WAGA
Western Alliance for Greenhouse Action

ALTERNATIVE FUELS FOR COMMUNITY TRANSPORT FLEETS

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RMIT UNIVERSITY

Statement of Limitations

Blanche Verlie Associate Lecturer of RMIT University's Environmental Science Program, 'Client Based Research' students; Harry Goodman, Madelyne Scott and Patrick Milliner developed and prepared a research report for client: Fran MacDonald, Executive Officer of Western Alliance for Greenhouse Action (WAGA) to provide preliminary research into the available alternative fuels and vehicle technology that are appropriate for council level integration, which forms a part of WAGA Low Carbon West Strategy that is facilitating a sustainable transition of cities and local governments across Western Victoria.

This report provides:

- The examination of publicly available information, literature and personal communications regarding; the development of alternative fuels locally, the uptake of new motor technologies and the previous works of WAGA councils, relevant agencies and academic scholars or other relevant information gathered by the RMIT students.
- Comparative analysis and discussion of qualitative and quantitative data; and
- Recommendations that have been formulated from the data that has been collected and the opinions of authors who have been working in this area of study.

This report has been conducted by RMIT students and all materials created may be used and relied upon by Blanche Verlie, RMIT University staff, Fran MacDonald and staff and council officers within the WAGA region, purely for the academic purpose of evaluating students' performance. This report must be considered as a preliminary research report that requires further investigation into local alternative fuel conversion, with the paper not yet incorporating the comments by the project supervisors and academic staff.

Under no circumstances do Harry Goodman, Madelyne Scott and Patrick Milner permit the distribution of this report without express permission, nor guarantee the validity of data, results or conclusions that have or may be drawn from this report.

The authors express that the data, recommendations and conclusion provided in this report are purely academic. As the development of this report serves the purpose of stimulating and assessing the skills required for undergraduate students to enter into postgraduate research programs or the environmental service industry; and the report should be interpreted with these implicit purposes in mind.

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Executive Summary

The transition from internal combustion engines, to innovative technologies and alternative fuel sources, can be a crucial pathway towards improving air quality, reducing Greenhouse Gas (GHG) emissions and mitigating the externalities that arise from the use of fossil-fuelled vehicles to support personal and community transport fleets. Government action to correct a lack of infrastructure and market incentives has been essential in countries that have prioritised the uptake alternative vehicle technology. Despite decades of advancement in the innovation of alternative fuel technology, which has increased the competence in alternative fuel powered vehicles (AFV's) to operate on a large-scale. There has been a lack of governmental support in Australia to enact an increased uptake of AFV's, which has prompted community action and local-level governance to become the key drivers towards alternative fuel conversion and implementation, in order to decrease Australia's growing transport emissions. Critically, as the uptake of AFV's continues to expand globally, this paper identifies the prospect and barriers of adopting alternative fuel technology on a local level, through comparatively discussing the three major alternative fuel sources involving Electrification, Hydrogen fuel cells and Biofuels that have the capacity for successful integration across Melbourne's West and WAGA's council districts.

While the key findings indicate that a wide range of factors can influence the adoption and uptake of AFV's at a local-scale, Electric Vehicles (EV's) remains the most cost-effective and accessible vehicle technology to support the future needs of community fleets across the WAGA region.

Introduction

As the effects of human-induced climate change and the burning of fossil fuels continue to evolve over time, there has been an "increased awareness" to the level of emissions associated with fossil fuel dependent practices (Lorenzoni, 2007, pp. 446), which has prompted a number of countries, nations and local municipalities to design strategies to integrate the use of "sustainable fuel sources" to transform local populations into "zero carbon communities" (Bushnell et al, 2008, pp. 184). Crucially, as the risks of increases in GHG emissions continue to remain uncertain and inexact. Developing responses to achieve a net reduction of greenhouse gas emissions is becoming increasingly widespread, as the formulation of emission reduction targets and "just transition" initiatives to diverge away from a fossil fuel dependence in a range of sectors that include transportation, electricity consumption and agriculture production (Van Der Schoor & Scholtens, 2015). Is beginning to generate a range of social and economic outcomes that go beyond the means of reversing the effects of global temperature rise and local atmospheric changes. But is developing cost-effective solutions that can enhance a community's resilience to adapt to the effects of climate change, and ensure local and regional populations are not neglected in the crisis future global warming presents.

Specifically, with current emission targets in place within Australia to stabilise the growth of (GHG) emissions to 26-28% on the recorded 2005 levels by 2030, which is defined as a relatively weak and unambitious reduction target (Stock, 2018). In examining Australia's total emissions output by sector, in accord to research conducted by the Climate Council, 2018, which illustrates Australia's transportation sector as the "highest growing" emissions sector nationwide and regarded as the second largest source of GHG emissions, from this sectors heavy reliance "internal combustion engines" that burn-off petroleum and diesel fuel sources to meet the needs of a growing transport industry that contributes to the high emission output this sector produces annually (Byrne, 2014, p. 527). Thus, with the support from climate models projecting the growth of transport emissions to continue its trend into 2035. There is a sufficient lack of governmental support from a federal level to initiate emission standards on vehicle fleets, develop strategies towards achieving net zero emissions and to increase the uptake of alternative vehicles and motor technology (Vine, 2012, p. 401). As a consequence, questions are being posed to the long-term functionality Australia's transport sector when considering the global decline of "accessible oil reserves" and the depletion in oil stocks across Australia (Byrne, 2014, p. 532), which can increase the level of vulnerability experienced within this sector.

Accordingly, to meet the future energy demands of Australia's transport sector solutions need to be focused towards "diversifying Australia's fuel mix" (Curran, 2012, pp.239) through introducing a variety of alternative vehicle options to the consumer market, investing in the relevant infrastructure to increase the uptake of alternative vehicle technology and develop strategic targets to commence the transition away from internal combustion engines, in order to adequately reduce the growth of transport emissions and the vulnerabilities that exist within this sector. Thus, as markets globally begin to shift towards increasing the uptake of alternative fuel-powered vehicles (Struben & Stenman, 2008), the WAGA organisation should prioritise how each individual council across Melbourne's southwest can reduce their own transport emissions, and consider what options are available on a council-level to transition away from the conventional use of fossil fuel powered vehicles.

Research Question & Aims

With the WAGA organisation expressing the interest to explore and investigate how councils can generate further emission reductions through introducing sustainable transport solutions and alternative fuels sources, to service the demands of existing community transport systems and vehicle fleets in order to support the development towards efficient zero emission councils. This report will focus on questioning and conducting a review into;

What alternative fuels are most suited to support the needs of community transport fleets in terms of generating significant emission reductions and providing long-term economic benefits?

While maintaining the proposed aims and objectives of;

- To provide clarity to the council region of WAGA around the alternative fuels that have prominence to be integrated on a local level, which includes the fuel sources of Electrification, Hydrogen fuel cell and Biofuels technology.
- To describe the technical aspects and functioning of each alternative fuel source, while providing a insight to barriers, limitations and prospect that exist within each fuel when implemented on a local scale.
- To compare and analyse how each developed alternative can be effectively implemented across the WAGA region within the theme of greenhouse gas mitigation and delivery of future economic benefits.
- To develop a case and recommend what alternative fuel source should be adopted by local governments within the WAGA district to transition towards in order to reduce the emissions generated on a council-level.

Literature Review

Snapshot of Australia's Transport Sector:

Australia's current vehicle fleet of a combined 19.2 million light cars and heavy-duty vehicles, is regarded as one of the most "least efficient" and high polluting transport fleets on an international scale (Fuentes-Hutfilter et al, 2019, p.3). Notably with a lack of governmental guidance to enact policies improving air quality, delivering efficiency savings to drivers and diverting road users away from the ownership of high polluting motor vehicles. In addition to the current trends indicating that over one million new vehicles are purchased by Australian road users every year (Climate Council, 2017). Relevant climate projections are stipulating that in the near future there will be little improvement and reductions in the emissions produced by Australia's current transport fleet (Stanely et al, 2011), which is regarded as the second largest emission source within Australia's economy and has maintained a continual growth in emissions by 57% since 1990, which is illustrated in figure 1.1 and 1.2 below. Thus, with the majority of emissions within this sector accumulating from a variety of factors that include the high proportion of polluting motor vehicles on Australian road networks, the low share of alternative vehicles within the consumer market, the lack of "government incentives and infrastructure" to facilitate increased uptake of alternative fuels technology (Climate Works, 2018, p.22). With no regulated targets and governmental strategies in place to reverse these emerging trends. The implementation of "fuel-economy" standards (Hua et al, 2016, p.1048), as well as experimenting with alternative vehicle technology on a local government level is providing a crucial step towards achieving long-term emission reductions across this sector.

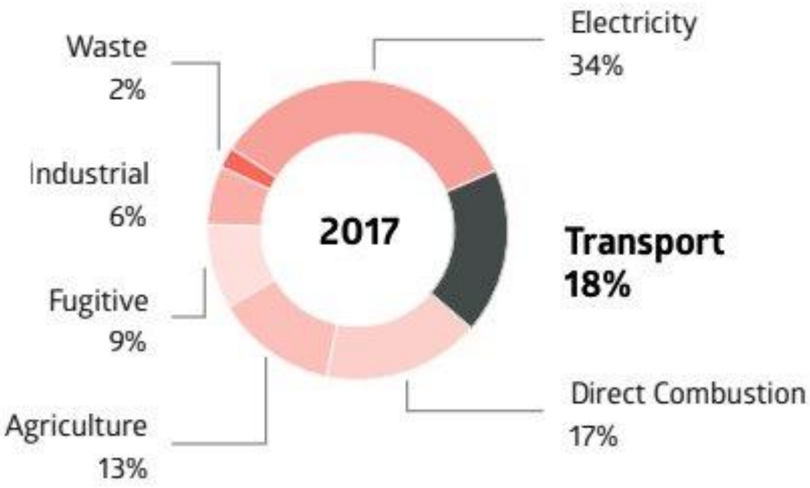

Figure 1.1 Breakdown of total emissions in Australia by sector. Adapted from, (Fuentes-Hutfilter et al, 2019).

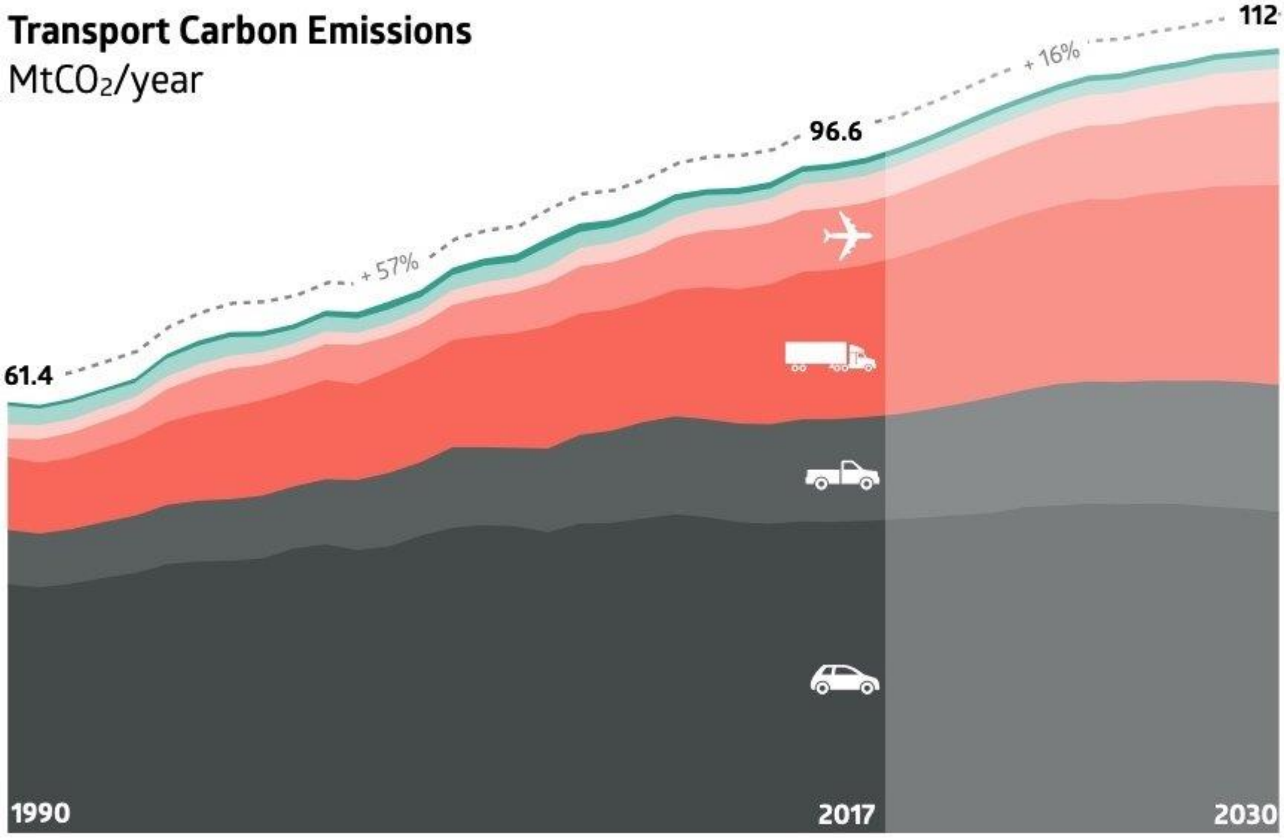

Figure 1.2 Annual transport carbon emissions from 1990 and projected to 2030. Adapted from, (Fuentes-Hutfilter et al, 2019).

Policies, Regulations & Issues of Governance:

Despite the projected emission growth within the transport sector set to continue until 2030, along with this sector roughly producing the same volume of "emissions per year" as "Queensland's entire coal and gas-fired electricity supply" (Climate Council, 2017, p.3). Australia remains within a small minority of countries that has yet to impose mandatory vehicle and fuel emission standards in order to increase the efficiency of the nation's vehicle fleet. Subsequently, with little coordination towards developing zero-emission targets on transport (Hua et al, 2016), coupled with the high proportion of inefficient heavy duty and passenger vehicles currently on Australian roads (Dobson & Sipe, 2010), can highlight the slow and lengthy process federal governments have taken towards the reducing emissions within Australia's growing transport sector. Importantly, with 80% of newly purchased passenger vehicles globally now subjected to some form of fuel economy or emission standard, as examined by (Climate Works, 2018) Australia is substantially falling behind the major global cities and economies in terms of reducing transport emissions and increasing the uptake of alternative vehicles on Australian road networks, with transport emissions per capita remaining 45% higher than the OECD average and Australia recording the "lowest market share of alternative vehicle options" when compared to the USA, Japan, India, and a majority of EU nations (Wolfram & Wiedmann, 2017, p.532).

Notably, with the apparent lack of political action and urgency enforced by governments to coordinate approaches to address the emission growth across a high polluting national vehicle fleet. In particular the failings of a federal Ministerial forum which was established in 2015 to intervene and implement strict standards on light-duty vehicles, that if applied could prevent the equivalent of 65 million tonnes of carbon emissions from being emitted by 2030 (Fuentes-Hutfilter et al, 2019, p.9), can suggest that the goal of achieving sensible emission reductions in Australia's transport sector is limited by an explicit failure of governance to develop targets, enact policies to transition away from traditional combustion engines and to invest in the infrastructure needed to increase the market share of alternative vehicles on Australian roads (Hua et al, 2016). Crucially this failure of governance can assert the need to roll out a variety of sustainable transport solutions across the state and local levels, of whom are becoming recognised as the key drivers and responsible entities towards mitigating Australia's increasing transport emissions.

Importance of Local Government responses and Initiatives:

Local government action is a vital aspect in terms of facilitating wide-scale societal change and contributing to a "community's adaption" to the progressive and "uncertain impacts" of climate change (Wilson, 2006, p.610). With upholding the purpose of inspiring change locally, the actions initiated by councils can reflect the desires and concerns of the local populace, and represent a communities resilience towards managing the local effects of continual increases in greenhouse gas emissions across Australia (Glavovic & Smith, 2014). While historically climate change policy has been largely focused at a national scale (Measham et al, 2011), the attention to local level mitigation has proliferated rapidly in recent years from a number of sources. Primarily, this growing attention towards local level adaption mirrors the belief that climate "adaption is local" (Bellard et al, 2012, p.368) as the impacts of climate change are experienced locally and maintain a sense of "geographic variability" (Measham et al, 2011, p.890), it, therefore, becomes the responsibility of local governance systems and institutions to manage such emerging impacts.

Thus, ascending as a "legitimate entity" in terms of responding to climate change (Measham et al, 2011, p. 891), local institutions maintain three critical roles within the field of climate policy and adaption, which defined by Wilson, 2006 is to structure the responses to the foreseeable climate impacts, mediate between the collective and individual responses to climate vulnerability and govern the delivery of resources to facilitate adaptation locally. Notably, with the perceived lack of progress and periods of instability and inaction at the international and national scales to secure significant reductions in greenhouse gas emissions, local organisations are vastly becoming the "key drivers" in climate policy and innovation to increase the capacity of communities to adapt and initiate the transition away from conventional practices that persevere a high yield of greenhouse gas emissions locally (Richardson, 2012, p.336), such as Australia's dependence nationwide on fossil fuel powered vehicles to meet the needs of community transport within a local municipality.

Importantly, in accord to local governments acting as legitimate entities in responding to the matters of climate policy, the willingness of local community members to support action towards managing wide-scale environmental issues, as observed from the recent federal election and research conducted by the Australian WWF (2018) indicates a high proportion of Australians (68%) now believe a healthy environment and a prosperous economy go hand in hand, with the majority of Australians (88%) accepting if no action is taken towards climate change mitigation the environmental impacts of the future will be unable to be managed and avoided, which can signify the beliefs and attitudes of a growing environmental conscious community, that should be reflected at the local municipality level. Subsequently, with the council's belonging to the WAGA region having already expressed the desire to combat climate change and mitigate (GHG) emissions, the future efforts in developing emission reduction strategies should be focused on the introduction of alternative transport fuels and vehicles that can serve the needs of transport fleets at a council level.

Alternative Fuel Trends in Australia:

With the internal combustion engine dominating the vehicle technology available in the global automotive sector for over a century (Weaving, 2012, p.8), the introduction of alternative fuelled vehicles have grown in prominence in recent years, in places where governments have implemented specific policy measures to increase the uptake, market share and attractiveness of alternative fuel vehicle ownership (Davies et al, 2016, p.2575). Notably, as the drivers for the development of these international policies vary on the geopolitical circumstances of individual countries and states, the key factor toward this transition and shift away from traditional combustion engines is to target future greenhouse gas abatement, energy security and improvements in local air quality and pollution levels (Husain, 2010).

While Australia maintains a low proportion and share of the available alternative vehicle technology observed throughout the global market which includes Electric Vehicles (EV's), Hydrogen fuel cell vehicles and Biofuel-powered drive trains and engines (Wolfram & Wiedmann, 2017). International trends associated with the uptake of alternative fuel technology is indicating more countries globally are "increasing the percentage and distribution of alternative vehicles" on national roads and transport systems (Dell et al, 2014, p.156). Thus, with major cities such China, California and Norway dominating the Electric Vehicle market due to China's "large scale production" and "commercial manufacturing of Electric powered vehicles" (Giannopoulos & Munro, 2019, p.69), along with the policy measures and tax exemptions enforced by Norwegian and Californian governments to incentivise the ownership of EV's. In conjunction to the expansion of Hydrogen fuel cell vehicles which is currently taking place in countries such as Japan and the EU (Behilng et al, 2015), due to the establishment of zero-emission transport targets and the relevant market opportunities that emerge from national and corporate investment in new hydrogen fuel cell technology. With countries such as the UK and Brazil that maintain the highest share of biodiesel production to sustain the needs of a growing transport fleet (Sasongko et al, 2017), can support the current trends that exist in relation to alternative fuel and vehicle conversion on an international scale.

Importantly, to consumer trends within Australia indicating that 61% of motorists will effectively purchase an alternative fuel vehicle if prices were to become affordable in the near future (Roy Morgan Research Institute, 2018). The current uptake of alternative vehicles in Australia is primarily driven by local government action and corporate business investment. With the majority of council regions such as Perth City and Moreland Council and private companies such as Toyota currently experimenting with hydrogen fuel cell technology on local vehicle fleets. In accord to data examined by Climate Works, 2018, indicating that 44% of councils within Australia are currently developing infrastructure to facilitate a higher uptake of EV's locally, with a further 38% of local governments across Australia planning to introduce EV's within council fleets. In addition to organisations such as Tesla working to enhance battery technology for light-duty EV's, can represent the current trends in Australia's alternative fuel and vehicle transition to support the growing demands of an inefficient transport sector and prevent the (GHG) emissions that will be produced by this sector in the future.

Research Methodology and Scope

Predominantly, with a comparative analysis of the potential alternative fuels and vehicle technologies that can be integrated across the WAGA council regions, forming as the main component of this report. The research process that was undertaken utilised a "mixed methodology" (Morse, 2016) that involves the use of a literature review, discussions with experts and industry representatives in the field of alternative fuel conversion and relevant case studies as examples to develop a robust analysis of the alternate motor technology that is available and can be successfully implemented by local government departments. Inherently, with the scope of this research limited to examining the alternative fuels of Electrification, Hydrogen Fuel Cells and Biofuels, an extensive in-depth technical and cost-benefit analysis is not provided in the comparative analysis that this presented in this report. Thus the research undertaken will summarise the prospect of each individual fuel source and identify the key barriers and constraints found within each fuel type, in order to evaluate what fuels and vehicle technologies can be introduced on a local scale and should be the priority of the WAGA councils to allow further emission reductions and support the needs of a community transport fleet.

Alternative Fuel Analysis

Electric Vehicles (EV)

Technical Breakdown and Overview:

The development of the electric car and motor technology have seen rapid improvements over the last decade. Known colloquially as EV’s (Electric Vehicles), this evolving technology is quickly becoming a viable alternative to the internal combustion vehicles that dominate Australia’s current transport fleet and contribute to the high emission growth experienced within this sector. Predominantly, as EV’s acquire a greater upfront cost when including the "initial vehicle cost" and the purchase of "at home charging stations" (Bansal, 2015, p.5), however the benefits of electrification accrue over the long-term in regards to the length of ownership, the life-span of EV's and the act of refuelling and recharging, which can reduce costs by approximately 78% (Energy Australia, 2019) when compared to the conventional petroleum vehicle. Subsequently, as examined by Alghoul et al, 2018, there is a high potential for greater emission reductions when EV’s are charged via renewable energy e.g. solar power, which can significantly reduce the environmental impacts of EV's and contribute further towards developing zero-emission transport sector.

Generally, as the uptake of electric vehicles increases with the availability and access to charging stations (Taylor et al, 2009), the infrastructure commonly required to service a greater number of EV’s includes the use of private and public charging facilities, which can be installed at the workplace e.g. council offices, public parking areas and within residential dwellings. Along with the employment of fast charging stations that have the capacity to accelerate the charging process for EV users, from the higher wattage contained at these “direct current” charging sites, which are feasible for motorways, street-side charging, commercial users and as an alternative for petrol station operators (Gnann et al, 2018, pp.318). Thus, as the current charging infrastructure has become more competitive in terms of cost effectiveness and convenience for Electric vehicle users, the charging technology available for a local-scale implementation can be broken down into three categories as defined in Table 1. Below.

Table 1. Different Levels for EV Charging. Adapted from, (Queensland Government, 2019).

	Average Kilowatt (kW) Produced	Installation Difficulty	Operation and Management	Typical Locations
Level 1 (Occasional Charging)	(1.4 – 1.9 kW), 2 to 10 hours charge time depending on battery size, suitable for charging during working hours and overnight.	Straightforward assuming a power outlet is within reach of carparking space.	Easily Self-managed.	Long dwell time, recommended solution for occasional EV charging.
Level 2 (Basic AC and Destination Charging)	(3.7 – 20 kW), 4 to 5 hours charging time depending on size of EV battery and vehicle.	Straight forward installation by a licenced electrician, with some difficulty in a public environment.	Can be self-operated or managed by a third party where costs could be recovered.	Appropriate for long to short dwell time locations, including workplaces, shopping centres, public parking spaces, home, apartments and tourist destinations
Level 3 (Fast DC Charging)	(22 – 350 kW), accelerated charging that has the potential to recharge an EV within 30 minutes at 20 – 25 km per minute of charging.	Difficult, requires the coordination with electricity networks, and possibly local government and road transport planning agency.	Likely to be operated by third party where installation and operation costs can be recovered.	Inter-regional travel on major transport routes or areas with high demand for fast charging

Even though it is widely acknowledged that the charging technology for electric vehicles is vastly accessible and can be directly implemented across a variety of destinations. The level of charging infrastructure for EV's may depend on the urban planning characteristics of different cities and council regions (Taylor et al, 2019), which can include the availability of public and private parking spaces within a local municipality or the average distances travelled by community transport fleets. That become the specific factors determining what charging technology is needed and where the infrastructure should be located.

Key Barriers and Limitations:

With the global push towards reducing emissions, Australia is slowly starting to build the infrastructure required to support the growing number of EV's that will be on our roads in the next 50 years (Australian Renewable Energy Agency, 2019). The modern and extensive range of vehicles available are becoming viable options for road users on a local and commercial level. There are luxury options available from companies such as Tesla, Jaguar and Mercedes and more affordable options from Toyota, Nissan and Mitsubishi.

Given the global move towards renewable energy since the signing of the Paris Agreement by most major countries, the future for electric vehicles looks to be the brightest and most prominent.

Commonly, with one of the many limitations towards a greater uptake of EV's within the commercial and consumer market, emerging from the relevant issues of purchase price and fuel efficiency In regards to the fears of an Electric vehicle running out charge, as examined by Broadbent et al, (2019) that arises from an inexperience of driving EV's and a lack of available technical knowledge around the operation of an Electric vehicle. Whilst other prominent constraints to the possible recommendation to the EV is the lack of current infrastructure within Victoria. Although there are charging stations available at shopping complexes and tourist hotspots in the wider regions of Victoria, outside of public transport options, there is a lack of infrastructure developed for EV community to support fleets of community buses and personal transport that is recommended, would grow the need not only to purchase vehicles but invest towards the development of charging stations across different community routes, which can be limited to a councils own monetary budgets and financial resources.

Prospect & Scope of EV's in Melbourne's West:

When considering the broad range of technology that is available to service a fleet of electrified vehicles across a local government setting, in conjunction to the global EV market and major manufacturers continuing to improve the battery and charging capacity of Electric Vehicles, while working towards decreasing the purchase price of standard plug-in EV's and Hybrid vehicles. The prospect of a successfully integrating light duty EV's across Melbourne's West to facilitate the needs of a community transport sector, remains quite high given the simplicity of EV engine technology, the flexibility of installing charging stations across public and private locations, and the positive environmental and economic gains arising from standard grid charging or facilitating "zero emissions charging" from a renewable energy source (Poullikkas, 2015, 1284). Thus, even though the efficiency of EV powertrains has its restraints when "powering a heavy duty vehicle fleet" that maintains a greater weight load (Budde-Meiwes, 2013, pp.779). The development of internal strategies and policy goals within the WAGA region can not only lead the way towards accelerating the uptake of light-duty passenger EV's and Hybrid vehicles, but provide a vision for the local councils of WAGA to prioritise and direct monetary value towards. In order to develop reliable and shared EV network between the WAGA council districts, which is not only an interesting prospect for the community transport sector but for all relevant departments, employees and community members.

Effective Implementation: Case Study Norway Electric Vehicle Sector:

Norway is one of the leading countries for electric vehicles with targets to ban all fuel and diesel cars by 2025 across the country. There has been a strong growth for the electric cars that is largely driven by the "amount of favorable policies introduced in recent years, which has driven the appeal of owning a hybrid or electric vehicle" (Hybrid & Electric Cars in Norway, 2018). A market analysis of Norway has shown that EV's are free from tax, adding as large savings for consumers, as well as a deduction in expenses of tollways and ferries across the country. The incentive program in Norway has ongoing revisitation and is constantly adjusted to be parallel with the markets development as well as the high taxes for high emission cars and lower taxes for the lower emissions cars to provide extra incentive for consumers to commit to EV.

As one of the limitations that has been identified within the Australian market as a lack of strategic policy and developed infrastructure to facilitate an increased uptake of EV's. This has also been experienced in Norway where there are gaps in the market "limited degree of choice for customers…" (Market Line, 2015) as well as "few manufacturers making a limited range of products, particularly in the all-electric segment" (Market Line, 2015). Due to the limited charging infrastructure in Norway, the Norwegian government have identified this as a major limitation and has in turn established targets to phase out fuel and diesel vehicles across the country to increase the growth EV's, which has resulted in "manufacturers investing heavily in brand building, infrastructure development, service relationships and mass manufacturing techniques" (Market Line, 2015) to service the needs of a growth EV fleet.

Biofuels

Technical Breakdown and Overview:

One of the major players in the alternative fuels industry, is Biofuels. Biofuels in Australia are split into two types. Bioethanol and Biodiesel. Bioethanol is a replacement for petrol and Biodiesel a replacement for diesel.

Bioethanol is created by using renewable plant matter. The plants that are used are predominately high is sugars, starch or cellulose (Biofuels Association of Australia, 2019). Its high sustainability rating however, comes from the fact that the plant materials used to create the Bioethanol are in fact waste products. Bioethanol is created by glucose being transformed into ethanol via yeast, this is called fermentation. This process is demonstrated in Figure 2.0 below

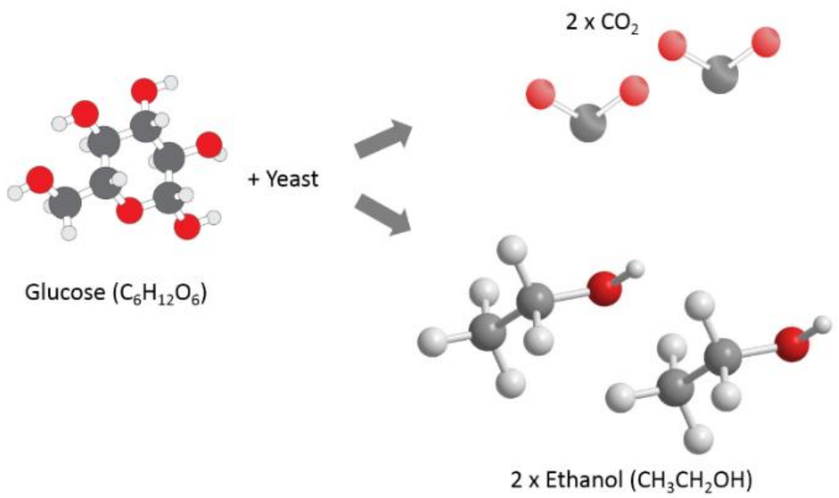

Figure 2.1 Chemical overview of the fermentation process. Adapted from, (Biofuels Association of Australia, 2019)

This means that no further pressure is added on the environment or food industries as these materials would have been simply thrown away. By using a plant matter as the means in which to create ethanol means that the plants absorb the emissions they create whilst they are growing via the photosynthesis process (Olsson, 2007).

Biodiesels are similarly made using waste products from the food and agricultural industries. However, Biodiesels are made from oils and fats. Commonly used oils are vegetable and canola oils and fats such as tallow and used cooking greases are also common (Biofuels Association of Australia, 2019).

Biodiesel is made through a process called transesterification. “This chemical process creates two products — methyl esters (the chemical name for biodiesel) and glycerin a valuable by-product usually sold to be used in soaps and other products” (Biofuels Association of Australia, 2019). This chemical process is shown in Figure 2.2 below;

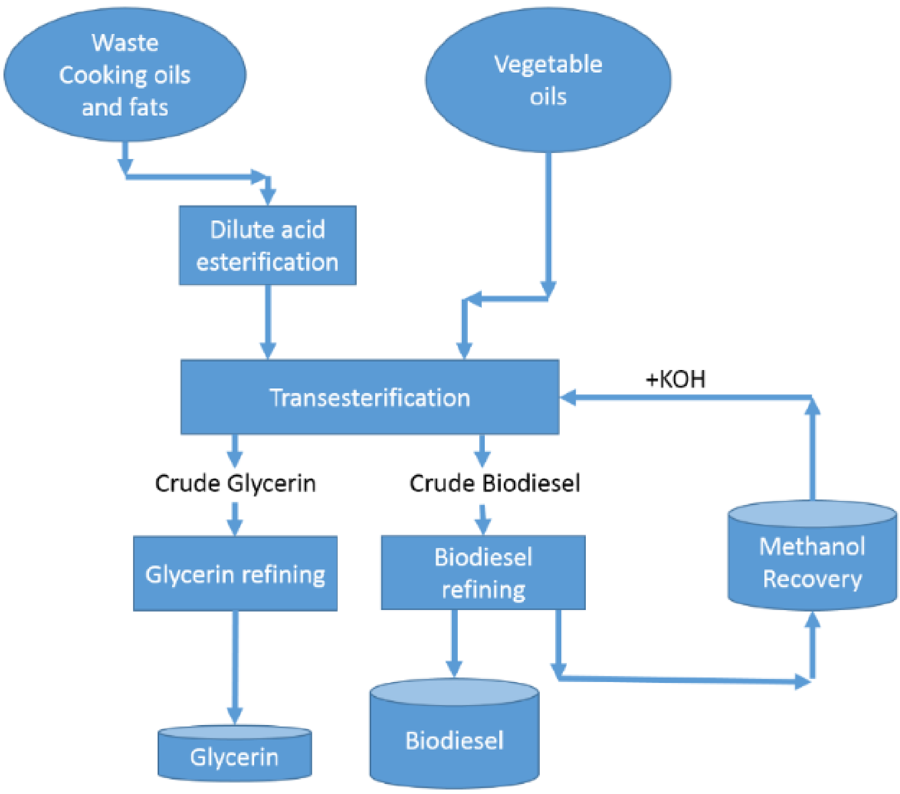

Figure 2.2 A technical breakdown of the transesterification process. Adapted from, (Biofuels Association of Australia[1], 2019).

Similar to Bioethanol, Biodiesel carbon footprint is relatively small. When plant oils are used to create the fuel the C02 has already been absorbed whilst it was growing. This means that, apart from the added components such as fertilizer to complete the transesterification process the fuel is carbon neutral (Sasongko, 2017). A further benefit to both Biodiesels and Bioethanol's is that they are both non-toxic. This means a massive risk reduction when it comes to fuel spills and other accidental releases of fuels. Reducing the massive environmental harm that has come from past oil spills.

Key Barriers and Limitations:

Unfortunately, there are numerous disadvantages that arise from the use of Biodiesel and Ethanol fuel sources. Respectively, if Biofuels became a replacement for conventional fuels on a commercial scale, the greatest asset of Biofuels being a by-product of the food production industry may be completely extinguished. Importantly, if Biofuels start to become a widely available commodity, there is a risk that plant matter will only be "harvested and exploited" for the production of this fuel source (Rutz and Janssen, 2014, pp.11), which would increase the price of food and eliminate Biofuels from being a by-product, a major factor contributing towards the sustainability of this fuel source. Furthermore, as Biofuels maintains approximately 30% less energy per litre than traditional fuels, while still releasing some form of (GHG) emissions during the engine combustion process (O'Connell, 2007). There are significant concerns arising that if Biofuels were to expand and become a prominent fuel source that no substantial emission reductions will be achieved. With meaningful carbon reductions to be projected only in the short to medium term of transitioning to Biofuel vehicles (Azad et al, 2015), due to the low concentration of GHG emissions a Biofuel-powered vehicle still emits. Specifically, within the scenario of transitioning to Biofuel sources, a major barrier towards advancing the uptake of this alternative vehicle, is the “food versus fuel” trade-off where the expansion of Biofuel production and conversion to fuel, would require substantial amounts of land to be cleared (Olsson, 2007, pp.23), which can threaten the habitats for a number of species and the level of biodiversity within regional areas.

Prospect & Scope of Biofuels in Melbourne’s West

As biofuels maintain the status as a clean burning-low emission fuel source that can directly replace the conventional transport fuels of petroleum and diesel. The prospect of a successful local level integration of Biofuels is heavily constrained by a variety of factors. In particular, one of the many limitations towards implementing biofuels locally emerges from the recognition Biofuel resources nationwide and on a local-level are heavily undeveloped (Sasongko et al, 2017). Implicitly, with lack of infrastructure investment to expand the current biofuel industry that is responsible for generating less than 5% of Australia’s total energy production (Azad et al, 2015). The current technology available for producing crops for biofuel energy production accumulates “high upfront costs” (Lichtfouse, 2010, pp.123) and utilises infrastructure that is not easily accessible for local governments. The prospect of developing Biofuels across the WAGA district can be observed as an impractical venture when considering the council regions that are already limited by budgetary constraints, and the life-cycle of biofuels in a transport sector that is rapidly becoming electrified and hydrogen powered. Thus, as biofuel sources maintain the capacity to abate the emissions released from “heavier truck and vehicle fleets” (Sasongko et al, 2017, pp.8), the scope for a successful integration of Biofuels to service the needs of a light-duty community transport fleet, would go beyond the levels of local government and become dependent on the specific partnerships that can be fostered between individual councils and outside businesses in order collaborate and achieve the targets of a greater uptake of Biofuel-powered vehicles across Melbourne’s West.

Effective Implementation: Case Study Sertaozinho Biofuel production Brazil

The town of Sertaozinho in Brazil was once a epicentre for biofuel & sugarcane production. For over 50 years the town was relied on sugarcane production to supply the food industry. From the start of the 1990’s the demand for fuel outgrew the demand for sugar, which caused a “limited food supply” from the shift towards an increase in Biofuel production (Amuia, 2015, p.255). Thus, over the next 2 decades the town and the biofuels industry grew exponentially. Brazilian cars were manufactured to be able to withstand high ethanol and gasoline. These cars were called “Flex Fuels” and so this day still make up 90% of cars on the market (Valdes, 2011). Unfortunately, during recent years with Brazil's economy slowing down and the biofuel production sector was hit hardest (Arruda, 2017). With global oil prices rising, the brazilian government kept inflation down by making oil relatively cheap through the state run oil company Petrobras. This effectively shut down the entire Biofuels industry in a matter of months in Sertaozinho.

If the Biofuel industry was going to expand throughout Australia, then the sugarcane industry in Queensland would be a major player. However, as futurist Paul Higgins said when he addressed sugar industry leaders in Mackay recently, the industry must diversify itself. Sugar companies must create bioproducts as well as sugar and Biofuel. As the example in Brazil demonstrates the Biofuels sector is highly unstable with relative concerns emerging in relation to “long term fuel security and production” (Tomei & Helliwell, 2016, p.7). Significantly, this creates uncertainty in the public, private businesses and governments in making large scale changes towards growing the Biofuels as an alternative means of fuel for vehicles. Specifically, If Biofuels is to become a major player in Australia then the lessons learned from Sertaozinho must be taken on board.

Hydrogen Fuel Cell Technology

Technical Breakdown and Overview:

Hydrogen is the simplest and most abundant element. Only comprising of one proton and one electron. Unfortunately for us hydrogen isn’t a naturally accruing gas on our planet and is found attached to other elements, such as oxygen which makes water. To use hydrogen gas as a fuel it must be split from hydrocarbons such as propane, natural gas, gasoline and methane. This process is done by heating up these substances via a method called reforming, which is the most common way and is shown in Figure 1.3. Another more contemporary, yet less established method, is called electrolysis. This method sends an electrical current through the chosen substances to split the elements apart as described in figure 3.1 below. Once created, Hydrogen fuel is a high energy substance that has the power to send rockets into space. It has almost zero harmful emissions and most of the byproducts of burning hydrogen is clean drinkable water **(**Hristovski et al., 2009).

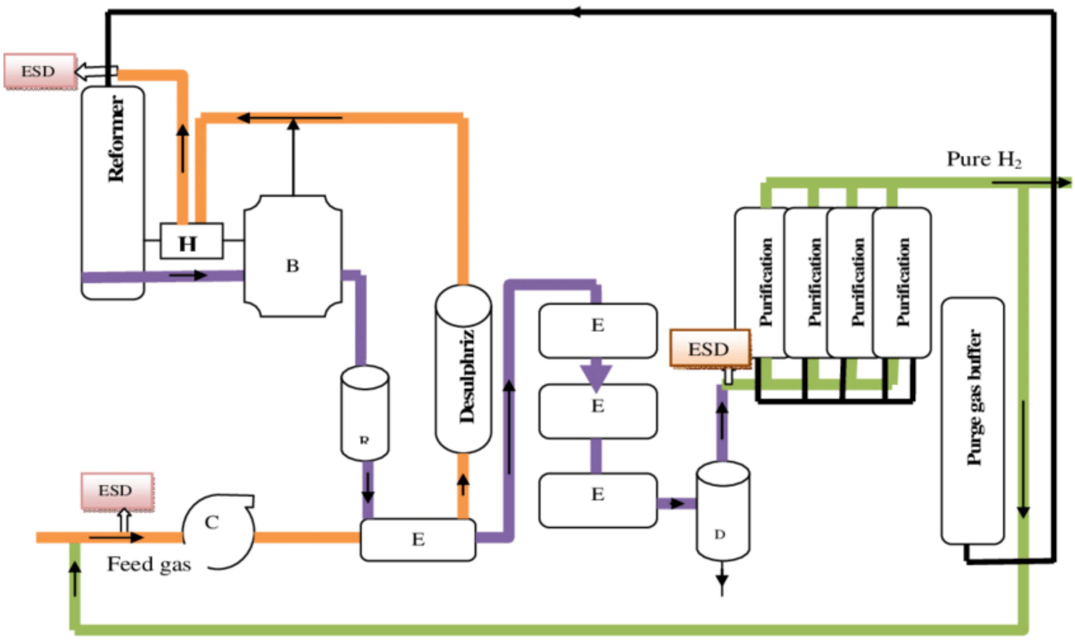

Figure 3.1 A diagram explaining the process of electrolysis. Adapted from, (Renewable energy world, 2019).

Hydrogen as a way of powering vehicles is able to be produced from fossil fuels such as the conventional coal or natural gasses. It is also able to be produced from the unconventional sources such as nuclear power, or renewable resources such as hydropower, which can be used to create hydrogen by electrolysis of water (Denton, Tom. 2018). In most cases, hydrogen-powered vehicles are obtained by steam reformation from the natural gases. One of the limitations of this is that the CO2 is around the same as the conventional powered cars with petrol/gasoline or diesel engines (Denton, Tom. 2018). One of the by-products of hydrogen is water, making it environmentally friendly at its immediate point of use.

Solar energy is not able to be stored in its primary form, however, it can be produced by solar or photovoltaic panels as examined in figure 3.2 below. These panels are used to charge batteries, or to create the alternative fuels such as hydrogen power fuel (Denton, Tom. 2018).

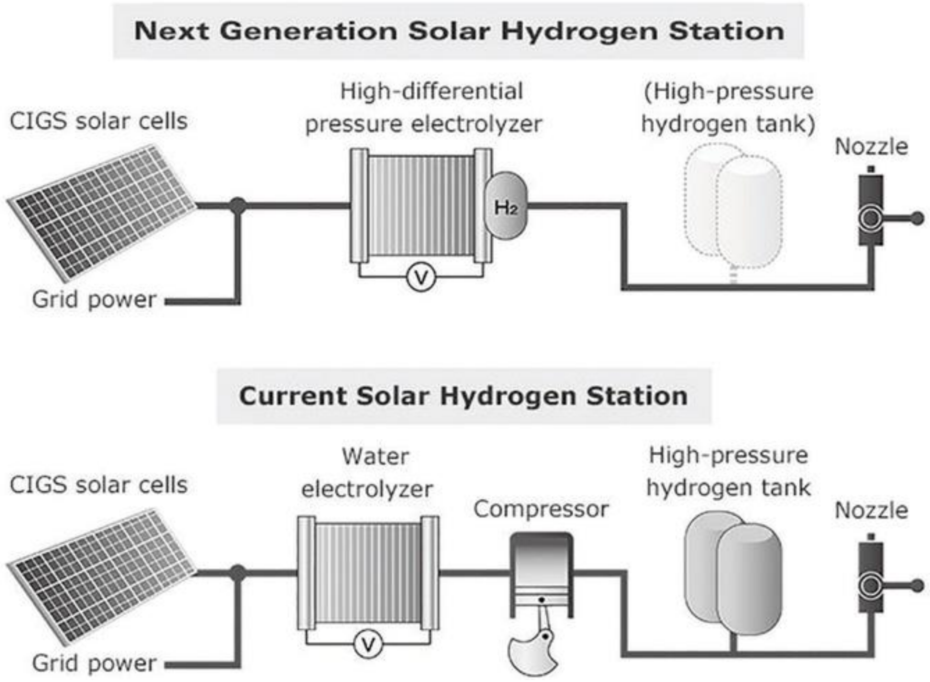

Figure 3.2 The process of creating zero emissions hydrogen fuel with solar energy. Adapted from, (Global.honda, 2018).

The above figure is a demonstration of what a previous solar hydrogen station looks like. It requires both an electrolyser and a separate compressor unit to create high pressure hydrogen (Denton, Tom. 2018). The compressor was the most expensive and largest part of the station and it it often reduced efficiency of the system. The new system however have added a new high differential pressure electrolyser, eliminating the compressor in the process and reducing the size of the other components of the station (Denton, Tom. 2018).

Key Barriers and Limitations:

A key barrier that is experienced by hydrogen powered vehicles is that it is extremely expensive to run. One of the issues that the hydrogen fuel that is stored in the motor contains a high concentration of CO2 that has accumulated over the production process. Notably, the CO^2 poisons are poisons the expensive platinum catalysts, leading to deterioration in efficiency over time and the eventual need for replacement" (Professor Devinder Mahajan, 2004). Due to the high capital cost of operating hydrogen-powered cars and charging infrastructure, there are very limited spaces and locations where charging facilities can be implemented to refuel vehicles when compared to other fuel alternatives such as Electric Vehicles. Along with the high upfront costs with the introduction and operation of Hydrogen vehicles forming as a key limitation. There has been a wide perception that hydrogen as a fuel source an "extremely volatile" and "flammable substance" (p.3025), due to the pressure (PSI) hydrogen fuel is stored within tanks, which has limited the uptake and advancement of hydrogen as a transport fuel especially as it is in the early stages of development and innovation (Sharma & Ghoshal, 2015).

From the expensive costs associated in operating and maintaining a fleet of Hydrogen fuel cell vehicles, there are limited monetary benefits provided to consumers and those investing in a wide-scale uptake, from the high purchase price of the available technology and infrastructure required to service fleet of Hydrogen vehicles. Notably, with the increase of fuel prices over the last few years, the Hydrogen motors still require the combination of petrol and hydrogen to run effectively (Schlapbach, 2009), which creates a demand for the production of fossil fuels to balance the supply and operation of an expanding fleet of Hydrogen vehicles commercially or on a local level. The emissions that are produced by Hydrogen (PCV) cars are relatively clean burning, however, consumers still have to have the petrol to run their car, thus, if willing consumers are looking at the hydrogen car for the monetary benefits by limiting the consumption of traditional fuels, then there are exclusively no benefits.

In a thorough technical analysis, the fuel storage of Hydrogen (PCV) represents another barrier limiting the uptake and application of Hydrogen fuel technology. As an advantage, Hydrogen fuel stores an "estimated three times more energy" than standard petroleum and gasoline sources (Sharma & Ghoshal, 2015, p.1115), which allows a Hydrogen vehicle when fully recharged to travel considerably longer distances EV's and conventional internal combustion engines in comparison. Conversely, the disadvantage of this increased efficiency is that Hydrogen fuel requires approximately 4 times more volume and capacity than petroleum to store (Niaz et al, 2015), which creates a severe challenge and limitation of utilising Hydrogen and fuel source to power a predominantly light to medium vehicle fleets, such as the community transport sector.

Prospect & Scope of Hydrogen Fuels in Melbourne's West:

As the prospect of expanding and incorporating hydrogen cell technology in vehicle fleets may be limited to barriers of affordability, versatility, safety and economic viability as discussed above. There still remains some level of potential to upscale the quantity of hydrogen-powered vehicles locally across Melbourne's West, from the number of Hydrogen (PCV) trials undertaken by council jurisdictions within Australia such as Moreland and Perth City Council to replace the use conventional fossil fuels and mitigate the emissions generated by waste trucks, bus and heavier vehicle fleets, which have recorded some considerable success and positive results (Barns 2014 & Hudson 2017). However, the certainty of this prospect can be hampered by the lack of proven success of utilising Hydrogen fuel cell technology to support the demands of a light-duty vehicle fleet, such as the needs of the community transport sector across the WAGA region. Notably, with the technology surrounding fuel storage and charging infrastructure still observed in the early phases of becoming "economically viable" (Abbasi & Abbasi 2011, p.3039). Promoting relationships with car manufacturers such as Toyota, which has commenced the development of large Hydrogen fuel production and charging site (Arena, 2019). Can be an example of how councils within the WAGA region can lead the way to foster the uptake of Hydrogen (PCV) to support the needs of a community transport sector and further mitigate local level (GHG) emissions.

Effective Implementation: Case study Hydrogen Powered Taxis Paris

During the United Nations Climate Change Conference of 2015, in partnership with car manufacturing company Toyota and Air Liquide a multinational French-based gas supplier. The Taxi Association of Paris introduced the first fleet of hydrogen-powered passenger vehicles to advance the energy transition of the cities transport sector, and replace the conventional fuel sources of petroleum and diesel that operate an urban taxi fleet consisting of 17,000 vehicles (Erussard, 2018). In the early stages of initiating this wide-scale Hydrogen vehicle integration program that observed the introduction of up 75 Hydrogen powered vehicles in 2015, strategies have now been deployed by the Paris Taxi Association to integrate a fleet of 600 light-duty Hydrogen vehicles by 2020 (Logan, 2018, with French governments exploring to invest in this same technology to mitigate the carbon emissions generated by nations courier and postal sector (Sumaker, 2018), from the numerous benefits hydrogen fuel cell technology provides in terms of fuel efficiency, with achieving an approximate range of 500 kilometres in 3 to 5 minutes (Erussard, 2018) and assistance to towards meeting future zero emission transport targets.

Acknowledging that there is a relative lack of proven success and precedent around hydrogen fuel cell technology powering the needs of light-duty vehicle fleets internationally, with most examples demonstrating the positive capabilities Hydrogen fuels sustain in offsetting the carbon emissions generated in heavy vehicle fleets, which have been observed across countries such as Germany, California, Japan and intriguingly Australia. The actions initiated by the Paris taxi association and the relationships the private transport company HYPE have formed with agencies and companies including Toyota and Air Liquide, to accelerate the uptake of Hydrogen fuelled vehicles and charging facilities around the city of Paris to increase the energy efficiency of a demanding taxi fleet, which still operates a high proportion of petroleum and diesel-powered vehicles (Logan, 2018). Can exemplify how councils within the WAGA can begin enhancing the operations of community transport fleets, by shifting to the technology of Hydrogen fuel cells to replace the conventional fuels utilised by local government light-duty passenger vehicles.

Discussion of Potential Alternative Fuels

As discussed above in the analysis of the most promising alternative fuels for local-level integration, the most effective alternative resource to support the needs of a community transport sector is electrification. Exclusively, the rapid growth of EV technology has made it one of the most efficient options available to service the needs for a community transport fleet among the WAGA councils. Notably, EV’s have become a financially viable alternative than biofuels and hydrogen fuel cell technology. With the benefits of transitioning to EV fleets accumulating over the long-term, in regards to the length of ownership, the life-span of EV's and the act of refuelling and recharging, which can reduce costs by approximately 78% (Energy Australia, 2019). While supporting further cost and emissions reductions when the charging infrastructure is powered from renewable energy sources such as solar panels or wind energy.

In comparison, Bioethanol is created by using renewable plant matter. The plant material that is incorporated is predominately high in sugars, starch or cellulose (Biofuels Association of Australia, 2019). Its high sustainability rating, however, comes from the fact that the plant matter used to create the Bioethanol is mainly food waste, which maintains a "limited end-of-life usage" (Lewis et al, 2017, p.10). Importantly, Bioethanol develops from the process of fermentation that transforms yeast and glucose into ethanol. Inherently, the ethical use of Biofuels does not impose any pressure onto the environment, such as the way EV's consume electricity from the current grid network, Biofuels can utilise and offset a proportion of food and waste products that would normally be disposed and lost to landfill (Iacovidou et al, 2012). Notably, as one of the key limitations towards expanding the use of Biofuels, is that this fuel contains "approximately 30% less energy" than conventional petroleum and diesel (Demibras, 2009, p.2243), and still releases a low concentration of GHG and particulate emissions from the combustion process. This fuel source can be observed as a highly less efficient alternative when implemented as a long-term strategy to achieve meaningful emission reductions and to support the needs of community transport fleets. With the viability of this replacement fuel generating substantial emission reductions existing in only the "short to medium term" of sustainable transitioning (Contestabile et al, 2011, p.10).

While in contrast, Hydrogen cell technology can achieve fuel efficiency that is far greater than EV's and Biofuels when completely charged and refuelled (Larsson et al, 2015). The advantages of an improved fuel efficiency comes at the cost of requiring larger fuel storage capacities within vehicles, which can limit the suitability of hydrogen fuels to power light-duty vehicle fleets when compared against other alternatives. Furthermore, one of the prominent barriers that emerge when upscaling hydrogen-powered vehicles is that they are extremely expensive to operate, along with the hydrogen fuel that is stored within vehicles containing high levels of CO^2 emissions, which accumulates in the production process of hydrogen and can lead to the "deterioration and inefficiency" of this fuel over time (Professor Devinder Mahajan, 2004). Due to the high cost of hydrogen-powered fleets, there are very limited spaces and locations where infrastructure and facilities can be developed to recharge your vehicle. Although there is an increasing number of examples where hydrogen technology is replacing the conventional use of petroleum and diesel fuels across different transport sectors, current technology is considered to be in the early stages of development (Lipman, 2019) and requires more time to advance a mature before it can be implemented on a council level across the WAGA region.

Understandably, one of the vital advantages of Electrification is that even though there is a lack of available infrastructure across a state and national level, there is a relatively high potential for EV infrastructure and technology to be easily developed and deployed. With policies and strategies already being drafted and designed by a number of councils locally across Victoria to facilitate a growth in Electric Vehicles (Climate works, 2018), along with the strategic development of EV technology already occurring in countries such as Norway, California, Germany and China that have evidenced positive environmental and economic benefits resulting from an increased uptake of EV vehicles and charging facilities. It is only reasonable to assume this same technology can be integrated throughout the WAGA region, to not only serve the needs of reducing a councils own emissions, but contribute towards greater emission reductions within the residential commuter population of Melbourne's West.

Recommendations

From current research and infrastructure that is already in place, this paper identifies that it is logical for Electric vehicles to be introduced to service the needs of community transport fleets operated by the councils of WAGA. With EV's becoming an easily accessible resource, due to the rapid advancement towards an electrified transport sector that is already occurring on an international scale. In addition, to the potential of EV charging infrastructure being able to facilitate "zero emissions charging" (Poullikkas, 2015, p.1285). The WAGA region could begin investing in the development of small infrastructure and enhance the facilities that already exist in order to roll out a sustainable EV system, which meets the needs of mitigating local (GHG) emissions and building zero-emission councils. Notably, with the correct policies and overarching strategies in place, the local governments across the WAGA district can begin accelerating the growth of a shared EV network of vehicles and charging stations between council regions, public areas and private businesses that does not only service the transport needs on a council level, but can service the needs of residential commuters across Melbourne's West.

Conclusion

With the Paris agreement signed, the global push towards renewable energies will make electric vehicles more sustainable and more affordable. This will therefore, make the technology behind them more advanced and will push EV's into the next dominant source of personal and public transport across the world (Unfccc, 2019). Governments at all levels, federal, state and local, need to embrace this change and become part of the solution to combat climate change. The transition for community transport fleets to electric vehicles is affordable, ethical and achievable. This report has shown the validity of moving away from internal combustion engines and provides guidance and clarity on why the switch should be made.

Other alternatives like Hydrogen and Biofuels do have a place in filling specific needs in replacing petrol and diesel engines. These options and technologies need to continue to be explored as these alternatives have the ability to fill various niche markets. However, in the case of community transport vehicles, like many others, electric power is the most prosperous and logical option. It is recommended that councils throughout the WAGA umbrella, grasp the importance of such action and commit to future research and investigation towards implementing electric powered vehicles and the available infrastructure on a local scale.

The local governments belonging to WAGA should leaders amongst the community in which it governs. Switching the fleets that move its citizens to electric vehicles provides a fantastic opportunity to showcase leadership in both environmental and community matters. It will display the ability to take action when others levels of governments have not. Demonstrating a strong, capable and representative local government.

Acknowledgement

The authors of this paper Harry, Patrick and Madelyne are very grateful to our supervisor Blanche Verlie for the valuable guidance and encouragement she has provided over the course of the semester in conducting this research project. We would also like to thank Fran MacDonald for her generosity and giving up her time and knowledge to allow us to facilitate and produce this report.

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