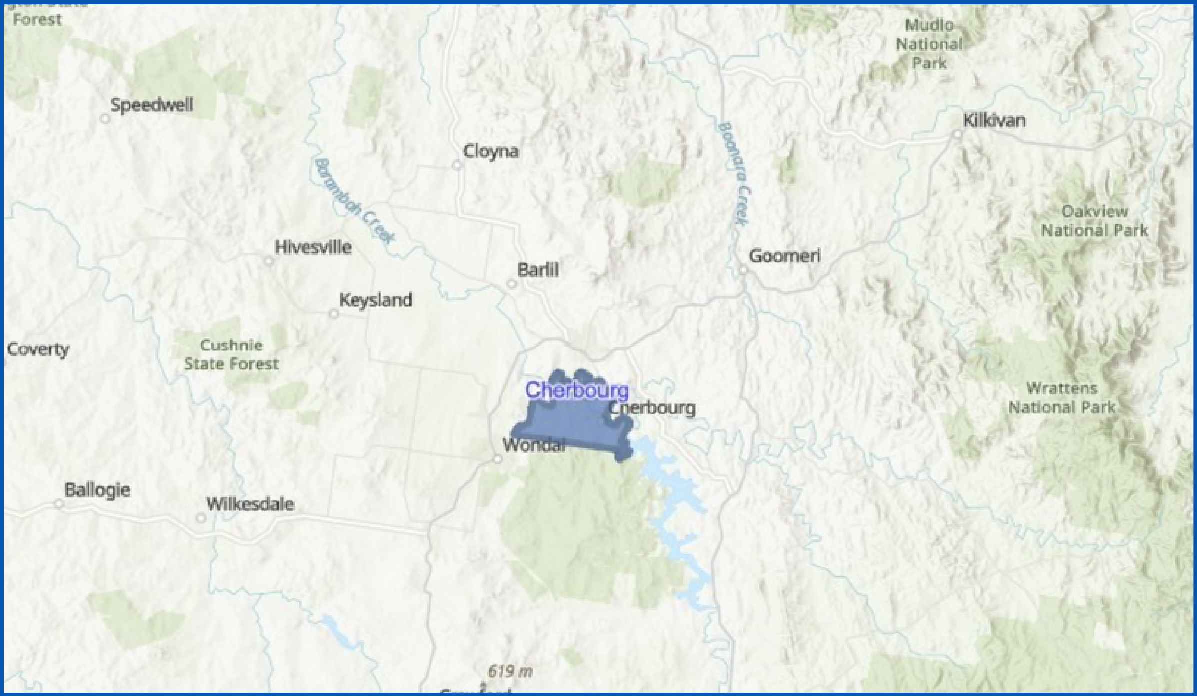


Figure 19

Magnified Australian LGAs from a multi-criteria analysis from the findings of TRY in Yackandandah, Victoria via ArcGIS. The LGAs shown are Mapoon and Wujal-Wujal within Queensland.

4.4 Recommendations for Further Research

As a general recommendation, our team suggests for Beyond Zero Emissions to further explore rapid decarbonization for the building (residential and commercial) and transport sectors. Additionally, we have specific recommendations on how the chosen case studies could be implemented in Australia. The case studies were selected due to their applicability in urban areas.

Two case studies stood out as particularly viable to Australia, as they were policy-based and relatively simple solutions. These two case studies are Local Law 97 in New York City (NYC) and the Plug in BC EV charger rebates in British Columbia. The size limit of 25,000 square feet that NYC uses in their Local Law 97 would likely be too large for smaller cities in Australia. We recommend that the size limit of 25,000 square feet (250 Australia squares, ~2,322 square meters) be reduced to a smaller level of 20,000 square feet (200 Australia squares, ~1858 square meters). This allows for a wider range of buildings to be subject to this policy, while maintaining an emphasis on the goal of targeting larger commercial and residential buildings. Our MCA of the Local Law 97 case study was unable to show expected CBDs as we did not have accurate CBD data and building dimensions. From our research, the best LGAs to target with a similar policy to Local Law 97 are large, condensed cities in Australia such as Melbourne, Sydney, Perth, Adelaide, and Brisbane. We see this policy as one that is most capable of collaborating with other clean technology solutions. Two main programs we see Local Law 97 working best with are the NABERS plan and Allume SolShare system.

We envision the NABERS plan collaborating with Local Law 97 to allow for the ranking of buildings based on their efficiency while quickly enforcing emissions caps. The emissions caps placed by the government can help increase the ratings of those large buildings. Additionally, another suggestion is adding building emissions as a factor in the NABERS rankings to assist in accelerating decarbonization in dense urban areas.

The second plan would be Local Law 97 working in conjunction with Allume Energy. Any apartment over the proposed size limit would be required to remain under the emission cap. This gives Allume an opportunity to present themselves as the premiere solution to landlords and owners. Such combination of solutions can provide incentive for landlords to implement shared solar to avoid incurring penalties. Renters gain more autonomy as this provides a solution for those interested in decarbonization and reducing the cost of their energy bills.

Electric vehicle (EV) rebates are another highly viable solution in Australia. Currently, EVs are sold at a low percentage in Australia partially due to only 3,000 EV chargers present in the country. An essential component to rapidly decarbonize the transport sector is to increase the percentage of EV usage and charger rebates. Charger rebates can assist LGAs located far from cities that need more infrastructure to support EVs. In regional and suburban towns, the need for EVs is greater from the reliance on cars due to low public transport. We recommend mirroring British Columbia's rebates as Indigenous communities and businesses can receive up to 100% on rebates in charger purchases and installments. This would ensure more EV chargers can be installed in areas of Australia in need while addressing underrepresented communities.

Further datasets can be explored to quantify and implement these recommendations involving community engagement, spatial data and grid and transport data. Volunteer hours and voting behavior would best reflect quantitatively the different community dynamics throughout Australia. For Allume's Solshare program and Yackandandah's TRY initiative, future research conducted in such area can provide further accuracy for identifying LGAs with strong community agency. Furthermore, beyond the SolShare program, data that is representative of all active sustainability teams in Australia can indicate community engagement as well. These sustainability teams are the driving force of renewable energy initiatives, especially those with benefits for underrepresented communities. Within spatial data, for those interested in NYC Local Law 97, building dimensions and CBD proximity are specific data that can categorize Australian LGAs in heavy metropolitan areas. Specifically, information detailing LGA building areas and occupancies can identify clear correlations between such buildings and those under Local Law 97. For the climate lens of spatial data, exploring temperature range data will be beneficial when addressing specific technologies, stated by Stroomversnelling, that accommodate homes and buildings in extreme temperatures. For facades, ventilation and heating cooling systems, such data is necessary in retrofitting homes and buildings to their needs. Within the grid and transport data of Australia, future research targeted towards electric grid stability is beneficial in pinpointing prime areas for SolShare technology. As an electric vessel for solar power, this network can provide telling information on where this technology will thrive. Lastly, along the same end of network datasets, transportation gridlines can be a primary variable for cases made for LGAs suited for "Plug in BC" program. Transport emissions can supplement such variable in coming research to highlight opportunities for EVs and EV chargers; an indication of EV demand.

5.0 CONCLUSION

Internationally, there is a need to address carbon emissions as increased temperatures will cause irreversible damage to the environment. The residential, commercial, and transportation sectors provide an area of opportunity for renewable energy to be implemented and assist in decarbonizing Australia. We identified viable solutions that address different scopes in clean energy for urban areas with a focus on rapid solutions while addressing environment justice. Through expert interviews, analysis of relevant case studies, and multi-criteria analysis, we provided BZE with broad guidance to conduct future research on urban area decarbonization. These recommendations will strengthen BZE's case for a nationwide implementation of clean technology and policy for rapid reduction of carbon emissions across Australia.

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APPENDICES

Appendix A: Interview Questions for Industry Experts

General Interview Questions:

1. What is your name and your position?
2. What made you interested in sustainability?
3. What is your perception of the local community's opinion on the transition to all-electric solutions and decarbonization?
4. Are you familiar with Beyond Zero Emissions?
5. Why do you think that some parts of the community are hesitant to move towards a zero-emissions future?
6. Are there any incentives that would improve community engagement in implementing clean technology?
7. Are you familiar with the concept of renewable energy industrial precincts or REIPS?
8. Can we use the information you provided in our final report?

Questions for Peter Hansford:

1. What have you done to gather and maintain interest from funders of these projects? What is the support level for these projects?
2. What are the most effective technologies to use in conjunction with microgrids based on your experience?
3. Are there any other parameters you think we should consider? (Talk to him about parameters pop size gas emissions)
4. What is the life expectancy for microgrids and how much maintenance do they require?

Questions for Allume Energy:

1. Can you tell us a little about your background?
2. In your opinion who are Allume's main stakeholders?
3. How do you promote SolShare to landlords and or tenants?
4. On average, do tenants or landlords approach Allume more frequently?
5. Considering that most renters in Australia are on fixed short-term leases of six or 12 months how do you convince them to invest money in SolShare?
6. In our research we noticed that Allume also caters to social housing, how are these projects funded and does it typically fall on social housing providers or tenants to front the cost?

7. Are there specific criteria you look for in apartment buildings in order for SolShare to be an applicable technology?

Questions for Gill Armstrong:

1. What parameters do you think best qualifies a region/neighborhood for retrofitting?
2. How do climate-ready homes suit renters vs homeowners?
3. What are the major contributors to high energy bills in housing? Is it primarily a lack of energy efficiency in homes/apartments?
4. Do you believe that the government should regulate building energy disclosures?
5. Are there certain technologies, in your opinion, that can be used in both the residential, commercial and transport sectors?
6. What is your perspective on microgrids in residential and commercial areas, respectively?

Questions for TRY:

1. In the feasibility report, it claims that this project is fully completable but needs a lot of funding. How possible is it to get this funding? Is TRY in the process of getting that funding?
2. Is there anyone other than TRY and Mach2 that are assisting with the construction of this microgrid? What are the other stakeholders who had influence in getting this idea in motion?
3. Is the whole town on board/cooperative with this project?
4. When do you see the microgrid being fully complete? We know it says 2024 is a possibility, but what the most realistic date?.
5. In the feasibility report, it says that Yackandandah is 60% renewable energy, how much harder is it to get that next 40%? What are the biggest hurdles?
6. What specifically spurred on the idea of a microgrid in this town?

Appendix B: Consent Statement

Before we begin the interview, we would like to read you a statement of consent.

We are students from WPI (Worcester Polytechnic Institute) and are conducting research on rapid decarbonization. Are you comfortable with potentially being quoted by name in reports done by the Clean Tech in Cities Interactive Qualifying Project (IQP) team? There are no risks associated with our interview process. Regardless, your participation in this interview is entirely voluntary and you can choose to stop the interview at any time. The information received from this interview will be used in our research on rapid decarbonization and may be published by Beyond Zero Emissions or within Worcester Polytechnic Institute. Are you comfortable with these terms and wish to proceed with the interview?

Multiples Template:

"Case Study"
Location

Organization:	Head of Dept. ?

How
xxx

Where
xxx

What
xxx

Who
xxx

Environmental Justice Aspect

Image

Conclusion/LGA Indicators
- xxx

Main Goal	Policy | Technology
	Community | Region | National

RES | COM | TRA | IND

Case Study Multiples:

Energiesprong
The Netherlands

https://energiesprong.org/

Organization:	Energiesprong

How
Energiesprong starts off with a pilot program in an area to determine if the project would work before advancing to larger retrofit projects. Some technologies used in these retrofits include prefabricated facades, insulated rooftops with solar panels, smart heating, and ventilation and cooling installations.

Where
A strong business minded approach is taken when determining where to add these retrofits, targeting where Energiesprong sees opportunity or a housing bottleneck. Originally, buildings part of a housing association were used as many had similar designs, streamlining the retrofit process as mass-producing the parts for the retrofit were made simpler.

Why
The goal of Energiesprong's Netherlands project (called Stroomversnelling) is to increase the amount of Net Zero Energy (NZE) buildings in the Netherlands. Along with this, they had goals to reduce the price of NZE renovations, increase the populations acceptance of NZE renovations, and increase the rapid growth of the NZE housing market. The decarbonization of the environment in the area is also a benefit as the reduction of fossil fuels can be seen.

Who
Collaboration is done between housing organizations, policy regulators, financial institutes, and Energiesprong's market development team to ensure the retrofits are affordable, and realistic. Once the market conditions are fulfilled, companies can invest and develop scalable net zero energy retrofits.

Environmental Justice
Although Energiesprong mainly targets single family homes, they are expanding their portfolio to include renters who are located in apartments

The payment for these upgrades is done through an energy service plan where occupant's pay the equivalent of their previous energy bill for the new energy and price of the upgrades

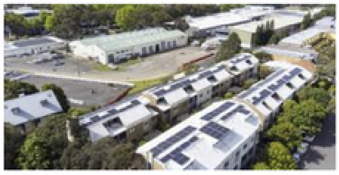
LGA Indicators
- Targeting LGA's which experience harsher climate (in terms of hot and cold) with retrofits will provide the most benefit
- Look at large amounts of residential emissions per capita as another indicator which could be useful in narrowing down

Main Goal	Policy | **Technology**
	Community | Region | National

RES | COM | TRA

Solar Panels For Renters
Australia

Organization: Allume Energy



https://allumeenergy.com/uk/solshare/

How
SolShare works by directing power from a rooftop solar system on a shared roof to participating tenants behind the meter. SolShare allows for the equal distribution and sharing of solar energy for each unit. This is possible by distributing power on an on-demand basis depending on each unit's energy load. Each apartment within the building is equipped with a monitoring device that feeds energy usage information to the SolShare unit. Any excess energy not used by the apartment will be returned to the grid and the electricity retailer will provide proper compensation.

Where
Allume is based in Melbourne, Victoria but has spread throughout Australia and to other parts of the globe. Allume's approach to solar energy is largely want based as a landlord or tenant must go through the process of implementing this technology. Although there is a focus on renters, this technology is applicable for any multi-dwelling building such as office buildings and retail centers.

Why
SolShare aims to bridge the gap for renters that are seeking renewable energy solutions and retrofits. Renters in Australia have little power in making permanent retrofits to their apartments and must consult their landlords before making most changes. This process can be discouraging and lengthy and could deter renters from pursuing sustainable living options.

Who
Allume specifically targets renters looking for renewable energy options and landlords looking to promote sustainable living options. Although we place emphasis on SolShare for apartment buildings, the same concept can be implemented for any multi-metered building with a shared roof. This could include office blocks and retail centers.

Environmental Justice
Helping renters and people in social housing have access to solar power. Can help to reduce energy bills.

LGA Indicators
- Easier to implement in LGAs where Strata committee only needs majority vote to implement SolShare.
- LGAs with local grid stability in order to compensate for the energy load produced by solar.
- Allume is already somewhat established in New South Wales, Victoria, and South Australia.

Main Goal: Policy | **Technology**
Community | Region | National

RES | COM | TRA

Local Law 97
New York City, USA

Organization: NYC Government

NYC LOCAL LAW 97

https://www.nyc.gov/site/sustainablebuildings/ll97/local-law-97.page

How
The main aspect of the law is the increasingly stringent carbon emission limits put on these buildings starting in 2024 and continuing to 2050. There is flexibility to comply with these restrictions, where if retrofits cannot be done in time, renewable energy credits or emission offsets can be purchased. There are penalties in place to incentivize those who may not want to follow the law.

Where
This law affects **all** buildings in **New York City** which are over 25,000 sq ft.

Why
The goal of Local Law 97 is to slowly increase emission restrictions in New York City to the year 2050 where emissions for large buildings (25,000 sq ft and larger) should be at net zero. This law is expected to target more than 50,000 separate properties in the City. Specifically, it is targeted towards buildings as they account for about two-thirds of New York Cities carbon emissions. This law is alongside New York's 80X50 plan, which aims to decrease emissions from every building 80% by 2050.

Who
This project was put forward by NYC's Mayor. The people who would make the change would be the owners of the buildings, either investing in retrofits or purchasing renewable energy from NYC to be used in their buildings.

Environmental Justice
There is a lot of flexibility with the compliance for this law. One example includes the fact that some affordable housing buildings can buy low-cost energy saving methods instead of the normal emission credit.

LGA Indicators
- Areas with a large amount of larger scale buildings is where this solution will best be implemented
- Look for more metro or outer metro based LGA's where large buildings will be much more common
- Look for LGA's that contain CBD's or other large scale epicenters

Main Goal: **Policy** | Technology
Community | **Region** | National

RES | COM | TRA

Plug in BC

British Columbia, Canada

Organization: CleanBC

Plug in BC

https://pluginbc.ca/go-electric-fleets/charging-infrastructure-incentives/

How

This plan allows for businesses and homes (including multi-family rental buildings) to get up to 50-75% funding via rebates to purchase charging station. There are certain regulations you must follow to get the chargers including charger purchase and permanent installation.

Where

Anyone who follows the qualifications listed is eligible to apply for the rebate. This is a possible solution that could be implemented anywhere such as in an area of poor charging infrastructure, or an area where the role of EV's can grow.

Why

Australia has a disproportionately low amount of EV chargers per the amount of EV's that are on the road. Increased amounts of chargers will be a form of promotion for those who are hesitant on getting an Electric Vehicle.

Who

The government puts the rebate plan out as a policy, but power is ultimately with the people. There are certain documents you must show proving you have approval from the landlord and are legally allowed to use the electrical power that the charger would require. If such proof is submitted, the rebate will be given to permit installation.

Environmental Justice

Part of this policy specifically gave special benefits to indigenous groups, which can get 100% of the charging station installation paid for (up to $6,000)

LGA Indicators

- Look for LGAs with high transportation and gas emissions
- Target areas with an indigenous population who could be specifically assisted
- Communities with multiple group-housing complexes could be specifically assisted
- Target areas with less access to public transport that may rely more on cars (Hopefully EV's)

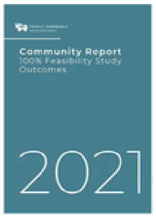
Main Goal: **Policy** | **Technology**; Community | **Region** | National

RES | COM | **TRA**

Yackandandah Microgrid

Yackandandah, Australia

Organization: TRY (Totally Renewable Yackandandah)



https://totallyrenewableyack.org.au/

How

So far, TRY has generated three operating microgrids, multiple solar and heat pump hot water offers, a community virtual power plant, and a 274 kWh community battery. For the remaining 40% of the grid that needs to be completed, solar and wind generation will locally sourced if possible. Such types are the main contenders for energy generation and will be assessed by Mach2.

Where

TRY has settled on a local area footprint that was determined by the electricity feeder that supplies all the loca properties. Establishing electricity facilities within that feeder area means the town can potentially continue to supply its own power. This makes the area ideal for the implementation of microgrids.

Why

The goal of this microgrid was to first and foremost, reduce carbon emissions. It also was helpful in developing greater resilience for the town during extreme weather and natural disasters. It provided a cost effective and resilient 100% renewable power supply for the entirety of Yackandandah, so they didn't have to rely on outside power sources.

Who

TRY is the small community behind Yackandandah, which consists of a band of volunteers. Their funds are provided by the Department of Industry, Science, Energy and Resources. They have partnered with a local firm, Mach2 Consulting, to manage the project and undertake the financial feasibility.

Environmental Justice

By transitioning to 100% renewable energy in the town, Yackandandah will be a net zero community, which are big steps towards reducing carbon emissions across Australia.

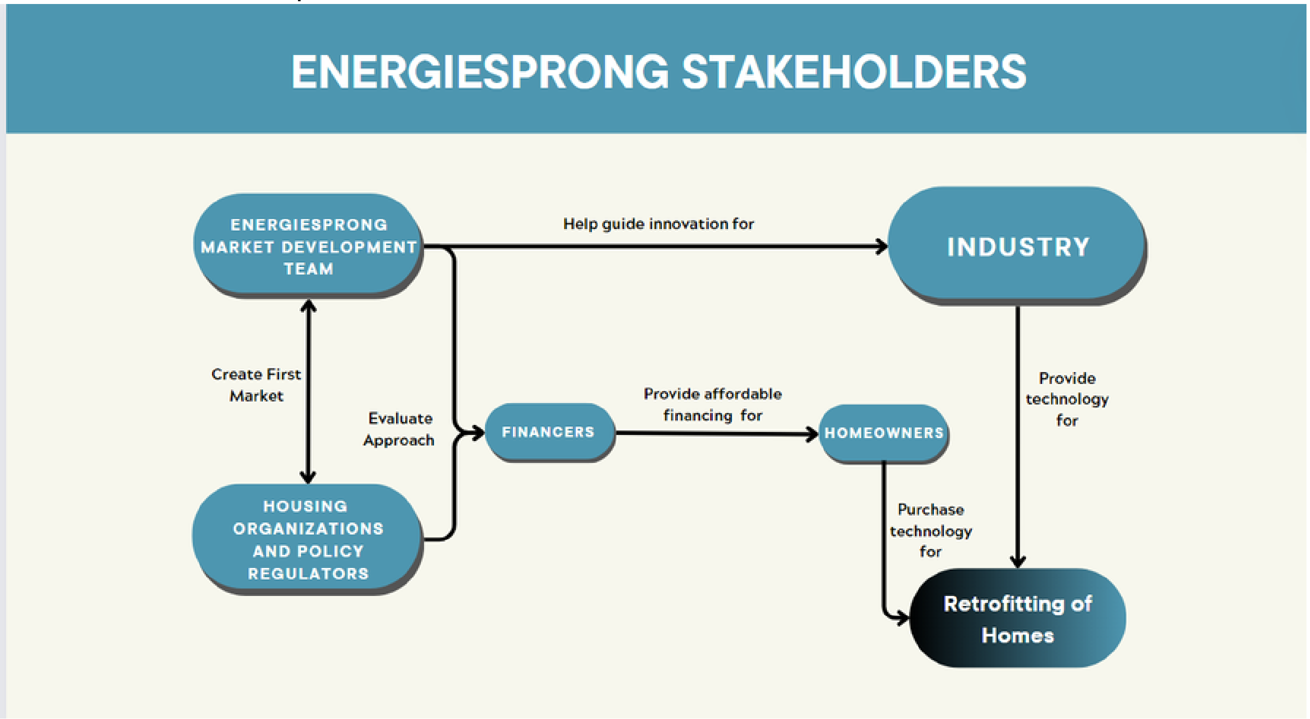
LGA Indicators

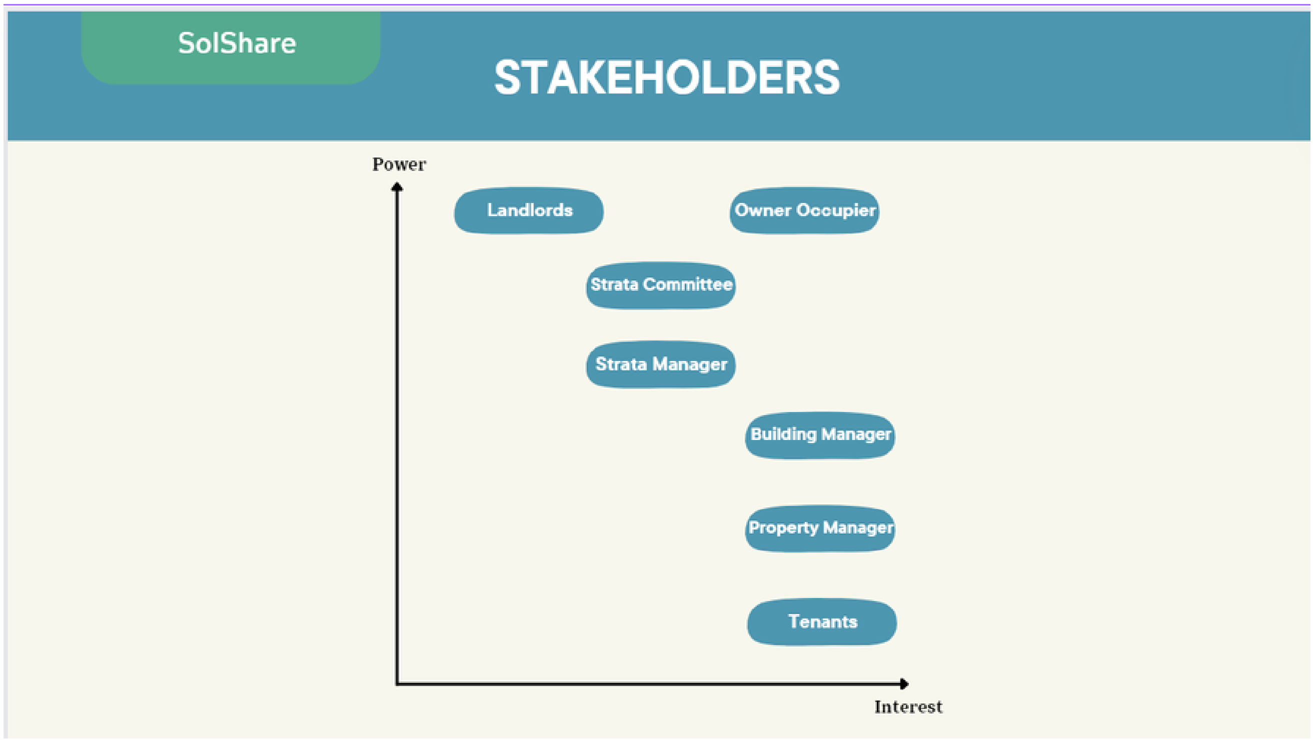
- Much easier to carry out in smaller areas, but has core ideas that could be implemented in residential areas
- Areas with a much higher percentage of volunteers can help band a community together and form change.
- Sense of community and cooperation is need in order for ideas to become a reality.
- Far off of the grid, has more incentive to use microgrid as they may have network or other issues

Main Goal: Policy | **Technology**; **Community** | Region | National

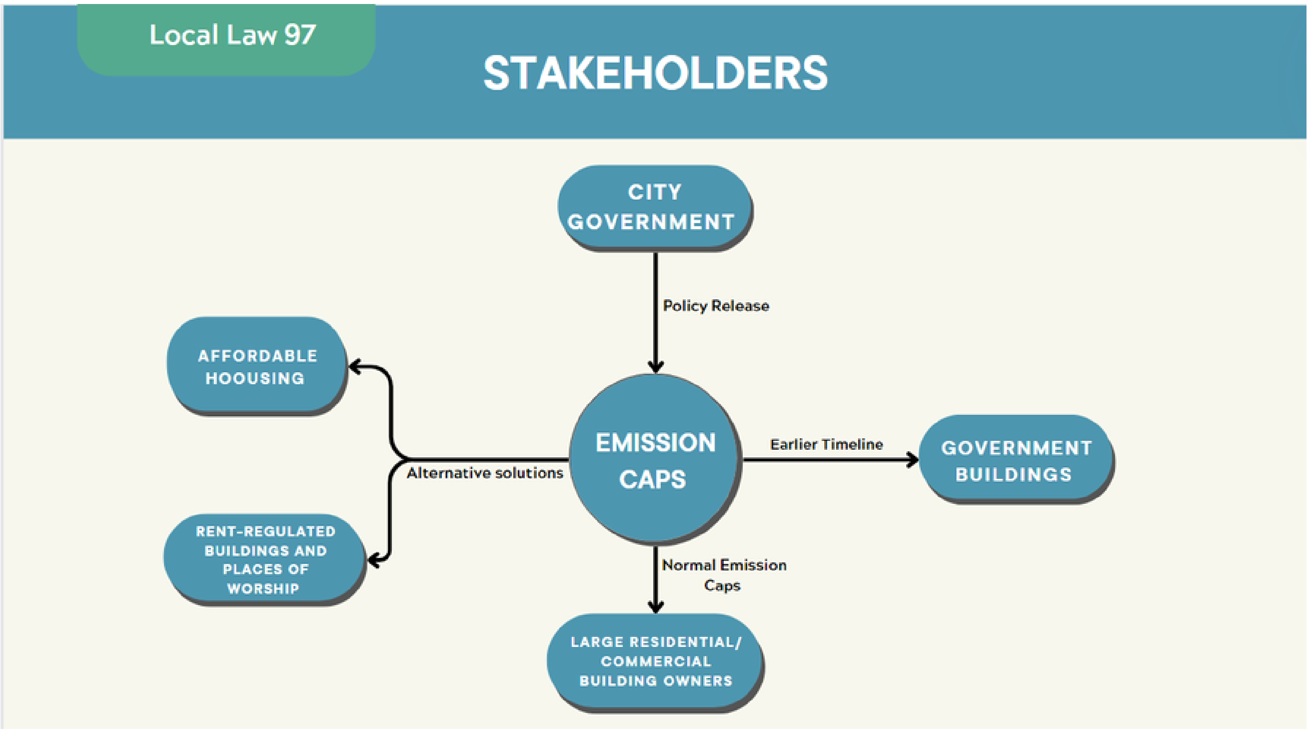
RES | COM | TRA

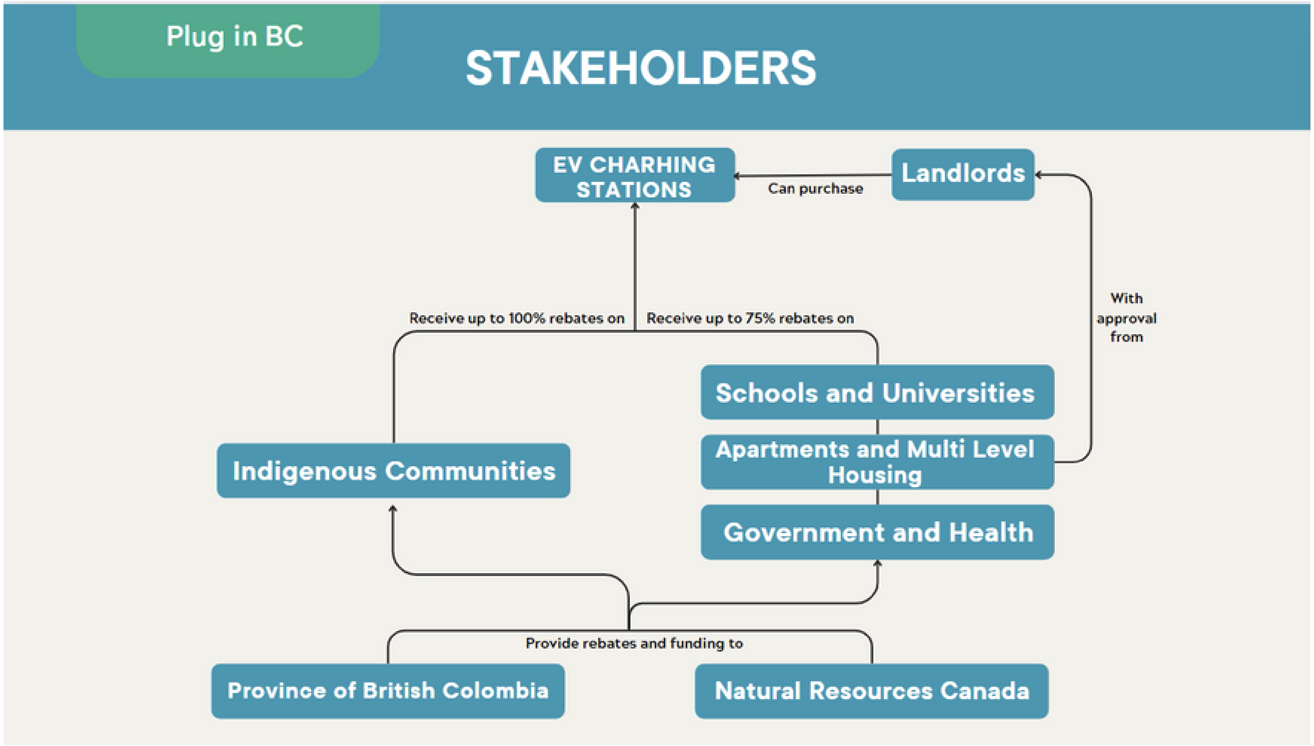
Stakeholder Maps:

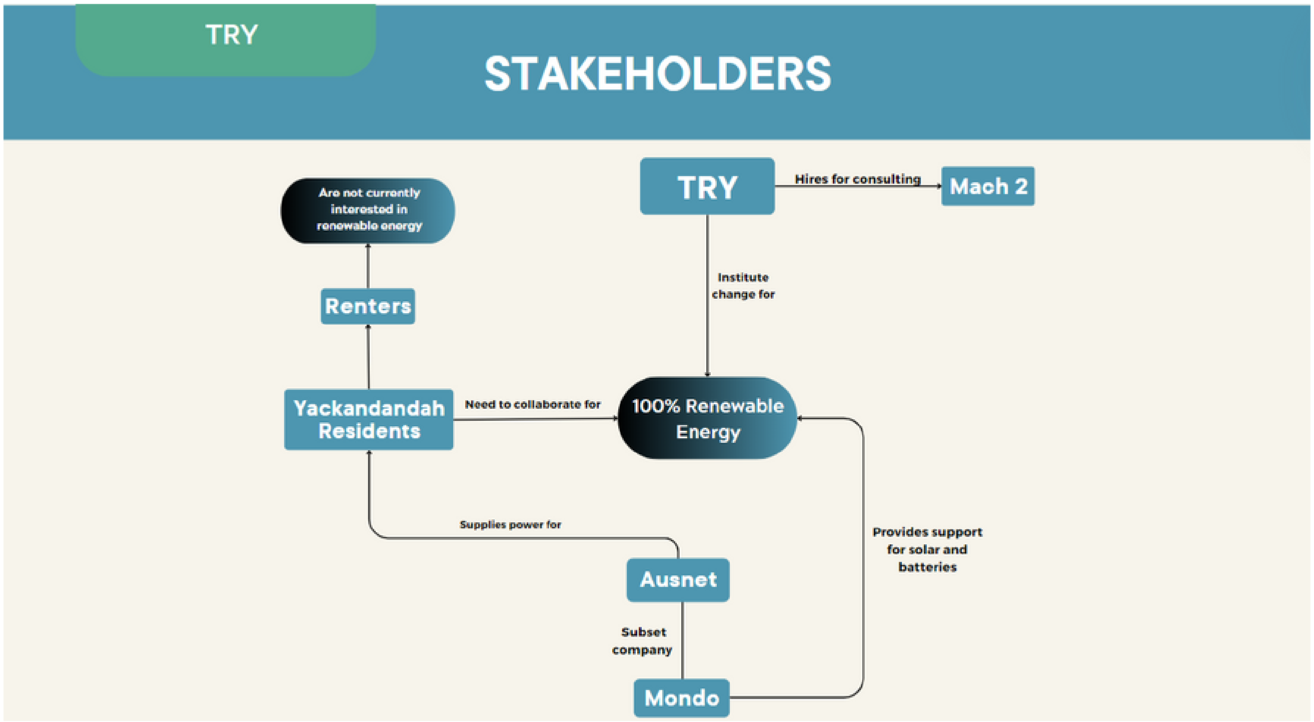




Appendix C: Multiples Reports and Stakeholder Maps






TRY
STAKEHOLDERS
TRY
Hires for consulting
Mach 2
Are not currently interested in renewable energy
Renters
Institute change for
Yackandandah Residents
Need to collaborate for
100% Renewable Energy
Supplies power for
Provides support for solar and batteries
Ausnet
Subset company
Mondo