COMMERCIALISATION OF ELECTRIC ASSIST UTILITY TRAILER

Electric Power Engineering Centre

ENMG680 Project- Final Report

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DISCLAIMER

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- Radnya Mukhedkar – Director EPECentre
- Isabelle Le Quellec – Project Sponsor
- Beverley Hall – MEM Secretary

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ACRONYMS & ABBREVIATIONS

BEV	Battery Electric Vehicle
CAGR	Compounded Annual Growth Rate
CAPEX	Capital Expenditure

EAUT	Electric Assist Utility Trailer
ERV	Electric Recreational Vehicle
GVM	Gross Vehicle Mass
ICE	Internal Combustion Engine
kW	Kilowatt
kWh	Kilowatt-hour
Li-ion	Lithium ion
NPV	Net Present Value
OPEX	Operation Expenditure
PHEV	Plugged-in Hybrid Vehicle
RXT	Range Extender Trailer
UC	University of Canterbury

EXECUTIVE SUMMARY

New technological innovations is currently the key aspect for sustainable development. There is a need for a more sustainable world due to factors like increase in carbon emissions (414 ppm) and transportation sector accounting for 28% of them. However, with the potential increase in electric vehicles fleet there also arises limitations such as towing trailers which consequently causes range anxiety. Thus, this paper focuses extensively to judge the market potential of a new technology conceptualised by the Electric Power and Engineering centre

(EPECentre) titled 'The Electric Assist Utility Trailer'. The main value proposition of this trailer is safety, sustainability and accessibility. This project also focuses on the feasibility to commercialise the technology in New Zealand market.

New Zealand currently has 17,831 EVs most of which are Nissan Leafs. The penetration of EVs in New Zealand has grown from 0.13% to 2% by 2019. The EV fleet is expected to dominate in the next 10 years facilitated by government policies, infrastructure and rise in renewable energy sources. The target market here are the owners of light EVs especially Nissan Leaf. The increase in EV fleet with more number of light EVs, paves a potential opportunity for electric trailer. Furthermore, a market analysis for light utility trailers was performed using the registered fleet data from Ministry of transport. The analysis showed slow to medium increase in light trailers with an average annual rate of 3%. A cost analysis was performed based on various reliable references including direct and indirect costs for which the final selling price was estimated for nearly $21,000 NZD. However, a sensitivity analysis was performed to estimate the selling price based on the varying Li-ion battery prices for which the least selling price would be $11,429 NZD. The cost analysis was fed to estimate the target market which was forecasted to be 2.6 million in 2025.

The commercialisation plan for the EAUT was hindered by legal and political factors. According to *Land Transport Act 1998,* the EAUT might qualify as motor vehicle and this perception may develop a potential barrier to operate the trailer on the New Zealand roads. However, a law change may be required to make it road legal but it depends on the dominant penetration of EV market in New Zealand. To conclude, the EAUT is not feasible enough to be commercialised in the current market but it is recommended that the technology could be implemented for the caravan market in New Zealand since there is no similar patent filed.

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1 INTRODUCTION

1.1 BACKGROUND

EPECentre is New Zealand's pioneering research centre for electric power and clean energy applications which was established in 2002 as an entrepreneurial endeavour by the University of Canterbury. It brings together a team of high calibre researchers, academia and students to foster innovation. The EPECentre delivers expertise, innovation and collaborative value to the electricity sector and society by defining the future of electricity and clean technologies through research, innovation and collaboration. The ultimate objective of EPECentre is to sustainably deliver research of national significance which is internationally recognised (EPECentre, 2021).

The EPECentre on behalf of its Power Engineering Excellence Trust (PEET), attracts students into engineers, develop the traits and talents and ties industries with the developed talents. The company has engaged in several outreach activities to spark interest early for primary and secondary school students and contribute to broadening the diversity of the talent pool. Additionally, the research centre excels in various capabilities and projects which includes power system engineering, modelling and analysis, electromagnetics and power electronics.

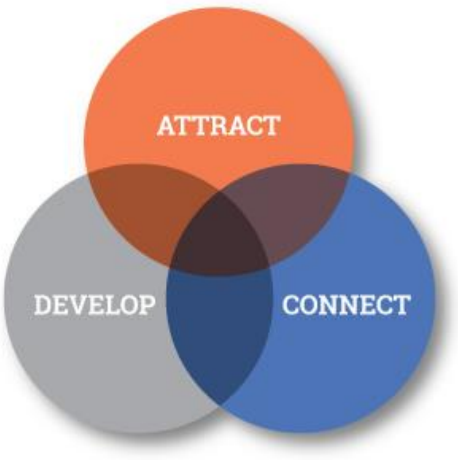


Figure 1 - Role of EPECentre towards Research and innovation (EPECentre, 2021)

Furthermore, EPECentre currently has nearly 20 employees ranging operations team, research engineers and research associates. The team is led by its unit director Radnya Mukhedkar. The EPECentre has worked with over 30 industry partners on research and consulting projects and grasps a global network of over 700 industries, research contacts and consultants.

1.2 PROJECT OBJECTIVES

The goal for this project with the EPECentre is to identify a market share for the Electric Assist Utility Trailer (EAUT) within the New Zealand market and in identifying a potential investor to sponsor for the product development and commercialisation. This involved assuming an entrepreneurial role tasked with investigating, researching and identifying the market and commercial feasibility of this product in the current NZ market. Some of the other project objectives includes:

1. Identification of potential applications and related services; along with the associated market size in NZ and overseas.
2. Assessment of the technical (high level design validation, with support from experts) and commercial feasibility.
3. Determine the commercialisation opportunities in NZ.
4. Identification and contact of investors/sponsors interested in developing and commercialising the solution.
5. Safety and compliance validation.
6. Potential for IP protection and licencing.

1.3 PROJECT CONTEXT

New Zealand is close to world leaders in car ownership with more than 740 cars per 1000 people (nzta, 2021). Figure 2 - Quarterly light EV registrations**Figure 2** indicates the increase in electric vehicle community, the number of light EVs like Nissan Leaf Figure 2 - Quarterly light EV registrationsand Hyundai Ioniq on roads are nearing to approximately 10,000 and the government is incentivising the EV uptake and currently has a target to reach 64,000 EVs by the end of 2021 (driveelectric, 2021).

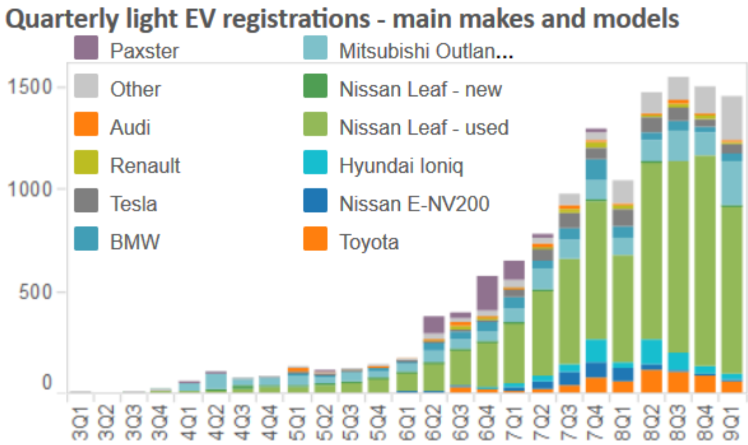


Figure 2 - Quarterly light EV registrations (SCHMIDT, 2019)

Moreover, New Zealand is a country where a considerable number of car owners use light-vehicle trailers for various applications like:

- Carrying Garden refuse and loose rubbish
- Carrying powdered and granular solids (cement, grain, fertiliser, soil, bricks)
- Airport services (Suitcases, cartons, boxes, trunks)
- Carrying logs, posts and firewood
- Hauling boats and gliders
- Recreational equipment (Surf boards, paddles, canoes, skis)
- Transporting animals (Horse trailers, birds)
- Farming and agricultural

The growing preference for consumers and international visitors to spend vacation in a campsite by towing caravans (Freedom Camping Literature Review, 2017), coastal boat rides and driving long trips has been urging the demand for light car trailers. But, on the contrary light EVs are not designed for towing trailers and the light EVs like Nissan Leaf and Hyundai Ioniq currently have zero tow ratings (carsguide, 2020). Besides, energy efficiency is badly effected when towing a trailer and it causes range anxiety for the drivers. The present approach to solving this trailer problem would be to increase the battery capacity and motor torque of the tow vehicle but this would result in a reduced driving range by the additional weight consumed during everyday use. However, an alternate approach is to equip trailers with electric assist. A trailer with electric assist would not only restore EV range but allow other design problems such as aerodynamics and safety to be addressed. The rising demand for light EVs and the potential applications of light trailers have paved the way for conceptualising the Electric Assist Utility Trailer.

Thus, the Electric Assist Utility Trailer (EAUT) is an alternate approach to provide electric vehicles with a means to preserve their EV range and avoid any aero dynamical and weight design issues. Additionally, there are potential market share for the Electric Assist Trailer in New Zealand and overseas due to the increase in demand for EV vehicles.

This project would look to provide a market evaluation of the idea in the New Zealand automobile industry whilst also assessing its commercial feasibility through trailer rentals and manufacturers. Additionally, this project will pave potential ways for a new niche market and potentially for the development of a new NZ based business. Following this, commercialisation opportunities could be investigated through communicating with industry leaders and potential investors.

2 PRODUCT DESCRIPTION

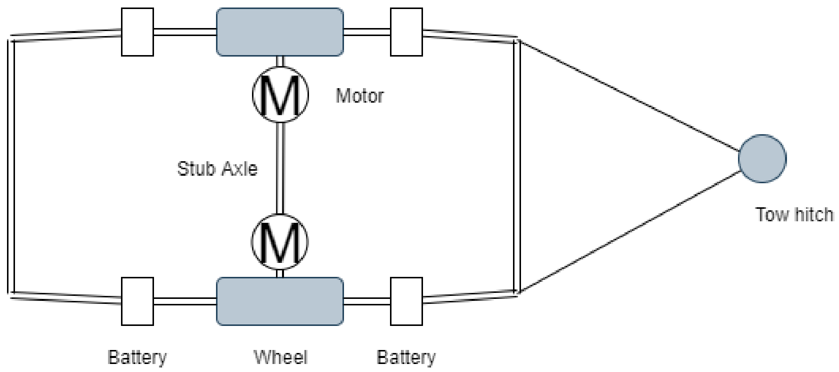


Figure 3 - Conceptual diagram of the EAUT (McQueen, 2020)

The Electric Assist Utility Trailer (EAUT) is eventually conceptualised for Battery Electric Vehicles (BEVs) for towing purposes (**Figure 3**). Since EVs have low towing capacity and hauling a trailer results in range loss for the vehicle, the present approach is to create a trailer with an electric assist. A trailer with electric assist would not only restore EV range but allow other design problems such as aerodynamics and safety to be addressed. The product basically involves a normal light duty single axle trailer (e.g., Most boat trailers and recreational trailers) to which a bank of batteries are attached under the tray of the trailer to neutrally balance on its axle and two motors being fitted to the stub axle to drive the trailer wheels.

Some of the requirements recommended (McQueen, 2020) for the EAUT include but are not limited to:

- The batteries should be of a useful capacity allowing goods to be delivered within a ~50km radius. Too many batteries would exceed the 2500kg combined weight limit for car and trailer reducing the usefulness as a Class 2 license would be required. Thus, a battery capacity of 10kWh and two motors of 10kW are used.
- In the tow-ball mount stress sensors so that under acceleration the trailer will power equivalent to forces imparted due to 90% of its mass,
- Initially the trailer will be electric assist rather than a more complicated pusher trailer which may require driver training and additional regulations,

- For braking mechanism in the trailer, there are two options to be considered. For the product development stage, a drum brake system could be installed whereas for the production stage, a regenerative braking could be used.
- The trailer should be of any light weight standard design e.g., aluminium, easily constructed by a fabricator in New Zealand,
- A safety mechanism, such as power from the trailer electric plug, would ensure the trailer is not powered when not connected to a vehicle.
- According to NZTA regulations for light simple trailers, the trailer should meet the legal dimensions and design qualification to travel on New Zealand roads. A detailed guideline describing the legal dimensional requirements are elaborated in **Appendix-**

3 REVIEW OF LITERATURE AND PATENTS

3.1 METHODOLOGY

The literature review for the EAUT mainly emphasise on the techno-economic and environmental aspect of the EAUT. The literature and patent review were performed considering the limited availability of resources for a similar technology. Google scholar search and UC library search with keywords such as ‘Electric trailer’ and ’Electric Propelled Trailer’ were used to fetch the results. The results of this search were more related to development of range extender trailers for electric vehicles and their performance analysis.

Similarly, Google Patents, NZ Intellectual property patent search (iponz), Wipo IP portal and Google search were conducted for patent research to identify similar technologies. Keywords like ‘Electric Trailer’, ’Electric Propelled Trailer’, ‘Range Extender Trailer’ were used for patent search. A detailed literature and patent review are explained below.

3.2 LITERATURE REVIEW

The article published by **Dongbin, et al. (2010)** highlights the development of a Range Extender Trailer (RXT). The authors consider the motivation of RXT is due to the limitations in existing batteries for providing extended range for electric vehicles. This system of RXT includes a pure BEV and an adequate performance engine generator which is attached to the trailer. A trailer mounted generator apparatus can be used to extend the range and increase the utility of that of a BEV with sustained cruising. Considering the technical aspects, the authors believe the utility of RXTs is applicable only for long trips during low battery State-Of-Charge (SOC). For a medium sized EV, the RXT needs to have an output of 20kW necessarily to provide comfortable cruising (Dongbin, Minggao, Languang, & Jianqiu, 2010).

Figure 4 - Range Extender Trailer with motor and generator (Lebkowski, 2019)

Additionally, as proposed by **Gage & Bogdanoff (1997)** the paper suggests a new configuration by placing the new generator set in the trunk of the EV for long trips. However, a weight target of 60kg is required and the RXT will have smaller rolling resistance and air resistance than the RXT system. In this concept a four-wheel hub motor drive system is used and instead of a battery, a generator with a constant voltage and frequency of 220V, 50Hz is used (Figure 4).

Imai, et al. (2008) further researched the performance of EV range extender trailer by comparing it to a PHEV. The motivation for his research was primarily based on the development of higher performance batteries and the possibility to run automobiles without the dependence on oil in the future. The adaptation of BEV and the elimination of PHEV was his ultimate goal and the only solution is to create a range extender for the BEVs. His paper proved that the EV range extender trailer will provide better range and milage than a PHEV. The author and his colleagues assumed a weekly driving pattern of 30km (6 days a week) for the RXT and PHEV. One of the drawbacks for the evaluation was the required power P for the EV with the RXT was relatively higher compared to PHEV (Figure 5). This was due to the *rolling resistance* and *drag resistance* of the trailer attached to the back of EV (Imai, Ashida, Zhang, & Minami, 2008).

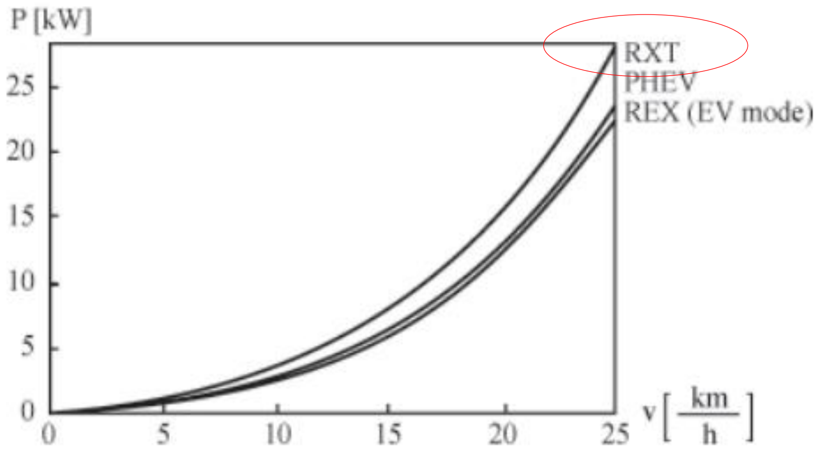


Figure 5 - Required power vs velocity for RXT and PHEV (Imai, et al. 2008)

The result showed that that 35.4 kWh/weeks is achieved for RXT and 36.5 kWh/week for PHEV. However, a more generalised research would provide the qualitative performance of the RXT.

In another article published by **Łebkowski & Soltysiuk (2019)**, the author reflects on the motivation of reducing the greenhouse gases by ICs and rectifying the range anxiety of EVs caused by the limited capacity of available batteries and charging time. Łebkowski found the RXT placed in the trunk causes more noise and vibration while driving and proposed the idea of attaching the RXT behind the vehicle by replacing the generator with lithium-iron phosphate batteries with 15.84kWh (Lebkowski, 2019). The authors considered the advancement of the battery technology and battery costs decreasing with increased production and recommended this solution to be expended in the forthcoming development of the RXTs.

Researchers from Belgium which includes **Hooftman, et al. (2018)** talks about the environmental impact of Range-Extender trailers. The author and his team emphasises their research on the application of a petrol generator RXT or a 50kWh battery pack for a typical 40kWh EV like Nissan Leaf and renault Zoe.

Hooftman (2018) suggested that fitting the trailer with an extra battery pack is better off environmentally and economically by allowing the EV's battery to be used in a charge-sustaining mode for an extra 300 km. The life cycle assessment (LCA) was presented for comparing the different power trains for the environmental impact with the decisive emphasis on the climate change. The author concludes in his research stating the petrol generator trailers are no long-term solution but should be considered intermediately until the costs for battery technology have dropped and thereby making it economically feasible to commercialise the battery trailers (Figure 6). Additionally, **F. Joint (2018)** addresses that the focus should be expanded to the environmental impact due to the unrestrained demand for high power during charging period and by placing fast chargers close to renewable power stations and facilities.

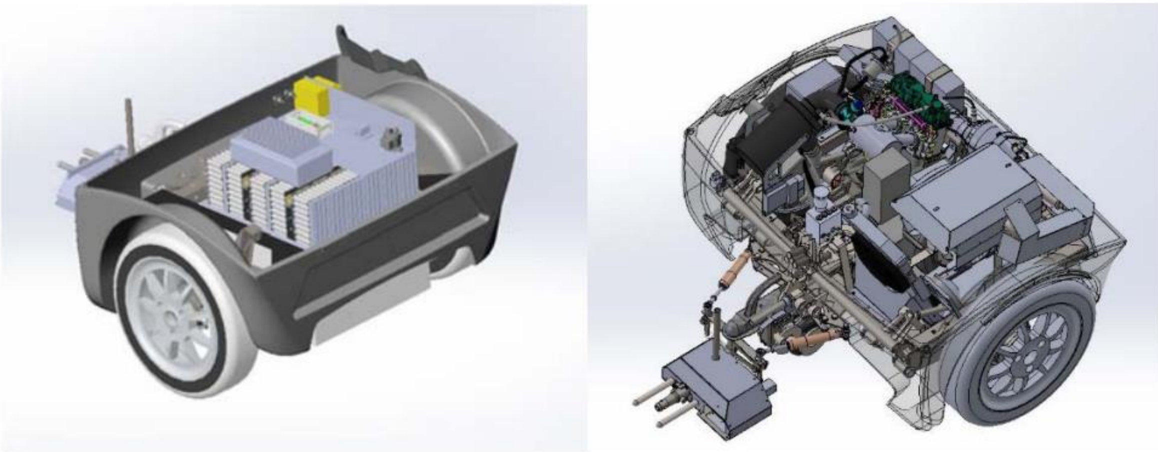


Figure 6 - Graphical representation of the petrol generator trailer (left) and the battery trailer (right) (Hooftman N. , Messagie, Jean-Baptiste Segard, & Coosemans, 2018)

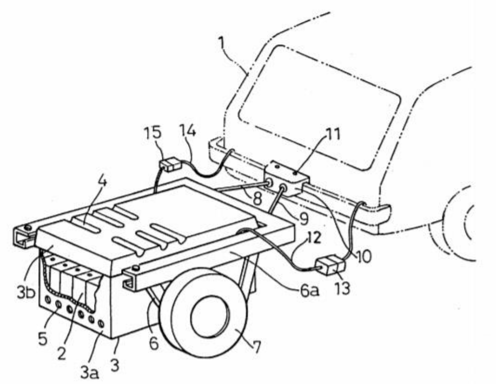
Insights: The above literature study entirely emphasise on the techno-economic and environmental aspects of utilising a simple electric trailer. Compared to the EAUT, the RXTs are used just for extending the range for the EVs but does not provide any storage due to the battery and motor specifications. Some of the key opinions in the literature review are the technological aspects where Dongbin, et al. (2010) states that a 20kWh output source is sufficient for a trailer to extend the range for a normal 30kWh EV car. Authors like Dongbin, et al. (2010), Gage & Bogdanoff (1997) start the evolution of the electric trailer concept by adapting to generators with a constant voltage and frequency of 220V, 50Hz respectively. On the contrary, generators of such capacity are denser and would increase the drag resistance of the trailer which in turn reduces the standard range of the towing EV (Imai, et al. 2008). Furthermore, placing the generator in the trunk of a vehicle is more of a non-starter. Considering the development of battery chemistries and reduction of Li-ion prices in the future, N. Hooftman (2018) claimed to use a battery pack with 50kWh capacity for a 40kWh

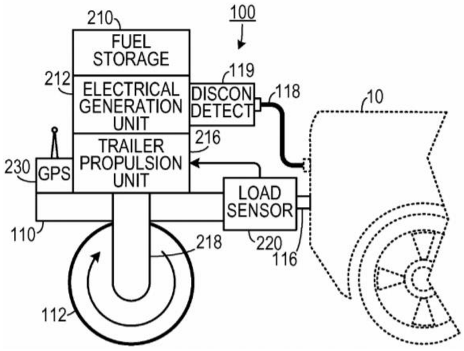
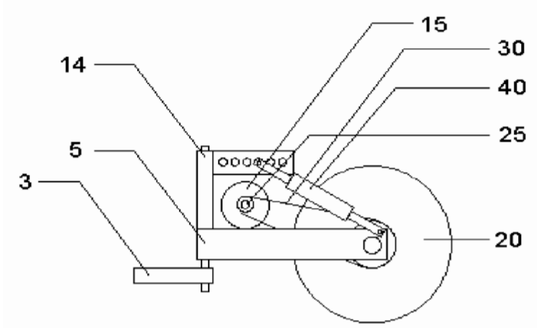
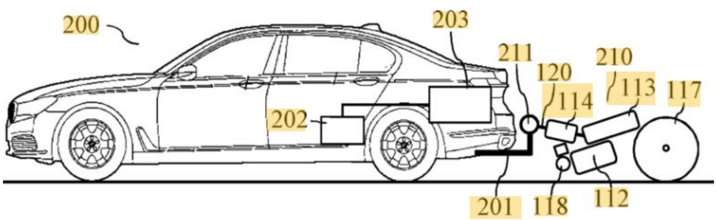
EV. This proposal from his team was much valid since the focus was targeted towards sustainability.

Reflecting the key aspects from the review, the EAUT would be developed based on better technological specifications and more economical conditions.

3.3 Patent Review

Patents provide exclusive details of the inventive activity and increase the idea of commercialisation through market transactions and promoting the diffusion of knowledge and innovation (Alvarez-Meaza, Rio-Belver, Zarrabeitia-Bilbao, & Garechana-Anacabe, 2020). The patent review was conducted to identify the similarities and differences in various electric trailer or range extender products compared to the EAUT. This review involved referring to the patent's abstract, background, summary of invention, drawings and descriptions. The patents had several claims which defines the scope or protection sought in the patent application. A brief description of the claims are explained in the review.

Company/Inventor Name	**Patent Code & Product Name**	**Description**
Akira Kohchi, Application filed by Institute for Home Economics of Japan Inc	US5559420A, Electricity supply unit trailer for electric vehicles	 Power packed batteries enclosed within a case for protection and air cooling. The encasement with the batteries rides on wheels and supply electricity to the towing electric vehicle. This unit generates additional electricity extending the driving range. **Claims:** A unit apparatus supplying electricity to an electric vehicle, encasement for closing and cooling the batteries, transportation means for permitting movement, encasement can be removable and slide onto and off the frame body and electric cords with multi-plug connector for receiving control signals. (US Patent No. US5559420A, 1993).

John K. Collings	US20100065344A1, Self-Propelled Electric Vehicle Recharging Trailer	 A recharging trailer for applying electricity to the electric vehicle. An electric generation unit is attached to the trailer andconfigured to generate electric power. Meanwhile, a trailer propulsion unit is used to propel the trailer. **Claims:** A rechargeable trailer for applying electric energy to an electric vehicle. The trailer frame is coupled to the towing vehicle. An electric generation unit is attached on the trailer frame. A trailer propulsion unit is configured to propel the trailer with a lo0ad sensor configured to sense the changes of speed of the EV (US Patent No. US20100065344A1, 2008).
Gregory A. Gibbs	US20090229895A1, Automobile vehicle pusher system, hybrid or electrical vehicle comprising the vehicle pusher system and a method of converting a vehicle to hybrid or electrical propulsion	 The invention is an automobile pusher system or an electric propulsion system. This setup could be connected to a trailer hitch aor at the rear of a PHEV or a BEV to provide propulsion in whole. **Claims**: AN automobile Vehicle Pusher (AVP) apparatus with one electrical motor and propulsion system. The motor and the propulsion syatem are coupled to a power transfer unit. Automotive lights and reflectors are attached to improve the visibility. The AVP system further comprising of software and hardware methods implemented to provide regenerative braking (US Patent No. US20090229895A1, 2009).
Peter Sigmund, Bayerische Motoren Werke AG	DE102019114772A1, Device for increasing the range of an electrically powered vehicle	 This is a device with which the range of an electrically powered vehicle can be increased efficiently. This range extender comprises of an internal combustion engine , fuel tank and a generator and generates electric current for the operation of the electric drive within the motor vehicle. **Claims**: A single track device comprising of a frame, wheel, coupling connected to an EV. A fuel tank is designed to hold the fuel in the trailer. A generator is designed to generate electricity to the trailer.An internal combustion engine to be operated with the fuel and to drive the generator (Germany Patent No. DE102019114772A1, 2019).

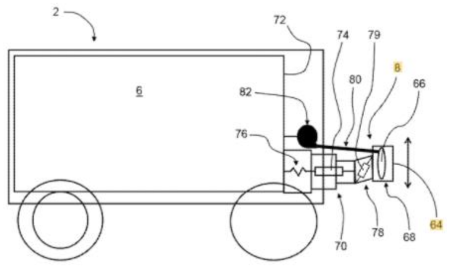
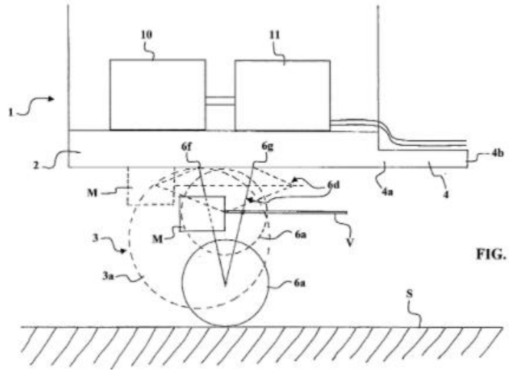
Manfred Baumgärtner, BVB INNOVATE GmbH	US20180290561A1, Use of an autonomous range extender vehicle and autonomous range extender vehicle	 The invention relates to a range extender which extends the range of an electrically driven motor vehicle. But, this extender has the possibility to automatically driveto the main vehicle to supply electric energy. **Claims**: Autonomously driving the range extender on road. Having a motor to drive the range extender vehicle. Receiving means for receiving information for automatically locationg the tow vehicle. Means of transmitting the energy through a wireless and inductive energy transmission (US Patent No. US20180290561A1, 2015).
SEGARD,Jean-Baptiste, EP Tender	WO2013132468, Road trailer with orientable secondary wheelset	 FIG. 2 This was the initial patent which was registered by the French start-up company EP-Tender. This invention started novel hitching trailer structure. This trailer can comprise means for generating or storing electricity by connecting to a towable vehicle with electric propulsion. **Claims:** Road trailer with trailer frame, main running gear and hitching device with secondary components like retraction means, rolling gear and a main running gear (France Patent No. FR2987808A1, 2012).

Table 1 - List of reviewed patent applications

Insights: The above patent review was performed to identify the existence of similar ideas, products and technology which was filed by an inventor or a company and to understand the technological expansion and development within the trailer industry. A patentability search was performed to ensure the idea developed by (McQueen, 2020) for the EAUT was novel and non-abstract (Zadrozny & Shalaby, 2019). Most of the filed patents have a similar and familiar background and design of a range extender trailer with various power sources. There were similar patent applications pertaining to the idea of a range extender trailer but not much developed to conceptual design to the EAUT subject. As searched in IPONZ, there is no similar technology in New Zealand and considering this, a patent can be filed for the idea of EAUT in New Zealand without any infringement.

4 Project Methodology

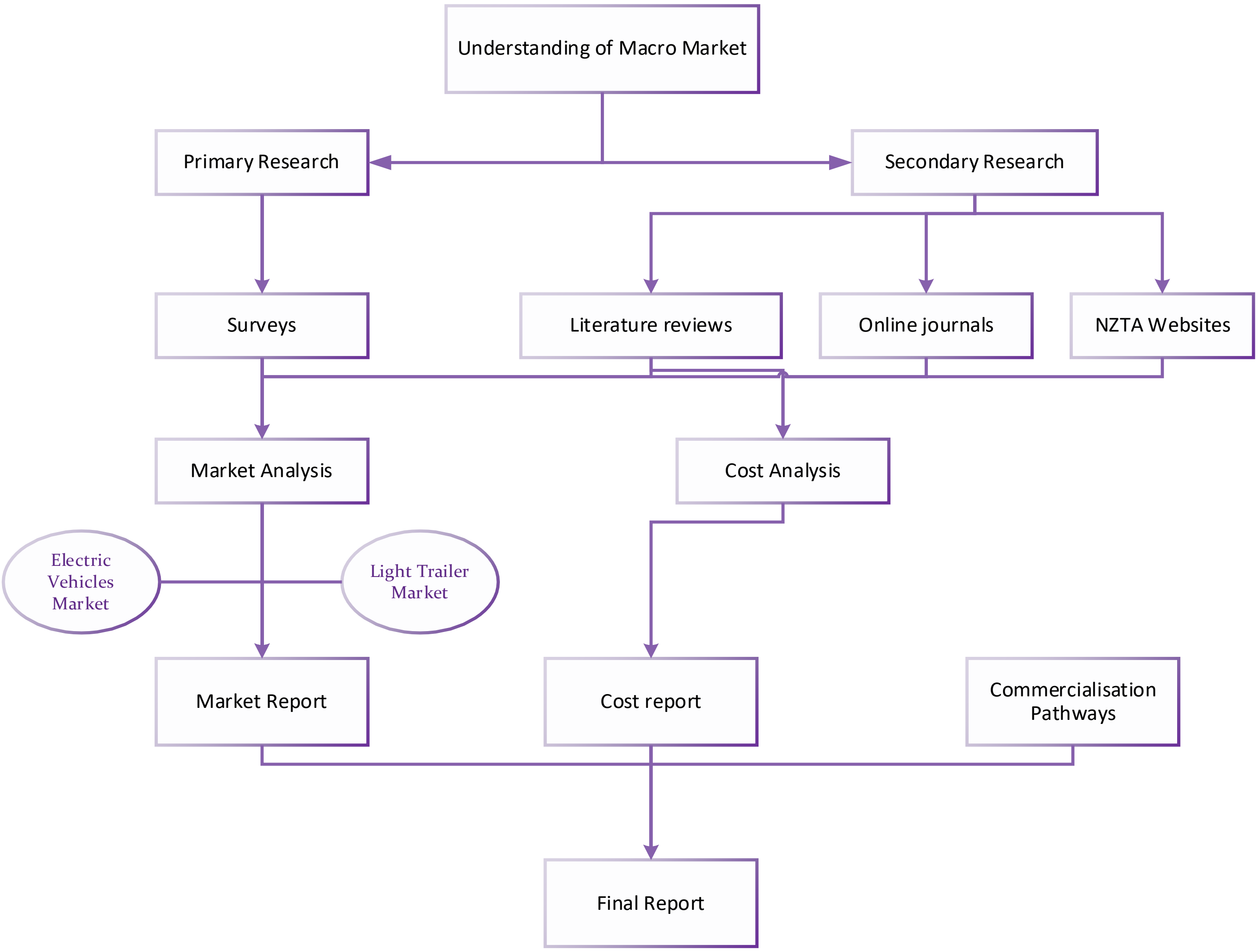


Figure 7 - Major tasks involved in the project

The major tasks involved in the project was to gain an understanding of the overall EV market, light trailer market and consumer usage patterns on light trailers for which the target market was identified as *the people who own light EVs and are interested in hauling trailers for long trips*. A detailed methodology is explained in the Market Analysis section. Furthermore, the methodology consists of primary and secondary research for data collection. The primary research was done by assessing the trailer usage pattern from the consumers in New Zealand. Additionally, market validation survey was also conducted to various stakeholders like EV owners, trailer owners and trailer rentals which attempted to find the needs, issues and opinions on the EAUT.

The secondary research was mainly a desk research conducted to collect data from literature reviews, competitor analysis, patent searches and market analysis based on the information fetched from various New Zealand government websites. One of the main sources used for analysing trailer market data was the NZTA website on registered vehicles in New Zealand. In addition, several journals, government and company annual reports were used as sources for researching the electric vehicles market globally and in New Zealand.

The cost analysis and financials were performed based on assumptions from various reliable sources to estimate the total manufacturing cost and selling cost. Stationed on the direct costs and the indirect costs, the revenue and expenses were consummated. From the cost analysis, the economic analysis of the EAUT was carried out with various assumptions which then led to the sensitivity analysis.

The target market was estimated using the forecasted details from government data for EVs and using the total profit margin in selling the EAUT.

The above mentioned steps were further consolidated with final discussion and conclusions for the project.

5 Market Analysis

The automotive industry is approaching a pivotal moment due to the shift towards the electric powertrain which are influenced by larger public demand, government policies and new entrants into the market (Arif , 2018). Additionally, with increase in fuel prices, consumers prefer to buy medium variant cars which consume less fuel and safer for the environment when compared to a powerful SUV (Housley & Brandwood).

Additionally, for consumers towing trailers for domestic purposes encounter many cons like reduced acceleration, increased fuel consumption, longer braking distance and limitations in trailer weights. Furthermore, the concerns arise when an electric vehicle is subjected to towing which ultimately causes less range to the EV. Additionally, the light EVs are not recommended for towing purposes due to their low towing capacity and ‘zero’ tow ratings. Therefore, these limitations centres the focus on the market opportunities for the EAUT. To understand the scope for EAUT, the EV market was deliberately the target market and data was analysed both globally and in New Zealand for light trailers and EVs. Moreover, to gain a deep insight of the product, the eventual target market was identified as: *The consumers who own light EVs and are interested in hauling trailers for long trips.* If this technology could be introduced in the caravans, then the secondary segment could be customers towing caravans and motorhomes for holidays or vacation.

5.1 Overview of Global Market for Electric Vehicles & Trailers

5.1.1 Electric Vehicles Market

The number of light EVs globally reached 2,264,400 units in 2019 with an average annual increase of 9% for the past six years (IEA, 2020). In 2020, the sales of electric vehicles reached 2.3 million globally boosting the total electric vehicles stock to 7.2 million. Electric cars, which accounted for 2.6% of global car sales and about 1% of global car stock in 2019, registered a 40% year-on-year increase (IEA, 2020). **Figure 8** shows the data for which the count of ICEs are gradually decreasing in the further run whereas the number of BEVs linearly increase to dominate a considerable light duty vehicle market by 2030.

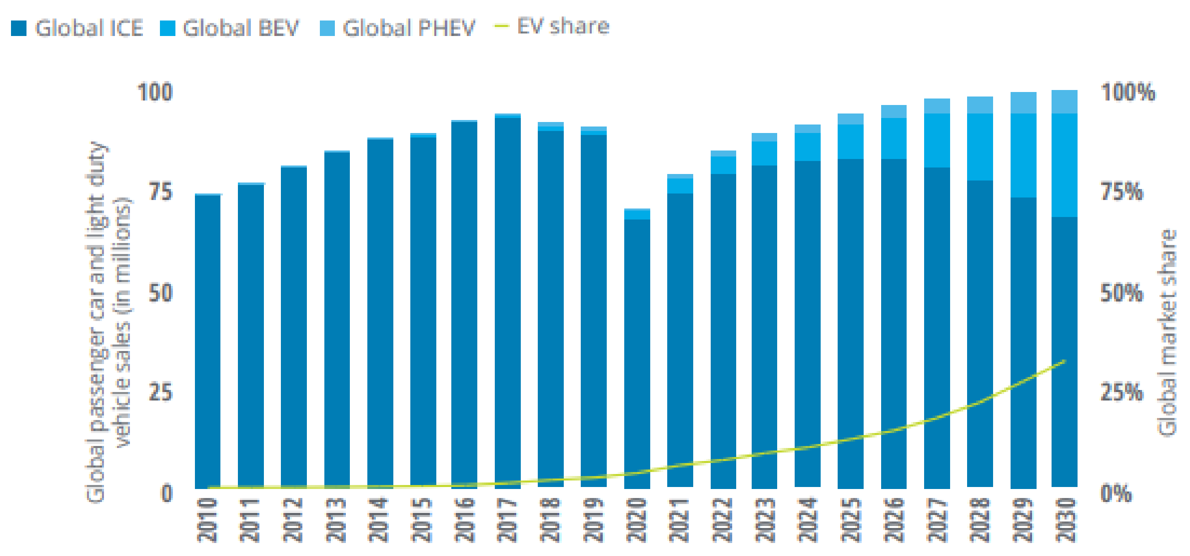


Figure 8 - Outlook for annual global passenger cars and light duty vehicle sales (Deloitte, 2020)

The global EV market has a CARG of 29% which would be achieved in the next 10 years (Deloitte, 2020). The current EV sales of 2.3 million in 2020 is estimated to reach 11.2 million by 2025. By 2030, the estimated market size for EV would be 31.1 million (Deloitte, 2020).

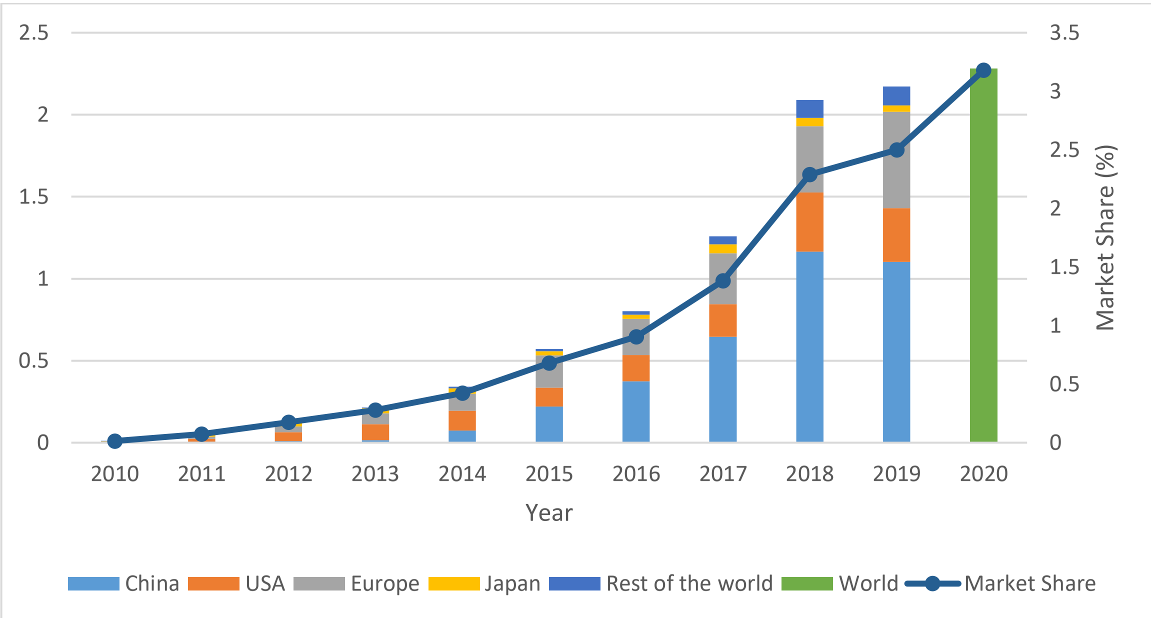


Figure 9 - Global market share for electric vehicles (IEA, 2020)

Developed nations such as the US, China, Germany, and the UK are actively promoting the use of EVs to reduce emissions, which has resulted in the growth of electric vehicle sales (Figure 9). According to Bloomberg NEF, China and Europe together represent 72% of passenger EVs. By 2030, both China and Europe will witness an increase in the EV sales due to theirCO_2 regulations, economy regulations and policies (BloombergNEF, 2020).

Furthermore, the USA falls further behind China and Europe but could be expected to catch up in the 2030s (BloombergNEF, 2020). The electric vehicle market is dominated by globally established players such as Tesla (US), BYD (China), BMW (Germany), Volkswagen (Germany), and Nissan (Japan) (crispidea, 2020). A detailed global market analysis for EVs are provided in **Appendix**

5.1.2 Light Trailer Market

The global automotive industry plays a vital role in the sales of car trailers. Throughout the time, the sales of personal vehicles has been increasing progressively since the advent of modern assembly lines that makes it viable to mass produce vehicles (thebusinessresearchcompany, 2020). This trend is expected to grow in the future as people demand more personal space and luxury while moving around.

Currently North America and Europe are currently dominating the market which is attributed to the presence of robust automotive industry that adopts innovations. Growing tourism places, solo travelling and domestic usage of trailers is also estimated to help the market grow steadily in the future (transparencymarketresearch, 2020). Countries such as New Zealand and Australia are bigger markets for light car trailers in the Asia Pacific region. The car trailer market is expected to reach nearly $103.77billion USD by 2022 globally with a significant CAGR of 11.5% (thebusinessresearchcompany, 2020).

Limitations: There were certain limitations for conducting the market research for global light duty trailers. The sources included online journals, websites and reports. However, there were a limited number of these resources and some of them were hindered by purchasing the report. The data extracted from these resource was sufficient for understanding the basic outline of the global light duty trailer market.

5.2 Overview of Electric Vehicles & Trailer Market in New Zealand

5.2.1 Electric Vehicles Market in New Zealand

According to MoT, there are currently 3.36 million light passenger vehicles in New Zealand. An increase of 23% over the last 10 years and light 4-wheel vehicles making up 93% of the vehicle fleet (MOT, 2020). In 2018, there were 802 light vehicles per 1000 people in New Zealand which makes it one of the highest car ownership rates in the world (EHINZ, 2020).

The light EVs in New Zealand accounted for 2.1% of the overall light vehicle registrations by 2019 (EHINZ, 2020). There are currently 17,831 BEVs registered in New Zealand which includes both used and new vehicles (Figure 10). (MOT, 2020). The penetration of EVs in New Zealand has grown from 0.13% to 2% by 2019 (EECA, 2019). Unlike Norway, there are no extensive subsidies by the New Zealand government. However, the growth of EVs in New Zealand is favoured by low operating costs, sustainability considerations and government incentives towards EVs (EECA, 2019).

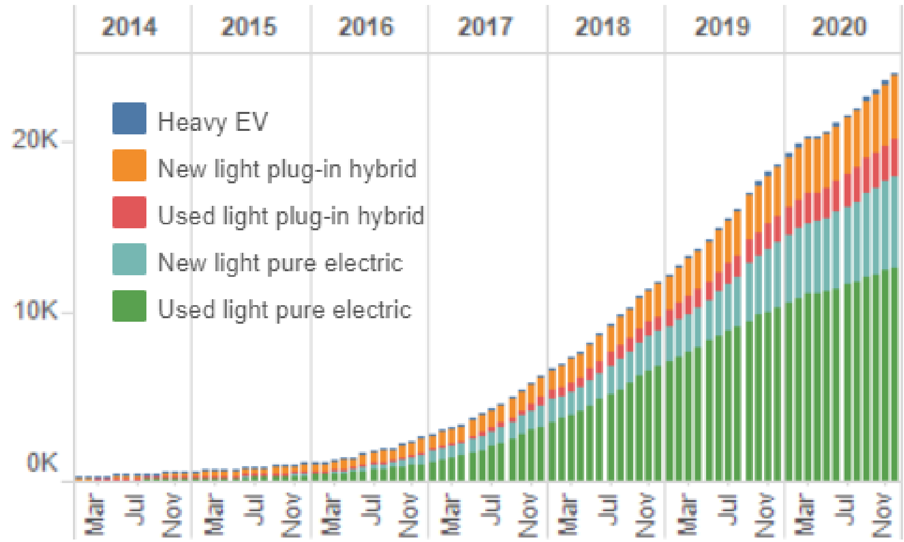


Figure 10 – EV fleet size in New Zealand (MOT, 2020)

New Zealand's EV fleet primarily consists of imported used vehicles from Japan (Magnusson, 2020). Due to higher cost of ownership of new EVs, New Zealanders prefer to purchase EVs in the used car market in a much greater proportion (EECA, 2019).

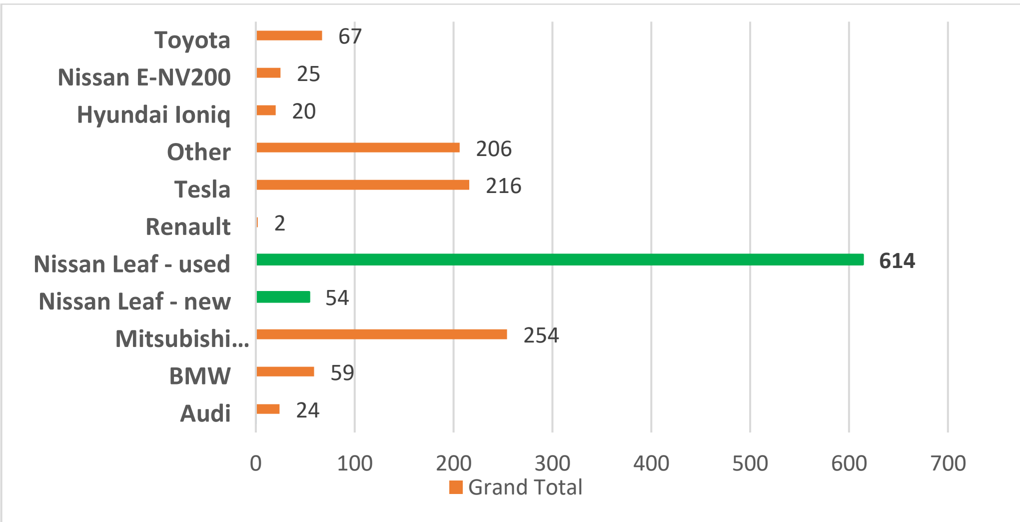


Figure 11 – Light EV vehicles brand wise registration (MOT, 2020)

Used Nissan leafs contribute to nearly 53% of the EV fleet in New Zealand. The data extracted from MOT over the registrations of main light EV models in 2020 displayed the increase in number for Nissan Leaf compared to other light EVs. There are nearly 668 registered Nissan leafs on New Zealand roads which includes new and used variants (MOT, 2020). Additionally, most number of EVs are registered by individual owners whereas a small segment of them are company owned.

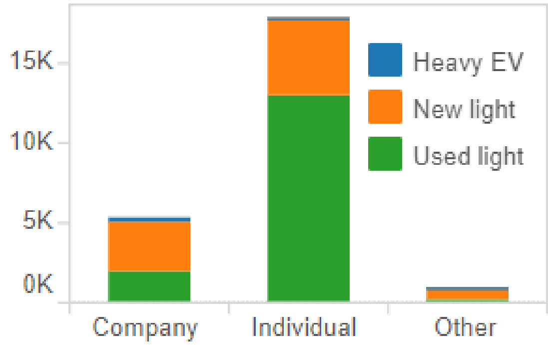


Figure 12 – EV ownership (MOT, 2020)

Currently, there are nearly 3.8 electric vehicles per 1000 people in New Zealand. Regions like Auckland and Wellington has the largest EV ownership rate of 4.8 EVs per 100 people while the West Coast region has the lowest ownership rate of 0.8 EVs per 1000 population. (EECA, 2019) (EHINZ, 2020).

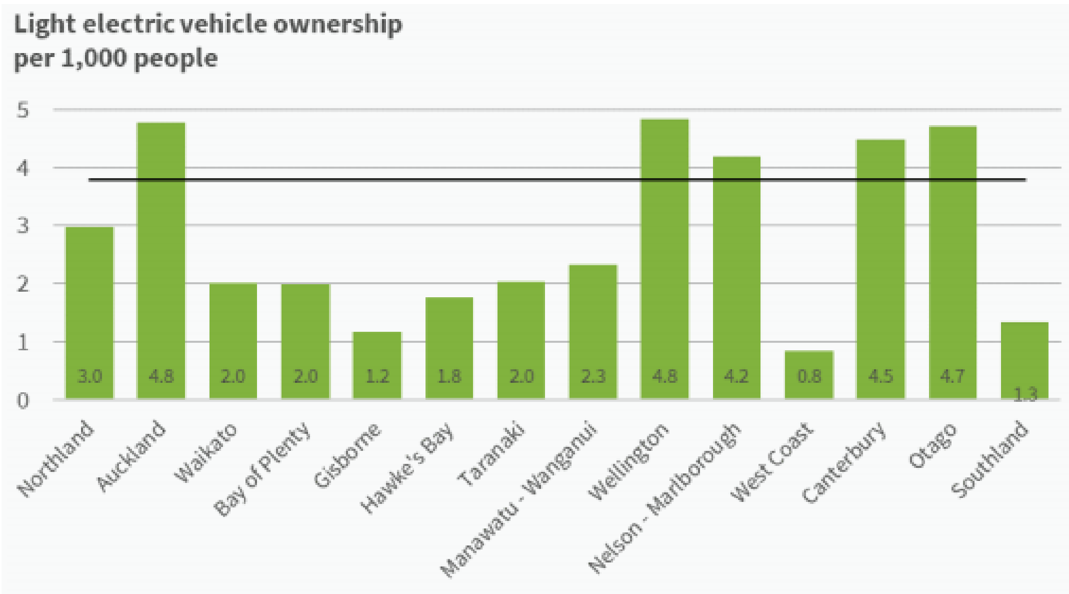


Figure 13 – Light EV ownership by region (MOT, 2020)

A detailed analysis of the New Zealand EV market, government policies, incentives and electricity generation are explained in Appendix-.

5.2.2 Projections of Electric Vehicles Fleet Size:

The assumptions and projections for the future EV fleet size was extracted from the data modelled by Ministry of transport (MoT). MBIE provided the key assumptions to MoT to estimate the results for future projections (Table 2 - EV projections in New Zealand. These assumptions includes total population, total households, number of light vehicles, uptake of EVs and fuel used. (MBIE, 2015). The method for determining the uptake of EVs includes:

- A medium and high projected rate were used.
- Both new and used imported EVs were considered.

	NZ new vehicles that are electric	
Year	**Medium Uptake**	**High Uptake**
2015	0.50%	3.40%
2020	1.40%	11.50%
2025	2.30%	19.60%
2030	3.10%	27.70%
2040	4.90%	43.80%

Table 2 - EV projections in New Zealand (MBIE, 2015)

However, the projections concerning to the project was done considering the EV uptake from 2020 to 2025. Thus, referring to the MBIE data over medium uptake, the percentages were assumed to be ranging from 1.40% in 2020 up to 2.30% in 2025 (**Figure 14**). Considering the current EV fleet in 2020 to be 17,831 (MOT, 2020).

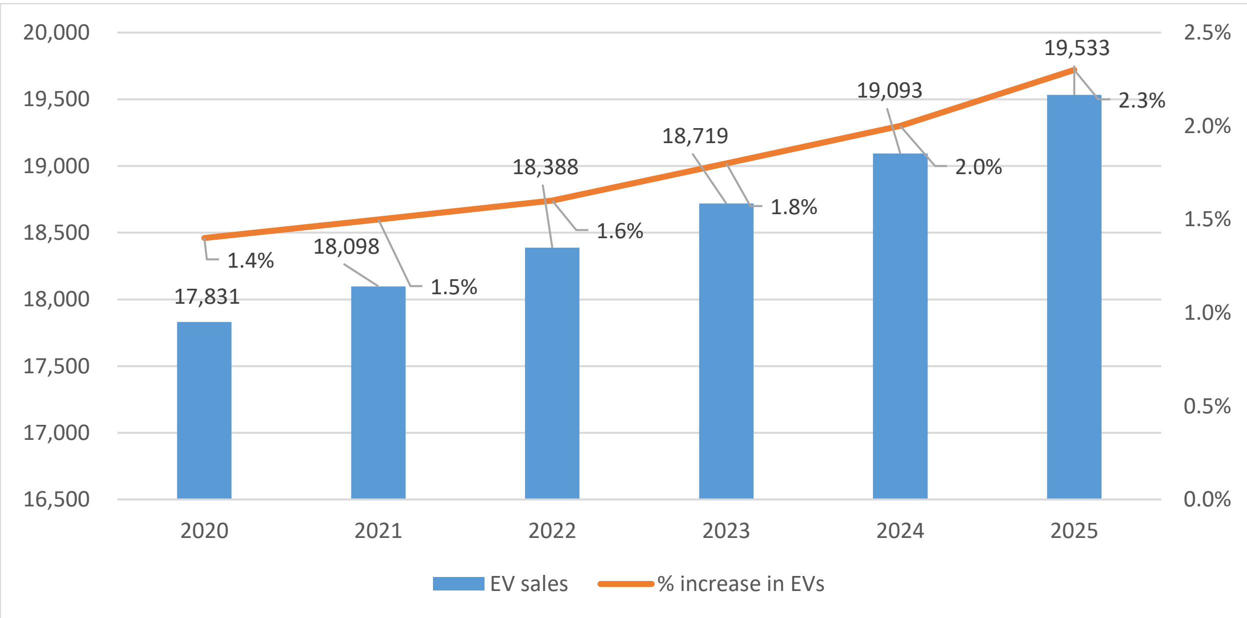


Figure 14 – Estimated EV projections in New Zealand

Based on the assumptions the EV fleet in New Zealand was estimated to be 19,533 by 2025 with a market size approximately $669.4 million[1] (MBIE, 2015).

5.2.3 Light Trailer Market in New Zealand

Methodology: *The methodology involved in this segment was the number of trailers registered was extracted using the NZ Transport Agency Motor Vehicle Register website (NZTA, 2020). The vehicle register data (excel format) was selected for the particular year and was categorised based on the vehicle types for which 'VEHICLE_TYPE' column was selected and 'TRAILER/CARAVAN' was filtered out. The data was further classified to 'Domestic Trailer', 'Boat Trailer' and 'Caravan' by selecting the 'BODY_TYPE' column to fetch the count of light trailers and caravans. Similarly, 'TLA' column was selected to assort the region wise registrations.*

Figure 15 shows the number of light duty car trailers currently registered and used in New Zealand for various purposes. This includes trailers such as Boat trailers, Domestic trailers flat-bed trailers and Caravans which are much affordable for light passenger vehicles.

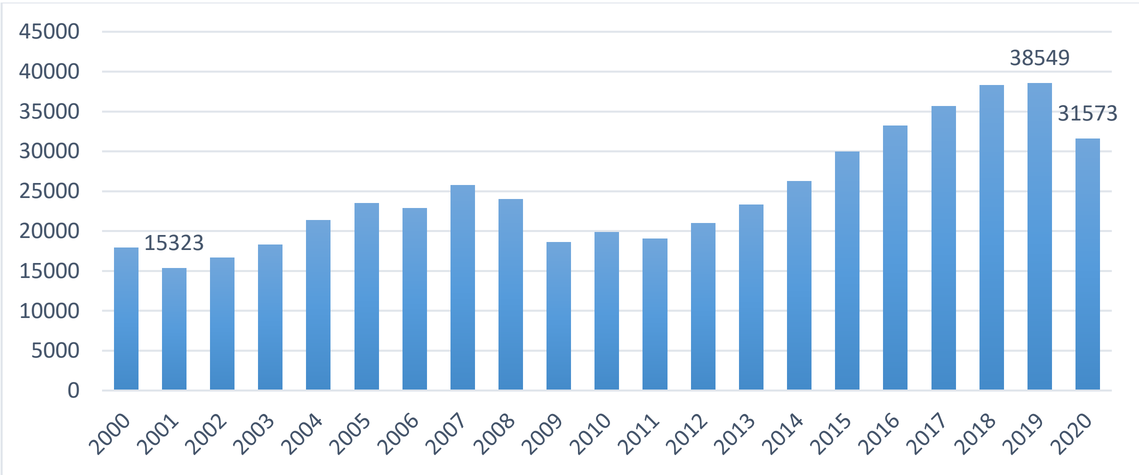


Figure 15 - Number of light-duty trailers used in New Zealand (NZTA, 2020)

Most of the car trailers are manufactured locally in New Zealand whereas the rest of the trailers are imported from countries like China, Netherlands, Australia, UK, Japan, Norway and USA (nzta, 2020). The number of registered trailers in 2001 were 15,323 and the count drastically increased to 38,549 in 2019. The current number of trailers registered as of 2020 are 31573. The calculated average annual growth rate over time is 4.62% in New Zealand and

[1] Total Number of EVs in 2015 (19,533) * MBIE projected average EV cost ($34,272)

it is forecasted to increase up to 48,496 by 2025 assuming the upsurge in vehicle uptake and as well as the demand in light trailers for various applications. Figure 2 shows the region wise registration for trailers in New Zealand and Auckland has more number of registered trailers compared to other cities over the last twenty years. Additionally, referring to the EV ownership by region in **(Figure 16)**, Auckland has the highest ownership rate. Therefore, it can be considered that Auckland would be a potential domestic market to commercialise the EAUT if the options become feasible in the future.

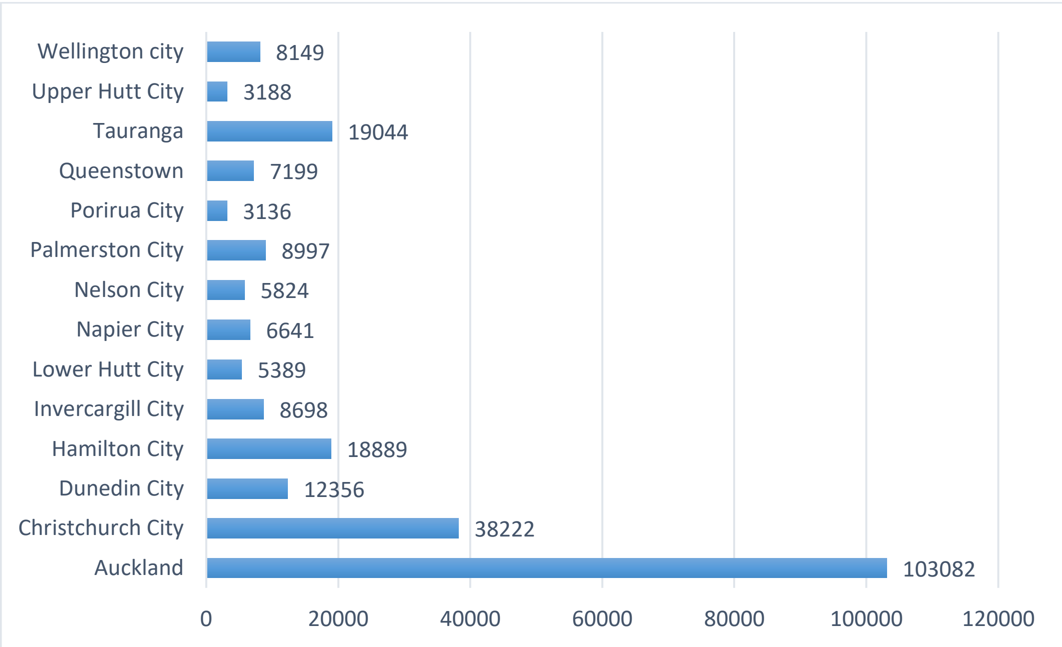


Figure 16 - Region-wise trailer registration (NZTA, 2020)

The trend analysis [2]in **Figure 17** illustrates the market behaviour for light trailers in New Zealand. The data displays a year by year trend which shows a chain of fluctuations till the year 2012. This may be assumed due to the relatively small size of the New Zealand market where the consumers were not inclined to the potential applications of trailers. Furthermore, a substantial growth percentage (10%) could be observed after 2012 and the trend increases linearly and drops down significantly in 2020 (-18%) due to the impact of COVID-19. From the trend analysis, the overall average percentage of light trailer registration for the past 20 years is 3%. However, when compared to the years from 2015 to 2019 where the number of trailer registration was significantly increasing, the average percentage of registration was 8% and

[2] The trend analysis for performed using excel. The data series for the trailer registrations was selected and the 'Trend ()' function was used.

can be assumed to increase in the future considering the increase in vehicle fleet in New Zealand.

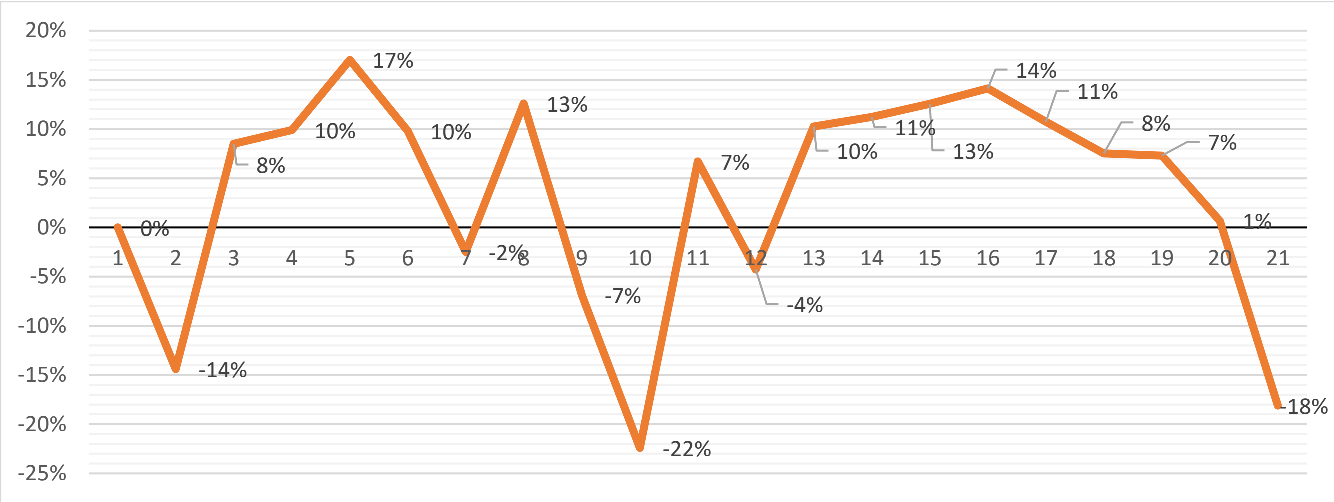


Figure 17 – Trend Analysis for light trailers in New Zealand

5.3 Macro-Environmental and Competition Analysis

5.3.1 PESTEL Analysis

The PESTEL analysis is a strategic management tool which provides a great detail about the operating challenges the EAUT will face in the predominant macro environment. This external environment possess variables that are beyond the control of a firm, but require sufficient analysis to manipulate the corporate strategy to shifting business environments (Sammut-Bonnici & Galea, 2015).

5.3.1.1 Political

This part of the framework identifies the impact of government intervention, policies and taxation on the development of the product. New Zealand values the contribution of entrepreneurs and small start-ups can make in developing the economy and the government is intensively involved in encouraging such fraternity (newzealandnow, 2020). The political environment which exists in New Zealand has a dominant impact on the performance of the small business enterprises. It can result to indorse policies to thrive the small businesses or to cripple it.

With reverence to some of the policies and regulations, the EAUT does not require a Fringe Benefit tax (FBT) according to the exemptions made on motor vehicles (ird.govt, 2020) and might not adhere to the income tax according to the exemptions made under the motor vehicle section of the Income Tax Act 2007 (legislation, 2020). Secondly, the product will comply with the policies of Land Transport NZ which infers about the WOF and registration procedures for new trailers and similarly about the loading and towing practices in New Zealand (NZTA, Light trailer requirements, 2021). Finally, the road user chargers (RUC) applies for the trailers or even caravans irrespective of weights, dimensions and distance travelled (NZTA, RUC rates and transaction fees, 2020). Referring to the policies and regulations, The EAUT has potential opportunity on New Zealand roads however, the trailer uses motors to be propelled thus making it difficult to access by law. The threat is discussed further on the 'Legal' section.

5.3.1.2 Economical

New Zealand has long enjoyed a stable economic conditions. The average economic growth in New Zealand grew 3.25% in 2018 but is expected to fall to -7.2% in 2020 due to the COVID-19 (wikipedia, 2021). However, the GDP is forecasted to pick up to 5.9% in 2021 (nordeatrade, 2020). Currently, the country relies severely on consumption to boost its GDP, although low interest rates, monetary policies and increase in wages due to decking unemployment also feature into its economic growth (nordeatrade, 2020). The country's entrepreneurial environment is one of the world's most efficient and competitive since it can boost up the employment rate and can contribute to the economic stability of the country (provisas, 2020). Additionally, the average annual household disposable income (after tax and transfer payments) in New Zealand is $81,934 (statsNZ, 2020).

In this development of commercialising the EAUT, the start-up or the business is geographically focused in New Zealand. The condition will be an opportunity for the business as both the suppliers (excluding battery suppliers) and customers are 100% local. Moreover the product targets consumers who are EV owners and most likely to tow trailers for long distance travel. The EAUT reduces the range anxiety for such consumers and be more economical in terms of conserving the battery power and extending the EV range while towing. The product will be more of an economical asset since it benefits both the usage of EV and also in towing without any range problems. However, one of the unsettling factors would be the annual disposable income for the consumers. As mentioned earlier, the average disposable income is $81,934, so it can be guaranteed that the EAUT will be preferred by consumers (preferably trailer rentals) above the average annual disposable income or any early adopter in the EV space. Thus, the EAUT has a medium level threat and opportunity in the economical viewpoint.

5.3.1.3 Social

Currently, New Zealand has the second highest private vehicle ownership rate of OECD countries and the average age of the light vehicle fleet is significantly older than other developed countries (EHINZ, 2020). Furthermore, EV uptake projections were assumed that the percentage of new electric vehicles entering the fleet each year increases linearly until it reaches 4.9% and 43.8% (respectively) in 2040 (iccc, 2020). Most of the consumers are shifting their interest towards EVs due to their zero carbon emission, low maintenance cost and other government incentives (EECA, 2019). Consumers travelling in New Zealand average approximately 12,500km annually (MoT, 2015). The amount they spend annually for fuel if using ICE vehicles is $2500 NZD but, if they are driving an EV, they would spend just $500 NZD (driveelectric, 2021). The cost of charging an EV is just 25c per kWh compared to $2.089 per lire of fuel in New Zealand (globalpetrolprices, 2021). This is a significance savings for the household budget.

Additionally, New Zealand is a country with growing interests in recreational activities which includes people travelling domestically for longer trips on their own vehicles by towing a trailer or a caravan. Additionally, on observation, most of them use light trailers for domestic applications or carrying their boat or hauling horses. Ideally, the EAUT would be much preferred to consumers who does long distance travelling since they are prone to range anxiety and specifically the EV owners. Thus, considering both the conditions of increased demand for EVs and light trailers, the EAUT will provide a great opportunity for such consumers and even for a start-up or rentals in New Zealand. Therefore, the EAUT has more opportunities in the social segment in New Zealand.

5.3.1.4 Technological

Technology is New Zealand's third biggest and fast growing sector and traditional institutions and enterprise businesses are benefiting from it (scoop, 2020). The speed of technology adoption is also a key driver of productivity improvement that influences the rate of economic growth with new opportunities (NZPC, 2019). Furthermore, new technologies inevitably modify and improve the business models with reduced demand and obsolescence (NZPC, 2019). New Zealand New Zealand invests on various technologies in producing clean and sustainable energy. Further technology infrastructure investment opportunities exist in clean technology in supplying renewable energies and clean transportation which includes the uptake of electric vehicles and increased charging infrastructures (EECA, 2019). In terms of transportation, a projected base case based on conservative assumptions of current trends and transport demand shows slow and non-disruptive evolution of technology in New Zealand (transport, 2020).

Besides, there are massive technological advancements in EV batteries shifting the adaptability from commonly used lithium-ion batteries to lithium-sulphur and lithium-silicon batteries. Lithium sulphur battery is one of promising technologies for next-generation energy storage device (Zhou & Yang, 2015). Silicon-dominant batteries are estimated to increase the energy densities from 100-265 Wh/kg to 400 Wh/kg by 2025 (Fotouhi & Auger, 2016). This makes it a promising solution for sustaining the battery life four times longer than the commonly used Li-ion batteries and by tremendously improving the EV range (ecotricity, 2020). Continuous improvement in cell technology has become the key to alleviate range anxiety and other automotive battery related trepidations (imerys, 2020). Nevertheless, the development of battery technology post exponential threat to electric trailers since the similar technology would be implemented in EVs resulting in increased range and offsetting the demand for electric trailers since most consumers would prefer to use a traditional car trailers with EVs with long battery durability. Thus, the EAUT has an impending threat in terms of the technological aspect.

5.3.1.5 Environment

New Zealand is very much adapted to the principles of sustainability. The government has introduced many policies and acts with the primary focus to protect and enhance the environment (MFE, 2020). Much of the economy relies on the natural environment but eventually have a negative impact on it due to the development of technologies in manufacturing and transportation sector. However, the Ministry for Environment with its pioneering policies are improving the energy efficiency, including encouraging energy-efficient transport choices, and reducing wastage (MFE, Sustainable development, 2020). Furthermore, the Zero Carbon or the Climate Change Response Amendment Act provides a scheme to contribute to the global achievement under Paris Agreement to limit the global average temperature to 1.5° Celsius above industry levels. The act also persuade New Zealanders to prepare, adapt to the effects of global climate change (MFE, 2019). The government contemplates to make the public sector carbon neutral by 2015. This would require the public sectors to measure and report their emissions and to offset by 2025 (Beehive, 2025).

Moreover, New Zealand has a consistent solid waste management strategy with a sustainable development plan but much arduous to execute the plan (MFE, 2021). New Zealand is way behind the rest of the world I terms of waste management (Recycle, 2019). Additionally New Zealand is trying to expand the landfill levies with an estimation of diverting 3 million tonnes of weight from landfill and by increasing the recycling rate by 60% (Recycle, 2019)The EAUT is assumed to be made with easily recyclable materials like Steel and Aluminium. Steel has the highest recycling rate of 85% (NZSteel, 2020).

This tractable approach ensures waste management and minimisation activities are appropriate for local situations (MFE, 2021). With transportation moving towards sustainability and with the government making initiatives to incentivise the uptake the EVs, the EAUT has a valuable opportunity in the market. Additionally, the batteries that is no-longer for automotive use may still provide significant value in other markets such as stationary energy storage for renewables (genless, 2017).

However, despite the potential opportunities, the products embraces more threat in New Zealand since the production of these Li-ion batteries have high greenhouse gas footprint and the materials used to manufacture the batteries are more toxic and hard to dispose or recycle (ecotricity, 2020). The current battery recycling plans in New Zealand includes storage in warehouse until effective recycling facilities are in place; and shipping to specialist offshore recycling facilities (genless, 2017). Thus, a significant local market for recycling and repurposing might unlikely emerge in the current scenario.

5.3.1.6 Legal

New Zealand has a very efficient legal framework for transportation which prioritise the responsibility to contribute to an effective and safe system for the public interest set out in the Land Transport Management Act 2003. There are many acts, rules and regulations which are instigated for range of activities from establishing toll roads to implementing driver and vehicle requirements (nzta, 2021).

In the case of the EAUT, It might qualify as a 'motor vehicle' as stated under the 'Interpretations' section of the *Land Transport Act 1998* (legislation, 2020). According to NZTA, a light/car trailer should be unpowered or it should be operable without any motive power (i.e**. they don't have pedals or a motor to drive the wheels**) (nzta, 2017). Thus, the EAUT along with its drive chain mechanism with motors might qualify as a motor vehicle and this perception may develop a potential barrier to operate the trailer on the New Zealand roads. Therefore, a law change may be required to facilitate the application of EAUT. Consequently, the legal segment possess a potential threat to the product in the current market.

As mentioned above, there are several factors which contributes in acclimatizing the EAUT in NZ market. Some of the influential in future market are listed below:

Factor	Opportunities	Threats
Technology	• Improvement in battery capacity/life. • Reduction in component weight and increased safety features.	• Improvements in battery technologies in EVs would be a potential threat for EAUT.
Regulatory Environment	• Not much of policies and regulatory context involved in accessing trailers in NZ.	• Might qualify as 'motor vehicle' since trailers should be unpowered.
Social/Demographics	• EV users who prefer long distance towing of trailers for camping or vacation are more likely to use.	• Not applicable since it applies for people of any age and application.
Parallel goals and promotions	1. Increased promotion of EAUT in general – more people buying more EVs and increased focus towards 'zero carbon'.	• Promotion of powerful EVs from Tesla and Mitsubishi would pave possible threats.
Attractiveness of alternative modes	• Increase in petrol prices for ICVs would focus the consumers to choose EVs. • Government incentivising EV interests among consumers.	• Decreased petrol prices and delay in government interference to increase EV uptake.
Environmental	• NZ has a strong sustainability development plan. • Aiming towards repurposing EV batteries locally. • Flexible waste strategy to ensure post-use waste management and minimisation for local situations.	• Li-ion batteries mostly used for EVs and preferably for the EAUT has high greenhouse footprints. • Not viable in setting up a repurposing facility in New Zealand currently.

Table 3 - Influences on future market

5.3.2 Porters Five Forces

The use of Porter's five forces involves the unceasing process of environment monitoring and gaining a competitive intelligence over potential rival force (Indiatsy & Mwangi, 2014). The intensity of these forces highly defines the average expected level of profitability of an industry and their thorough understanding is beneficial in deciding what industries to enter, and in evaluating how a firm/product can improve its competitive position (McGahan & Monbiot, 1997)

5.3.2.1 Threat of New Entrants:

There is a potential threat of new entrances in the electric trailer market due to the increase in more sustainable transportation globally. However, the competition in New Zealand for a similar technology is yet to be developed.

The EAUT is a new concept in New Zealand market which most of EV owners, trailer manufacturers and rentals have not appreciated yet (From Survey). With the increase in uptake of EVs in New Zealand, the product being developed and commercialised would have a niche market but would require significant amount of ground work to convince most of the consumers to possess a futuristic perspective of the product. If the EAUT becomes successful, there are chances for other companies to follow and replicate their own similar product and this would make the competitive rivalry much higher. If any of the top trailer companies in New Zealand e.g. Kea trailers, Hierace trailers develop their own electric trailer then the rivalry would gradually evolve considering the fact that they already have a loyal customer base. However, barriers to entry could be implemented by producing patents or licencing the technology to trailer rentals or manufacturers.

However, the greatest threat lies primarily on the path to global markets. The German company, E-Trailer founded by Rick Lenssen and Boy Trip have already positioned the electric trailers and electric caravans for production and now on the verge of developing a smart e-trailer system (Repetti, 2017).

Therefore, some of the barriers to summarise this force are: The economies of scale in producing the EAUT will be low in the current market since due to the high battery costs (Porter, 2008), the production could not be increased by lowering the expenses. Secondly, Customer switching costs would me more since with decrease in battery costs for EVs, customers could prefer buying an EV with better battery range than investing on the trailer (Porter, 2008).

5.3.2.2 Competitive Rivalry

With transportation moving towards sustainability, technology plays a vibrant role in developing new eco-friendly products. As shown in **Table 4** some of the potential competitors in the global market includes companies like E-Trailer (e-trailer, 2020), Dethleffs (dethleffs, 2019), EP Tender (Gibbs, 2020). These are companies who are currently commercialising the product in global market and would be a threat if they enter the New Zealand market. In this case the potential competitive rivalry is more towards the sustainable competitive advantage through innovation (Ural, 2014).

New Zealand possess a niche market for trailer manufactures but has a considerable number of trailer rentals and motorhomes. However, the EAUT which is still under development phase does not possess any rivalry in the New Zealand market and will not in the future market. Considering the development of battery technology and decrease in battery costs, the growth for the product will be slow and would be a huge challenge to capture market share (Indiatsy & Mwangi, 2014). Furthermore, with the introduction of new powerful and long ranged EVs like Tesla Model X, Jaguar I-Pace and Hyundai Kona Electric SUV would be potential external competitors in the long run where the consumers would prefer to tow a standard trailer with such powerful EVs.

5.3.2.3 Bargaining Power of Suppliers

For the likely case of the electric trailer being manufactured in New Zealand market would cause complexity since the product is under development phase. Having suppliers and manufacturers while maintaining a considerable level of quality in the development of the product will take huge amount of time, investments and more risks. One of the main suppliers will be the one for batteries for the trailers. But the production of Li-ion batteries are limited in New Zealand (fireandemergency, 2020). The most apparent suppliers would be the battery companies from China, Australia, Canada and Argentina where the production of Li-ion batteries is of large scale (scoop, 2019).

With such limitations it can concluded that the bargainaing power of the suppliers would be really high in this case. Therefore, in the initial stages, it is right to establish the right suppliers and have firm agreements to avoid any supplier issues in the future.

5.3.2.4 Purchasing Power of Buyers

The buyer power in this case is considerably high. The buyers could push down the price, prefer better quality and cost friendly products or could even let the suppliers compete against each other by applying price pressure to the trailer parts suppliers (Aktouf, 2005). There would be no robust demand for the electric trailers if there are more powerful and low cost EVs in the market which will arise the situation of high price sensitivity for the electric trailers. To neutralise the influence of buyer power, the buyers will need to be convinced on the sustainable advantages of the electric trailer.

5.3.2.5 Threat of Substitution

The threat of substitution for electric trailers is large. The two main contributing factors are reduction in price for Lithium ion (Li-ion) batteries and development of low cost battery technology or chemistries. These factors could contribute to the decrease in ownership cost of EVs and would underline the preference for consumers to buy powerful EVs with longer range than an electric trailer.

Lithium ion (Li-ion) batteries which have the capacity to recharge and used as a power source for most of the portable electronic devices. Li-ion battery is the main power source for the EAUT as well. On the contrary, the same Li-ion batteries of higher battery capacity like 40kWh are used in electric vehicles.

The Li-ion batteries have fallen 89% from 2010 in terms to $137kWh in 2020. By 2030, it is estimated to fall to an average price close to $100/kWh (bnef, 2020).At these price points the sticker price for EVs is likely to be lower than that of an IC vehicle. Additionally, using nickel cobalt aluminium oxide has the lowest cost-per-energy content and in turn produces highest energy per unit and is a potential replacement for Li-ion batteries (Viswanathan & Bills, 2020).

Thus, the eventual threat of substitution for the EAUT are the low cost and powerful EVs where the consumers could use such EVs for towing a stand trailer.

Company Name	Product Description
EP-Tender	 This range-extending trailer stores 60kWh batteries and can extend the range to 563km. EP Tender are targeting consumers with small EVs and renting them seems to be a logical choice (Turner, 2020).
Dethleffs GmbH & Co	 Dethleffs came up with the all-electric motorhome which uses battery as well as solar panels as power source. The critical advantage of having a caravan spin its own wheels is cutting down the tow load on the vehicle out front (Weiss C., 2017).
OzX Corp Pty Ltd	 OzXcorp is hard at work on a supplementary electric drive to turn hard-edged Australian off-road caravans into semi-self-propelled all-terrain RVs with Level 4 autonomous capabilities (Weiss C. , 2020)

Table 4 - Potential competitors for electric trailers

5.4 SURVEY SUMMARY

5.4.1 Survey Overview

A survey of interested stakeholders was undertaken to better understand the current climate of light trailers in New Zealand. The stakeholders includes EV and trailer owners and Trailers rentals (Kea Trailers, Sockburn). The EV owners were identified in the Facebook New Zealand EV owner group. The trailers owners were some members of the public. The trailer rentals were identified using a simple Google search and later meeting them through an appointment.

The survey was undertaken with 21 different participants including 15 EV owners, 4 trailer owners and 2 rentals with detailed survey logic designed to ensure each participant was asked only questions that applied to them. The survey conducted was in a semi-structured format and was done face to face with the trailer rentals, owners and online for EV owners.

The EV owners were surveyed based on their idea towards sustainable innovations. Based on assumptions the EV owners are early adopters of any new technology which contributes to the preservation of the environment. Additionally, the survey was conducted to the EV owners to understand how an electric trailer could benefit them and in what ways. The trailer rental was surveyed to understand the consumers purchasing behaviour towards light trailers. Lastly, the trailers owners were surveyed to understand the various applications.

The survey questionnaire can be referred in the **Appendix**

Limitations*: The survey was conducted with only 21 participants which is not enough of a response. One of the main constraints faced in the survey was identifying trailer manufacturers and rentals for an interview. Furthermore, communication barriers and lack of interest from some of the stakeholders constituted to the limitations. However, the survey was performed with the limited number of participants to analyse a basic insight towards light trailers. This led the survey to be in a semi-structured format with the participants especially with the trailer rental company. The sales data obtained from the company were very much inappropriate since it was made classified to their external stakeholders. Only a rough data on the trailer sales is displayed further.*

5.4.2 Survey Findings

When surveyed about the various uses of light utility trailers, most of the consumers stated applications like transporting domestic household materials or home clearance purposes, farming/gardening purposes, industrial needs like carrying or transferring heavy parts/machineries, long trips purposes like camping and hauling boats/jet skis using boat trailers. 12 out of the 15 EV respondents claimed that they have an alternative vehicle just for towing the trailers for various applications.

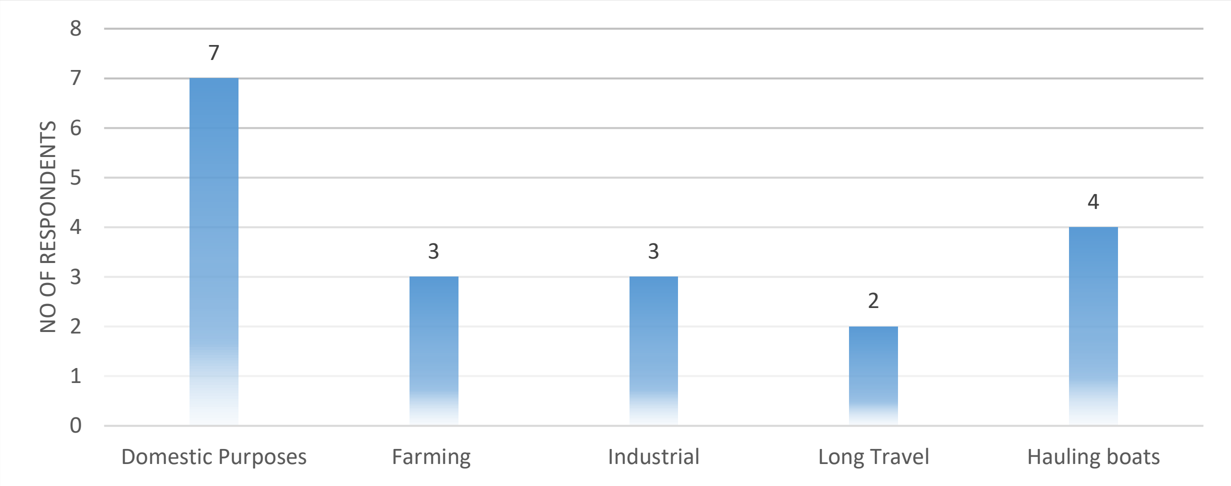


Figure 18 - Survey on types of applications

Additionally, the people who use the trailers as frequently as once or twice a week have determined that renting was still the most cost friendly option compared to purchasing a new trailer.

The other set of survey questions was conducted to one of the developing trailer rental companies ‘Kea Trailers’ to understand the purchasing behaviour of the customers. The average price for renting a trailer for a full day is $35 NZD and a maximum average of 22 trailers are being rented per week. On a semi-structured format, the trend for trailer being rented on a monthly basis was recorded and November appears to be the time for high number of trailer rental bookings. Based on assumptions, this may be due to the fact that New Zealand commence their vacation time during November to December till the mid of January. May to July might be the time for winter enthusiasts to load their skiing gears on trailers and travel for winter activities.

Other findings from the survey conducted with the trailer owners and some of the EV owners were that these consumers use their SUVs or powerful vehicles just for towing purposes. This includes the fuel expenses for just towing the trailer and the use of a powerful bigger vehicle just for towing trailers for vacations once a year (especially the EV owners with an extra vehicle). Additionally, one of the reported drawbacks was that struggle in controlling a trailer with loads due to its swaying motion. Furthermore, towing a loaded trailer uphill is very difficult and more fuel consuming.

One of the recommendations for future research would be to survey the trailer owners initially to gain a basic understanding of the potential disadvantages. This would guide to develop and address the value proposition of the electric trailer to various consumers.

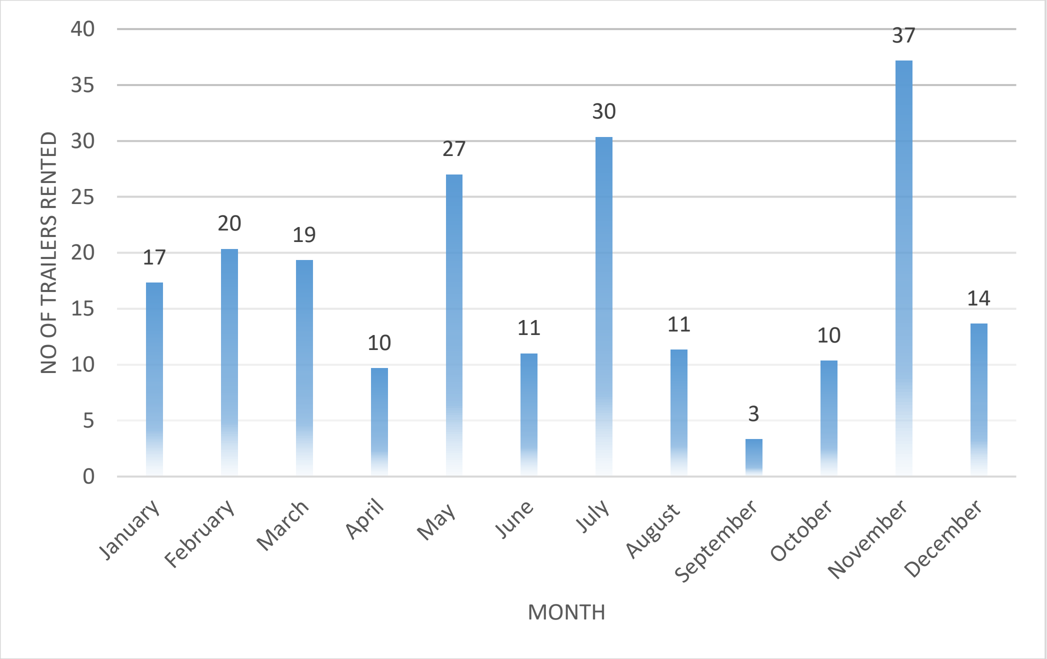


Figure 19 - Monthly demand for trailers from rentals

5.4.3 Key points from Survey

The EV owners, who were the early adopters in EV technology found it inconvenient due to the design complications and cost. Some of the respondents considered the economics of EAUT in EV space where the trailer with motors and battery pack attached would cost more. Moreover, consumers could spend the money on an EV with longer range i.e. instead of a 38kWH Hyundai Ioniq, get a 64kWH Kona as mentioned by one of the participants "Dynamically, it is better to have a powerful EV vehicle like Tesla Model X and a lighter trailer than spending on an electric trailer".

The trailer rentals find the idea has a value proposition in the future after the dominance of the EV uptake. However, they believe the idea do not have any scope in the current market and consequently, finding investors for creating a prototype is very much of a challenge.

As mentioned earlier, a standard utility trailer could be used for various domestic applications and using an EAUT for such small scaled purposes seems to be non-valuable considering the factors like distance and weight. However, some of the respondents were able to consider the value proposition of EAUT as to towing trailers for long distance purposes and if the EAUT could develop a niche market then most of the EV consumers would prefer it to rent for long-travel purposes but with a marginal cost.

6 FINANCIALS (NZD)

6.1 MANUFACTURING & SELLING COST

The cost of manufacturing the Electric assist trailer was estimated based on very basic and underlying assumptions with various external sources. The total manufacturing cost for the EAUT was estimated to be **$12,732.20**.

Part Description	Cost Each	Quantity Req	Total Cost
Direct Material Cost			
13 Rim + Tyre Kit	$171.00	2	$342.00
LED trailer tail light kit	$85.00	1	$85.00
Jockey wheel 150mm wheel	$56.00	1	$56.00
-Braked 2500kg - Tow Coupling	$158.00	1	$158.00
Tandem Spring Roller Rocker 2500kg set	$699.00	1	$699.00
10" Electric drum brake kit	$576.00	1	$576.00
3000kg 65mm Square Axle Kit	$443.00	1	$443.00
Battery Management System for Li-ion battery	$245.00	1	$245.00
Portable charging cable (230V/10A)	$210.00	1	$210.00
20kW Motor	$1,800.00	2	$3,600.00
20 kWh Battery	$5,500.00	1	$5,500.00
Driving Chain	$60.00	1	$60.00
Labour Cost (per hour)	$24.37	2	$48.74
Overhead Cost			
Workshop rent 500sqft-CHC per month	$2,100.00		$525.00
Electricity per month	$400.00		$100.00
Registration Cost for a trailer (<3500 GVM)			$84.46
Total Cost			**$ 12,732.20**
Markup%	65%		$8,275.93
Total Selling Cost			**$ 21,008.13**

Table 5 - Manufacturing and selling costs

Assumptions used:

- The calculation for direct materials was performed considering the basic components of a standard 2500kg Tandem axle (fabplans, 2021).
- The price of 20 kWh battery was projected considering the standard price per kilowatt-hour for a lithium-ion battery pack which is 236NZD/kWh (Boudway, 2020).
- The price of other components like battery management system, charging cables, 20kW motor and driving chain were referred to online sources for the rough estimation (batteryspace, n.d.), (evchargeplus, n.d.).

- The labour cost was calculated based on the survey undertaken with Kea Trailers. Thus, the average labour cost for manufacturing or assembling the trailer was presumed to be $24.37/hr. Additionally, two labours were assumed to be working on a single trailer.
- The overhead cost was estimated considering the rent of a 500 square feet workshop in New Zealand which was estimated to be $2100 per month (realestate, n.d.). Furthermore, the cost of registration of a trailer (GVM < 3500) which is $84.46 was added (NZTA, 2021).
- The electricity per month was estimated to be $400 [3] for a 500 square feet commercial workshop. In this case, according to the report published by build magazine, the average cost of electricity for a new office building is 100kWh/m²/yr (Bishop, n.d.).
- A basic whole sale mark-up value of 65% (aucklandchamber, 2014) was included to estimate a total profit margin of **$8,275.93** per electric trailer.
- Therefore, the total selling price of the EAUT was estimated to **$21,008.13.**

6.2 Revenue and Expenses

The revenue is calculated to be generated annually from the sales of the EAUTs to the rentals or direct customers. Conferring to the survey, most of the participants preferred to acquire the EAUT from rentals rather than purchasing one due to its increased cost of ownership. However, the revenue can be derived based on the annual output. Some of the assumptions made in this case are:

- The target market for the EAUT is the EV owners who tow trailer for long trips. Hence, the predicted initial percentage of the target market range from 1% in month1 of Y0 to 10% in month 12 of the same year.
- Due to the limited numbers in the initial period, it is assumed that one trailer could be manufactured per day and the total building capacity per month could be 20 trailers.
- The revenue at the end of month12 for Y0 by selling an average of one EAUT per month is projected to be $16,551.86 NZD.

[3] (100kWh/m²/yr * 47 m² (500sq.ft.))/12 = $392~ $400

Year	Quarterly servicing capacity	Month	Trailer capacity (% of the target market)	Total building capacity	Month wise Capacity for production	Rev
Year 0	Q1	M1	1%	20	0	$ 1,655.19
		M2	1%	20	0	$ 1,655.19
		M3	1%	20	0	$ 1,655.19
	Q2	M4	2%	20	0	$ 3,310.37
		M5	2%	20	0	$ 3,310.37
		M6	3%	20	1	$ 4,965.56
	Q3	M7	4%	20	1	$ 6,620.74
		M8	4%	20	1	$ 6,620.74
		M9	5%	20	1	$ 8,275.93
	Q4	M10	6%	20	1	$ 9,931.12
		M11	8%	20	2	$ 13,241.49
		M12	10%	20	2	$ 16,551.86
Total Year					**9**	$ 77,793.74

Table 6 - Estimated revenue for Year 0

The revenue and expenses are further analysed for economic feasibility in New Zealand. Some of the assumptions made for estimating the cumulative NPV are:

- The tax rate was assumed to be 18% (newzealandnow, 2021) and the discount rates for the NPV is 5% as referred in the 'Treasury' (treasury, 2021).
- Two labours (student in case of a uni project) are assumed to be adequate for assembling the EAUT. Due to the development stages, no additional labours needs to be included.
- The other OPEX costs includes, the rent for the workshop, electricity, consumables, material transport and branding. These costs are assumed to have a year-on-year increase of 5% starting from year 1.
- From the output obtained from the economic analysis, it can be observed the NPV for the first 9 years of operation is in negative. Commencing from year 10, the profit grows linearly and the value of NPV becomes positive and exceeds further. It can be concluded based on the market analysis that the uptake of EV fleet would increase more after 10 years and with the development of EV infrastructure and batteries, the EAUT will develop a niche market since the number of customers could increase in New Zealand and thereby increasing the production levels of the electric trailers.

Year	Y1	Y2	Y3	Y10
Revenue				
Trailer Kit	77,794	85,573	94,130	183,434
Grand Total	77,794	85,573	94,130	183,434
Fixed expense ($)				
Salaries ($)				
Labour Cost @2 people full time	93,581	95,452	97,361	111,838
Total salary	93,581	95,452	97,361	111,838
Workshop rent 500sqft-CHC	25,200	25,200	25,200	25,200
Variable expense $				
Electricity	4,800	4,896	4,994	5,736
Material transport	1,556	1,711	1,883	3,669
Branding & Marketing	1,556	1,711	1,883	3,669
Consumables (Materials) + Workshop miscel	1,556	1,711	1,883	3,669
Total Operational expenses	34,668	35,230	35,842	41,942
Total expenses	128,248	130,683	133,203	153,780
Gross Profit				
Finance charges				
OH @ 12%	15,390	15,682	15,984	18,454
Grand total expense	143,638	146,365	149,188	172,234
Profit/loss				
EBTA ($)	(65,844)	(60,792)	(55,057)	11,200
Profit/loss%	-85%	-71%	-58%	6%
Tax @ 18% ($)	0	0	0	2016
PAT ($)	- 65,844	- 60,792	- 55,057	9,184
NPV @5% ($)	-61537	-56815	-51455	8583

Table 7 - Economic analysis of EAUT

6.3 Sensitivity Analysis

A sensitivity analysis for performed to analyse the potential variables like cost of lithium-ion battery pack and how it affects the selling cost and overall profitability of the EAUT.

The assumptions made in this analysis are based on the price projections by BloombergNEF (Goldie-Scot, 2019). Some of the assumptions based on their forecast between price and volume of the Li-ion battery packs.

Note: In the below description the prices are presented in NZD

- 18% reduction rate for Li-ion prices forecasted till 2030 (Goldie-Scot, 2019).
- Based on that some of the assumptions were made for decrease in Li-ion battery prices for 5% and 10%.

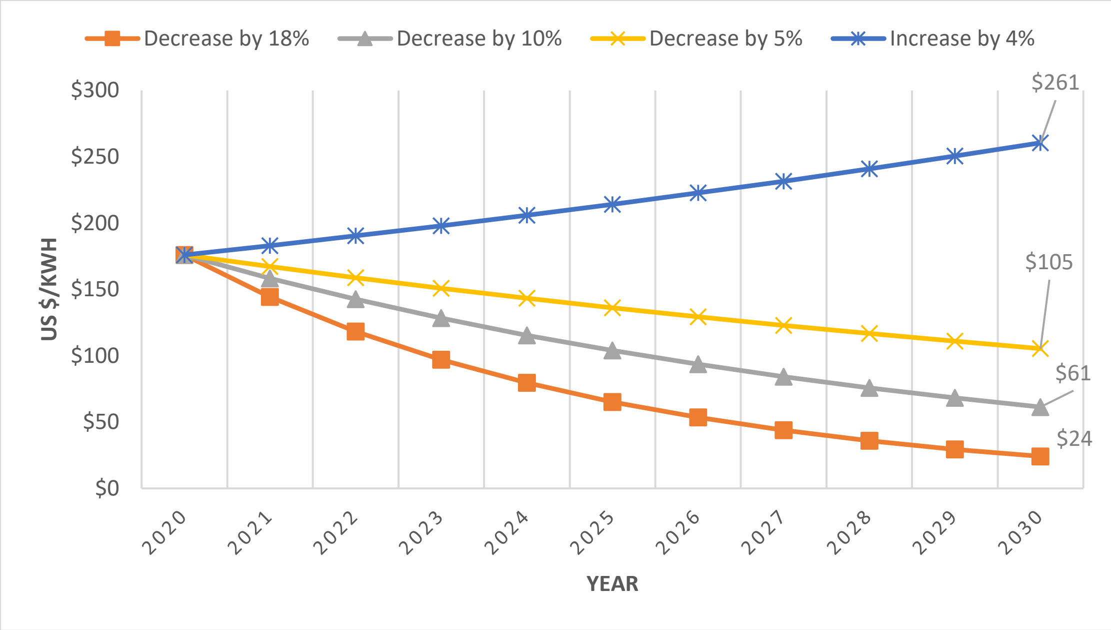


Figure 20 - Sensitivity analysis for battery price

- Lastly, based on the metal prices and desire of battery manufacturers to increase their profit margin, an increase if price of 4% was assumed.
- Based on the assumptions on the battery price, there were variations in the total selling cost of the EAUT as well.
- At the normal price of Lithium battery pack which is $236/kWh NZD, the cost of a 20kWh battery used in the EAUT is estimated to $5500kWh and consequently, the total selling cost of the EAUT is **$21,008.13 NZD.**
- The assumed reduction rate of 18% for the price of the battery pack yields up to $23/kWh NZD for which the selling cost is estimated to **$11,429.19 NZD.** Additionally, a reduction rate of 5% is projects a standard battery pack cost of $102/kWh which lays the price of the EAUT to **$14,633.69 NZD.**
- Lastly, the increase rate in price for the Lithium-ion battery pack by 4% surges the battery cost to $252/kWh NZD. In this case the cost of the EAUT is estimated to be **$20,738.19 NZD.**

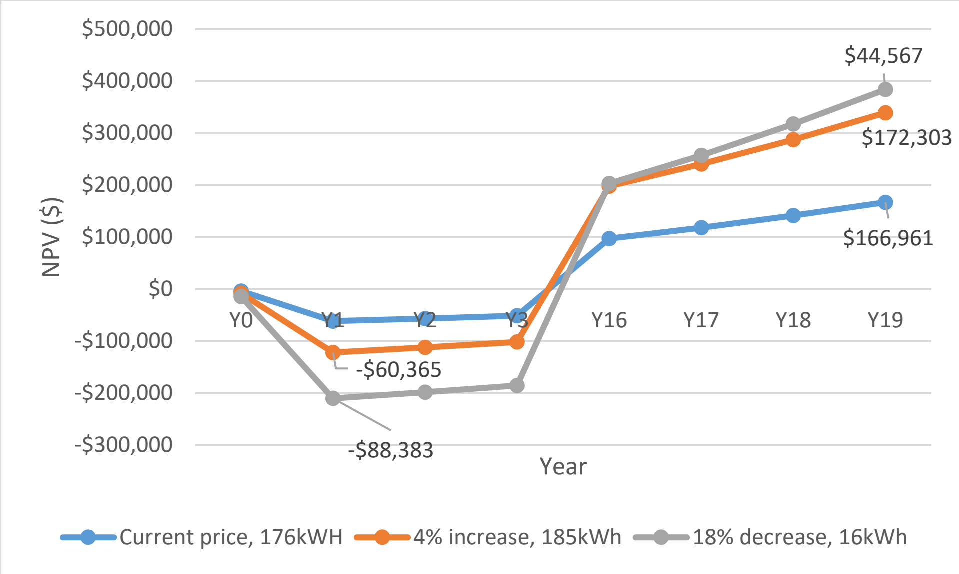


Figure 21 -Sensitivity analysis for NPV

Besides the baseline price scenario, the assumed variables of the Li-ion battery pack with the current price ($176/kWh), 4% increase in battery price ($185/kWh) and 18% decrease ($16kWh) were considered.

- With current price of the Li-ion battery, the NPV of the EAUT stays negative in the first 9 years. However, a gradual increase in the NPV occurs on year 10 and linearly increases further on. As roughly plotted in **table,** by year 19 of operation, the NPV holds a higher and positive value of $166,961.
- When the prices of Li-ion battery pack increases moderately by 4%, The NPV reaches to a negative value of -$60,365 during the initial 8 years of operation. But after year 8, the value of NPV invariably increases to a positive value and yields a total value of $172,303 by year 19.
- On the contrary, when the prices drop down with a decrease rate of 18%, The NPV reach the lowest value of $88,383 and possess a negative value till year 12. However, due to the low battery cost, the value increases progressively but at a very slow pace. The NPV by year 19 is estimated to be $44,567.

By combining the above assumed factors, the increase in battery cost results in a high selling price but the value of NPV seems profitable after 10 years of operation. Nevertheless, with a low battery cost, the selling price appears to be amiable but in terms of profitability, low battery cost consumer longer period and is not economically feasible.

7 Target Market Size

As mentioned in the **Market Analysis,** the ideal target market for the EAUT is electric vehicle owners who prefer to tow a trailer for long trips. They may lease the trailers from rentals or a very low margin of them could afford to purchase the trailer. Some of the assumptions includes:

1. Based on the data obtained from the forecasted EV fleet size by the Ministry of Business, Innovation and Employment (MBIE, 2015) and establishing on their growth percentage, the number the Forecasted EV sales was projected as shown in **Figure 22**.

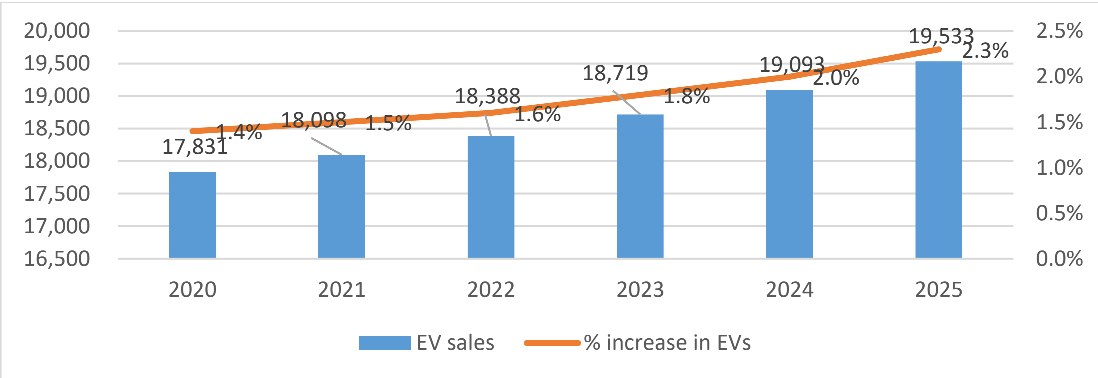


Figure 22 - Projected EV sales in New Zealand

2. Secondly, the data for light passenger vehicles and trailers registered in New Zealand were obtained from Ministry of Transport website (MoT, 2019). The data was selected for the time period from 2000 to 2019 for both trailers and light passenger vehicles. The percentage of trailers to cars ration in New Zealand was calculated to be 1.15% in 2019. In other words, there is one trailer for every 87 cars in New Zealand.

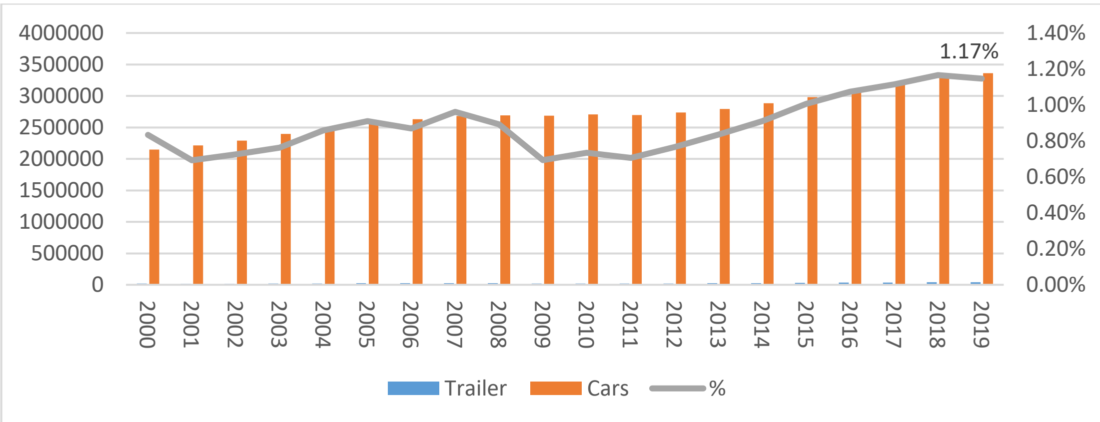


Figure 23 - Percentage of trailers to car ratio

3. Based on the assumption from 1 and 2 by considering the EV fleet size and percentage of trailer to car ratio of 1.15%, the target market count for the next five years was estimated as **below**. The percentage was further assumed to be 1.50% and 2% based on the current ratio.

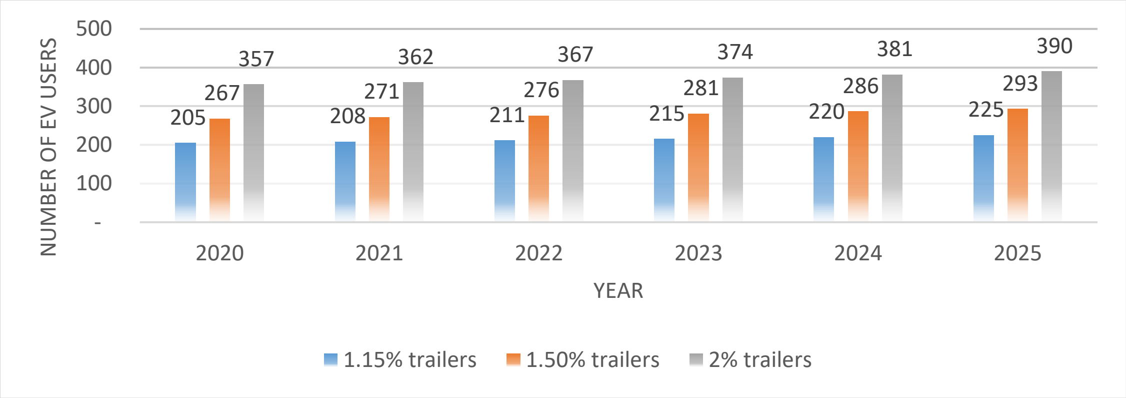


Figure 24 - Target market size (a)

4. Furthermore, the market size was calculated by combining the profit margin and the target market size. The market for 1.15% of EV owners was estimated to be 2.6 million by 2025. Similarly, the market size for the assumed proportion of 1.50% and 2% was estimated to be 3.5 million and 4.6 million respectively.

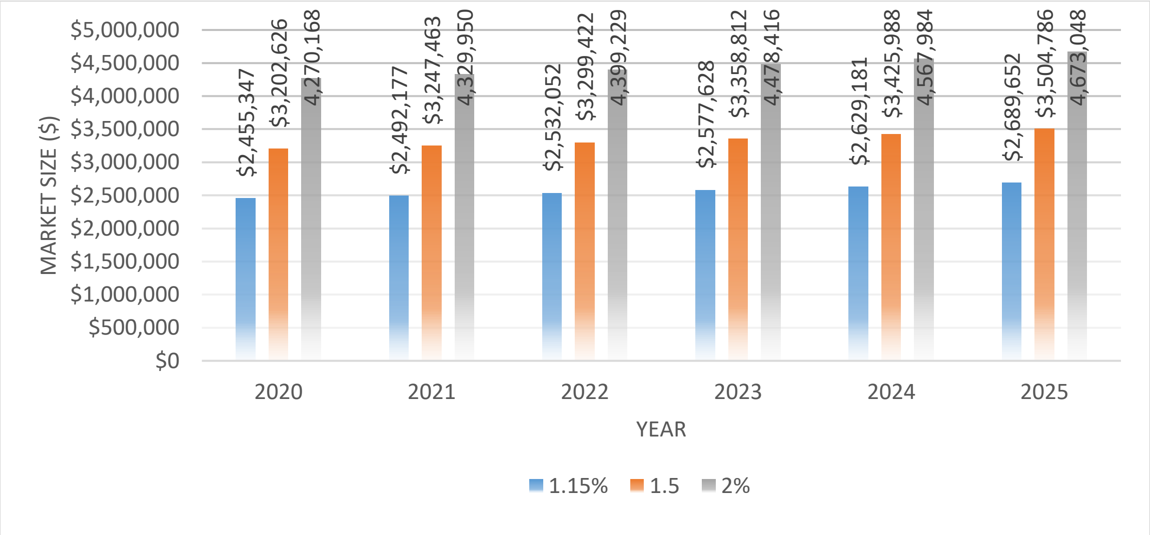


Figure 25 - Target market size (b)

5. The overall evaluation for the market size was concentrated only to New Zealand market. However, there were limitations in extracting and referencing the data from other markets and preferably the data for registered trailers.

8 LEGAL AND REGULATORY FRAMEWORK

As mentioned in the 'Legal' segment of the PESTEL analysis, New Zealand has a very efficient legal framework for transportation which prioritise the responsibility to contribute to an effective and safe system for the public interest set out in the Land Transport Management Act 2003. There are many acts, rules and regulations which are instigated for range of activities from establishing toll roads to implementing driver and vehicle requirements (NZTA, 2021).

In the case of the EAUT, It might qualify as a 'motor vehicle' as stated under the 'Interpretations' section of the *Land Transport Act 1998* (Legislation, 2021). According to the Land Transport Management Act of 2003, it is clearly stated that a motor vehicle means '*vehicle drawn or propelled by mechanical power'* (Legislation, 2021). A law change may be required to facilitate the application of EAUT on New Zealand roads. Additionally, NZTA describes a light trailer as 'Vehicles with no motive power (they don't have pedals or a motor to drive the wheels) (NZTA, 2021). Light Trailers include class TA trailers with a GVM of 0.75 tonnes and class TB trailers of 3.5 tonnes (NZTA, 2021). Furthermore, a light simple trailer has one, two or three axles and is attached to the rear of the towing vehicle. Other trailers like boat trailer, campervans horse trailers cannot be termed as 'Simple Trailers'. Thus, by contemplating the conditions the EAUT if made legal would not be therefore considered as a simple trailer (NZTA, 2021).The NZTA, gives more accurate context and describes the types of trailers and its corresponding dimensions that are legally allowed on the New Zealand roads. A detailed prospectus on the legal framework for light trailers are described in **Appendix**

With reverence to some of the policies and regulations discussed in the 'Political' segment of the PESTEL analysis, the EAUT does not require a Fringe Benefit tax (FBT) according to the exemptions made on motor vehicles (ird.govt, 2020) and might not adhere to the income tax according to the exemptions made under the motor vehicle section of the Income Tax Act 2007 (legislation, 2020). Secondly, the product will comply with the policies of Land Transport NZ which infers about the WOF and registration procedures for new trailers and similarly about the loading and towing practices in New Zealand (NZTA, Light trailer requirements, 2021). Finally, the road user chargers (RUC) applies for the trailers or even caravans irrespective of weights, dimensions and distance travelled (NZTA, 2020).

One of the other major concerns to be discussed is the ‘zero tow rating’ specification of most of the light EVs. Naturally, electric motors are recommended to pull loads and with the high amount of torque produced from a stand still EV, it is easily the best option to tow when compared to an ICE vehicle (Lucas, 2019). However, cars like Mitsubishi Outlander PHEV is the most affordable towable car in the market with a towing capacity of 2000kg. The only fully electric car capable of towing with tow ratings is Tesla Model X. Some of the main factors to be considered for towing with a pure EV are:

- Most of the car manufacturers do not approve the EVs for towing and most instances EVs by different manufacturers are not approved. Tesla can be an exception (Saarinen, 2020).
- The weight of the car is one of the reasons why EVs are not approved for towing conditions. The battery pack inside the vehicle constitute a high GVM and when a trailer or caravan is attached, it affects the major components like brakes and strain electric motors (Saarinen, 2020).
- The main contributing factor is ‘Range Anxiety’. This is the main reason for ‘zero tow ratings since the extra load and torque required could drain the battery capacity rapidly.
- Based on the Australian consumer law, it’s stated that the warranty will not be voided if there is any damage incurred to the EV due to towing purposes (Hunt, 2019). Additionally, the US Nissan Leaf manual and guide states that warranty will not be covered by misusing the vehicle like overloading and towing (Nissan, 2020).

Figure 26 - Damaged caused in Nissan Leaf due to towing

- **Figure 26** displays a non-claimable road accident incurred. The warranty was not claimed since the tow bar attached to the Nissan leaf ripped the chassis rails during the collision. This picture was shared by one of the participants of the survey from the Facebook New Zealand EV community.
- It is illegal to tow trailers or campervans using a pure EV if the manufacturer has specified the maximum towing capacity to be zero (Saarinen, 2020).
- Lastly, according to NZTA, it clearly states that ***vehicles may carry loads irrespective of the dimensions but provided the load does not exceed the maximum permitted dimension of that particular class and type of vehicle*** (NZTA, 2021). In the case of EAUT this may stance as another potential barrier since the mass of the trailer loaded with battery packs is unknown.

9 LIMITATIONS

The overall project had much of limitations than opportunities. One of the limitations of the project is data collection during primary research. The primary research methods used here are observation and survey with stakeholders. The data collected was not much accurate since not many assumptions were made by observing the consumer's trailer usage patterns. Secondly, the survey was conducted with a limited number of 21 participants which is not much of a response to have an accountable evidence. Moreover, the interview was in a semi structured format where there is lack of extensive resources. Though it was semi-structured there were not enough participants to draw conclusions and make comparisons over the content. Furthermore, finding an interviewer in trailer rentals and manufacturing companies was much challenging. Not many of the participants were interested to be a part of the survey. The data collected from the trailer rental company (Kea Trailers, Sockburn) was just limited and no conclusions could be made since it's the only company to be enquired.

The secondary research sources were very limited especially for developing a perception on the light trailer market in New Zealand. However, an adequate data was gathered and analysed to comprehend the trend but not the customer behaviour. Additionally, more prevalent assumptions were used in cost analysis and market evaluation instead of a peculiar approach due to the confined data on light trailers.

In terms of the product, the studies and ideas were very delicate in the field of electric trailers since it's a new entrant into the New Zealand market. Therefore, some of the technical assumptions like battery and motor specifications were made. No previous prominent technical data were available. Therefore it is hard to draw solid assumptions on the advantages of EAUT. Moreover, most of the external stakeholders (EV owners, rentals) are interested in making decisions by witnessing a working prototype but the product has not reached to the development phase. Therefore finding an external investor for funding the development phase of the project was complicated thereby making the commercialisation options very narrower.

10 KEY FINDINGS & CONCLUSION

The aim of the project was to analyse, estimate and provide an evidential validation to EPECentre's decision to commercialise the Electric Assist Utility Trailer specified within New Zealand market. Various analysis and perceptions were considered for the commercialisation pathway.

It was found that the light EVs in New Zealand accounted for 2.1% of the overall light vehicle registrations. Used Nissan leafs contribute to nearly 53% of the EV fleet in New Zealand. The penetration of EVs in New Zealand has grown from 0.13% to 2% by 2019. Used Nissan leafs contribute to nearly 53% of the EV fleet in New Zealand. Furthermore, the EV sales in New Zealand are expected to increase from 17,831 to 19,533 by 2025. There are government policies and regulations which incentivise the upsurge the EVs in New Zealand. Thus, New Zealand has a better projected market for light electric vehicles.

A considerable number of New Zealanders use trailers for various purposes. One of the application of light trailers include towing trailers for long trips. Most of the car trailers are manufactured locally in New Zealand. The average annual growth rate over time is 4.62% in New Zealand and it is forecasted to increase up to 48,496 by 2025. The percentage of trailers to cars ration in New Zealand was calculated to be 1.15% in 2019.

The competitor analysis revealed that there is no potential competitor within the domestic market. However, in terms of global market there is a potential for competitive market since there are companies which has developed and commercialised electric trailers in their regional markets especially in Europe. Furthermore, in terms of the patent review, there were no registered patents for a similar idea and technology in New Zealand.

In terms of financials, the total manufacturing cost for the EAUT was estimated to be $12,732.20 and the selling cost was $21,008.13. In terms of the economic analysis, the profitability is very low and grows to a positive margin after 10 years of operation. Additionally, based on the sensitivity analysis, higher battery costs yields a faster profit margin whereas the lower battery cost consumers longer period of time making it economically unfeasible.

The potential market size for the EAUT was estimated 2.6 million by 2025 with a target market of 1.5% of the EV owners. Similarly, the market size for the assumed proportion of 1.50% and 2% was estimated to be 3.5 million and 4.6 million respectively.

However, in terms of the legal frame work, the EAUT, It might qualify as a ‘motor vehicle’. According to NZTA, a light/car trailer should be unpowered or it should be operable without any motive power (i.e**. they don’t have pedals or a motor to drive the wheels**) .Thus, the EAUT along with its drive chain mechanism with motors might qualify as a motor vehicle and this perception may develop a potential barrier to operate the trailer on the New Zealand roads. Therefore, a law change may be required. Consequently, the legal segment possess a potential threat to the product in the current market.

Implying to the various insights of the report from market analysis, surveys, cost analysis and macro environment analysis, the EAUT potentially has less scope for marketability and thus commercialisation are very narrow in the current market.

11 RECOMMENDATIONS

Some of the recommendations from the project includes:

- The technical aspects of the EAUT should be sorted out initially. This makes it much facile to make solid assumptions based on market and cost.
- This market research is limited to the New Zealand market. However, research over international markets needs to be conducted to define the potential of the product. Potential markets include Europe, China and Japan since the number of EVs are high and they are early adopters of innovation and technology.
- The technology could be aimed to be implemented in caravans since most of the New Zealanders tow caravans for long trips and vacations compared to trailers. There are more caravan rentals in New Zealand and could be a better target market.
- In terms of revenue and profits to be higher, the production capacity of trailers should increase per month. Since the battery cost is high and with lack of customers, there will be no profit in the current market. However, the market can be valuable after 10 years with the increased number of electric vehicles and less battery cost and in this manner the production can be increased.
- If commercialisation is feasible, forming a joint venture with any of the trailer manufacturers or rentals in the initial stages would be lucrative.

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13 Appendix-A EV Incentives in New Zealand

On 5 May 2016, the Government announced its electric vehicle uptake package, a cross-government programme of work that aims to accelerate the uptake of electric vehicles in New Zealand to reach 64,000 vehicles by the end of 2021, reducing our greenhouse gas emissions. ***Currently, 84% of New Zealand electricity is generated by rain (hydro dams), geothermal, and wind, so the source of the car's fuel is environmentally friendly, and inexpensive, and produced locally. To reach the goal of being net zero carbon by 2050, 100% of cars entering NZ from 2030 would need to be electric. All this would demand 17% more electricity, which can either be largely met by the closure of Tiwai aluminium smelter or building consented renewable power stations*** (nzherald, 2017). From figure (3), (4) and (5) it is evident that the light pure EVs or BEVs are substantially increasing in numbers. There are currently 22,621 EVs (PHEVs and BEVs) being registered in New Zealand out of which there are 16,939 BEVs (transport.govt.nz, 2020).

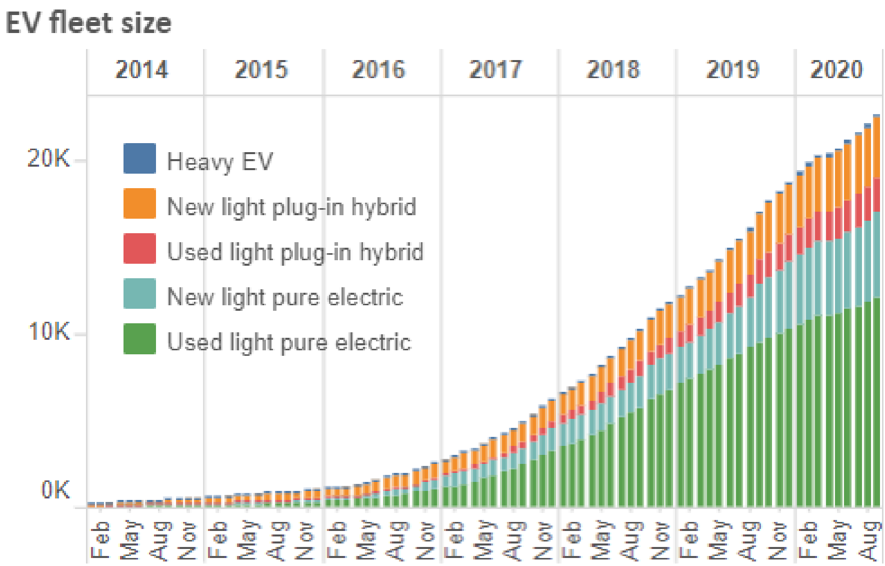


Figure 3

https://www.transport.govt.nz/mot-resources/vehicle-fleet-statistics/httpswww-transport-govt-nzmot-resourcesvehicle-fleet-statisticshttpswww-transport-govt-nzmot-resourcesvehicle-fleet-statisticsmonthly-electric-and-hybrid-light-vehicle-registrations/

Recently, pure EVs have out-sold plug-in-hybrids. Since the fourth quarter of 2016, more than 70% of light EV registrations have been pure EVs.

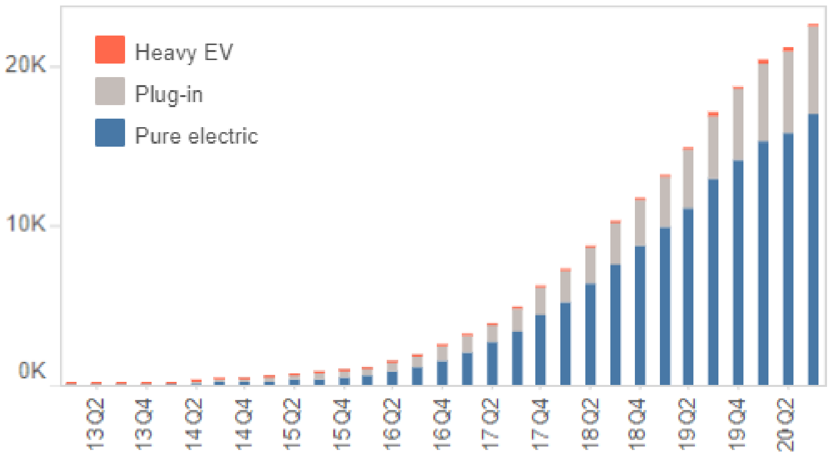


Figure 4

https://www.transport.govt.nz/mot-resources/vehicle-fleet-statistics/httpswww-transport-govt-nzmot-resourcesvehicle-fleet-statisticshttpswww-transport-govt-nzmot-resourcesvehicle-fleet-statisticsmonthly-electric-and-hybrid-light-vehicle-registrations/

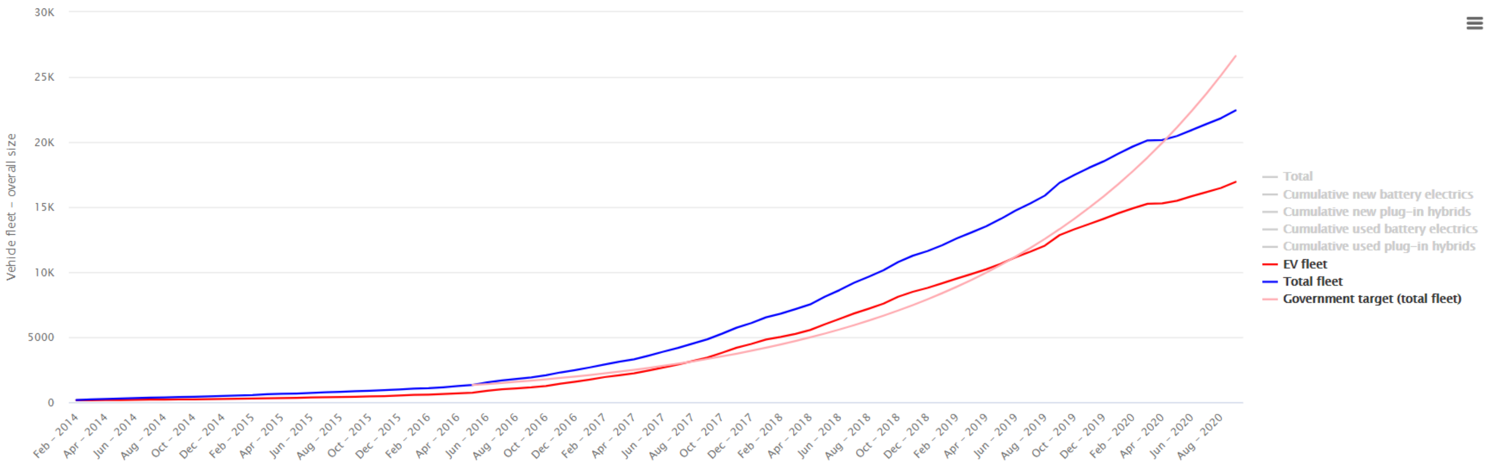


Figure 5

https://dashboard.flipthefleet.org/reports/public/9c9ec8f5-e30d-4923-b133-3ddb36cc5728#

New Zealand is well suited for electric vehicles and the Government is committed to supporting the uptake for the following reasons:

- Around 80 percent of New Zealand's electricity generation is from renewable sources and there is enough supply of renewable electricity, either existing or consented, to power New Zealand's entire light vehicle fleet in coming years.
- New Zealand has more than enough consented renewable electricity generation waiting to support the widespread adoption of electric vehicles.
- Driving a fully electric EV in New Zealand results in 80 percent fewer carbon dioxide (CO_2) emissions than driving a conventional vehicle. As the renewable proportion of New Zealand's electricity continues to grow, the CO_2 emissions from EVs will reduce further.

- Increased use of electric vehicles will replace petrol and diesel with clean, green, locally produced energy, lessening our reliance on imported oil. Rising petrol prices and fuel taxes also make electric cars attractive.
- High renewable energy levels mean that the emission reduction benefits of electric vehicles in New Zealand are greater than in other countries and reducing our reliance on imported fossil fuels, which currently cost New Zealand consumers around $9 billion per year.
- New Zealand motorists drive on average 29 kilometres per day. Average commutes in urban centres are even shorter, at about 22 kilometres a day—a distance electric vehicles can handle easily without recharging.
- 85 percent of New Zealand homes have off-street parking, meaning electric vehicles can be easily charged overnight at home.
- New Zealand’s 230-volt electricity system means every home has the potential to charge an electric vehicle.
- Electric vehicles are cheaper to run than petrol or diesel vehicles. On average, charging an electric vehicle at home is equivalent to buying petrol at 30 cents a litre, compared to petrol, which is around $2 a litre.

13.1.1.1 Electric Vehicles Programme by NZ Government

- New Zealand's intended nationally determined contribution to the new climate agreement is to reduce greenhouse gas emissions by 30 percent below 2005 levels by 2030. This target corresponds to a reduction of 11 percent from 1990 levels.
    - New Zealand’s gross greenhouse gas emissions in 2018 were 78.9 million tonnes of carbon dioxide equivalent (Mt CO2-e). Compared to 1990, this is a 24 per cent increase in emissions.

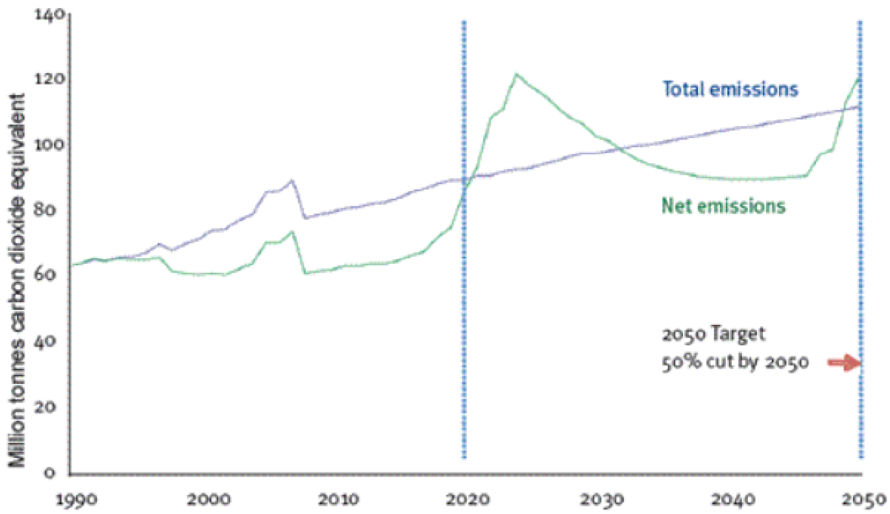


Figure 6

https://www.mfe.govt.nz/publications/rma/gazetting-new-zealands-2050-emissions-target-ministers-position-paper/gazetting-new

- Transport accounts for almost 17 percent of New Zealand’s greenhouse gas emissions. Transport emissions are currently 60 percent above 1990 levels and

projections in the Ministry for the Environment Second Biennial Report1 indicate that by 2020, transport emissions will be 58 percent above 1990 levels.
- A range of measures are already in place to reduce transport emissions. However, the contribution that EVs could play is underexploited. Benefiting from EVs potential requires consideration of the role government should play in facilitating an uptake in EVs.

The Electric Vehicles Programme includes several initiatives:

Extending the Road User Charges (RUC) exemption on light vehicles until they make up two percent of the light vehicles fleet:

- On 22 September 2016, the RUC exemption for light electric vehicles was extended until 30 December 2021.
- This will save the average electric vehicle driver approximately $600 per vehicle each year. The incentive is part of a government programme that aims to see 64,000 EVs on New Zealand roads by the end of 2021.
- Below are some of the proposed options to use the RUC system to encourage electric vehicle uptake:
  - ***Option 1:*** The status quo – the RUC exemption applies to light electric vehicles until 30 June 2020 by which time they are expected to make up about one percent of the light vehicle fleet.
  - ***Option 2***: Amending the RUC exemption for light electric vehicles to apply from the date each vehicle is registered in New Zealand, for a finite period (for example, 5 years).
  - ***Option 3:*** Extending the RUC exemption to apply until two percent of the light vehicle fleet is electric in New Zealand.
  - ***Option 4:*** Extending the RUC exemption to apply to heavy electric vehicles until two percent of the heavy vehicle fleet is electric.
  - ***Option 5***: Amending the RUC Act to enable a discounted RUC rate for heavy electric vehicles (transport.govt.nz, 2020).

Work across government and the private sector to investigate the bulk purchase of electric vehicles:

- In December 2016, New Zealand Government Procurement (NZGP) added 15 new electric vehicle models to all of government vehicles contract to support the uptake of electric vehicles.
- NZGP is continuing to work to increase EV fleet purchases and is undertaking a pilot programme to assess EV demand across public and private sector organisations.

Government agencies coordinating activities to support the development and roll-out of public charging infrastructure including providing information and guidance

- The New Zealand Transport Agency (NZTA) has worked closely with local and central government agencies, power companies, technology providers and the motor industry to produce guidance on public charging infrastructure for electric vehicles.

A contestable fund of up to $6 million per year to encourage and support innovative low emission vehicle projects

- The Government established a contestable fund to encourage innovation, investment and help accelerate uptake of electric and other low emission vehicles in New Zealand.

Review of tax depreciation rates and the method for calculating fringe benefit tax, for electric vehicles to ensure electric vehicles are not being unfairly disadvantaged

- Inland Revenue has been asked to review the tax depreciation rate, and the method used to calculate fringe benefit tax, for electric vehicles to ensure it is fair.
- Inland Revenue has received information from several stakeholders that have made their own analysis or assessment of electric vehicles, to aid in its review.

13.1.1.2 Cost projections for Electric vehicles in New zealand:

The incremental cost for an EV may be less in the future due to the increase in cost for ICEs. Figure (7) shows the High, Medium and low projections of the incremental manufacturing costs for a BEV with 120km range like Nissan Leaf, VW e-Golf and Renault Zoe (Kuschel, 2015).

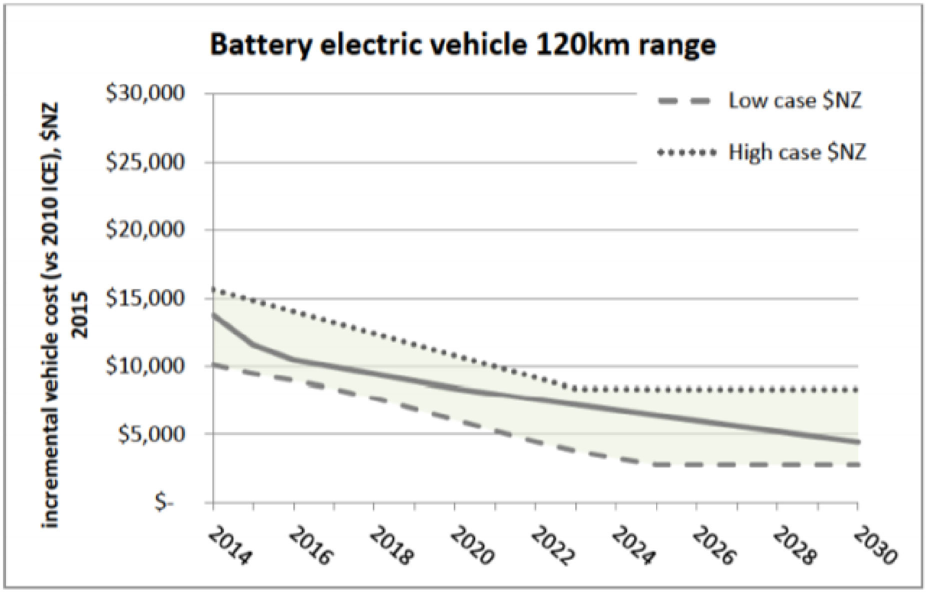


Figure 7

https://www.transport.govt.nz/assets/Uploads/Our-Work/Documents/d29e8fb80f/Report-New-Electric-Vehicle-Trends.pdf

A summary of the cost projections shows the incremental cost of an EV is expected to decrease in the further run due to the demand in its increased usage. The below figure lays out the current cost of manufacturing a BEV with various ranges.

		2015	2020	2025	2030
		NZ$ 2015			
BEV - 120km range	low	9,461	6,060	2,782	2,782
	medium	11,569	8,425	6,393	4,422
	high	14,821	10,790	8,363	8,363
BEV - 160km range	low	11,186	7,139	3,232	3,232
	medium	13,707	9,966	7,548	5,192
	high	17,595	12,793	9,904	9,904
BEV 240km range	low	14,631	9,292	4,130	4,130
	medium	17,975	13,042	9,855	6,730
	high	23,131	16,792	12,980	12,980
PHEV 50km range	low	10,707	7,922	5,292	5,292
	medium	12,175	9,568	7,805	6,433
	high	14,438	11,214	9,176	9,176

Figure 8

https://www.transport.govt.nz/assets/Uploads/Our-Work/Documents/d29e8fb80f/Report-New-Electric-Vehicle-Trends.pdf

It can be observed that the cost of an EV with 120km range (e.g. Nissan Leaf) is between NZ$9500 and NZ$15000 and is expected to drop somewhere between NZ$3000 and NZ$8500 by 2030.

13.1.1.3 Relative cost for electric vehicles:

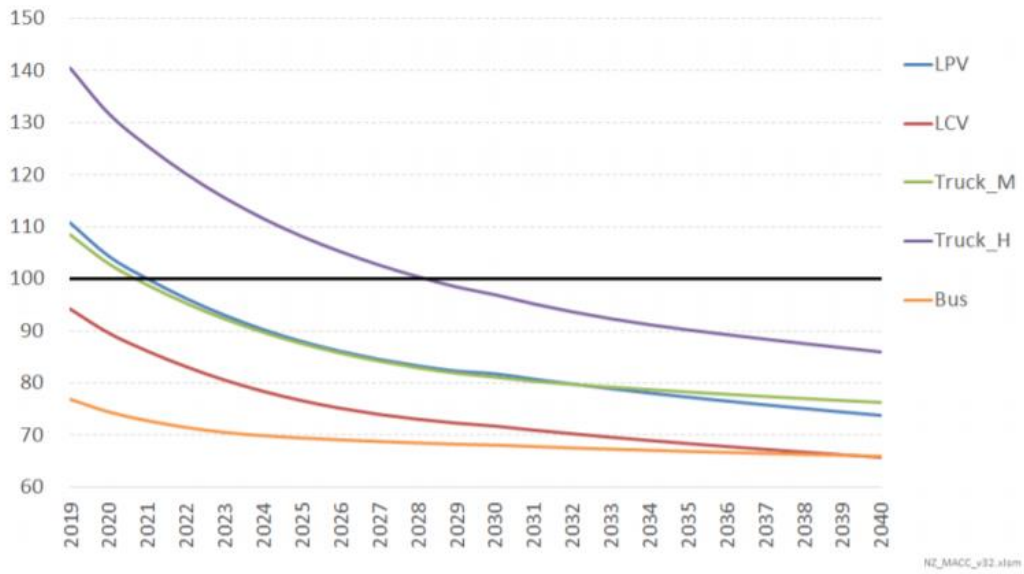


Figure 9

https://www.oriongroup.co.nz/assets/Value-of-EVs-to-NZ-Concept-Consulting-August-2019.pdf

Figure (9) shows the change in the projected lifetime total cost of an EV vehicle relative to an ICE vehicle, averaged across all vehicle situations, from a whole-of-New Zealand perspective – i.e. based on the underlying economic costs of purchasing and running the vehicles, and including the respiratory health costs associated with ICE tailpipe emissions, but excluding carbon costs. From this whole-of-New Zealand total lifetime cost perspective, the model is projecting that, even without a cost of carbon, electric vehicles are already lower cost options than their ICE counterparts. The below figure (10) shows the lifetime cost components for new vehicles purchased in 2025. This includes the cost of carbon, with carbon emissions notionally priced at NZ$100/tCO2-e.

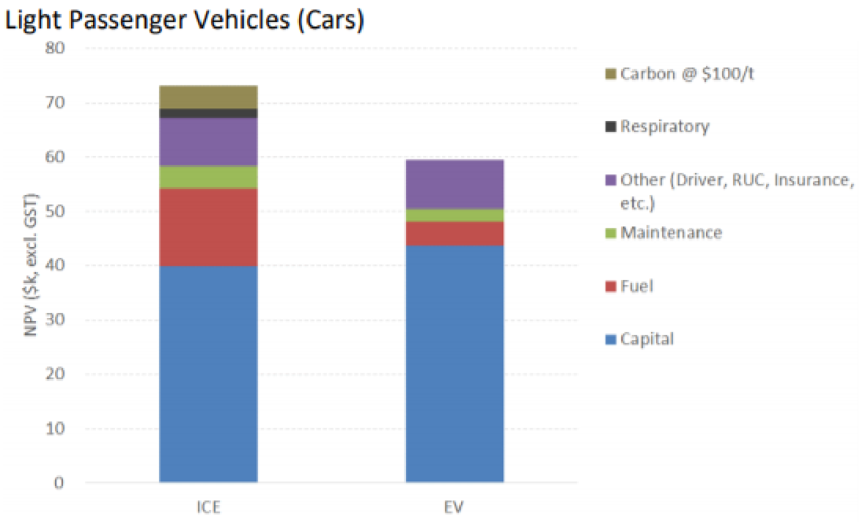


Figure 9

https://www.oriongroup.co.nz/assets/Value-of-EVs-to-NZ-Concept-Consulting-August-2019.pdf

It is very much evident that EVs in 2025 still have a higher up-front capital cost but deliver lifetime savings from lower costs of operation per km travelled – fuel, maintenance, and emissions related.

13.1.1.4 NPV benefit of scenarios of EV uptake:

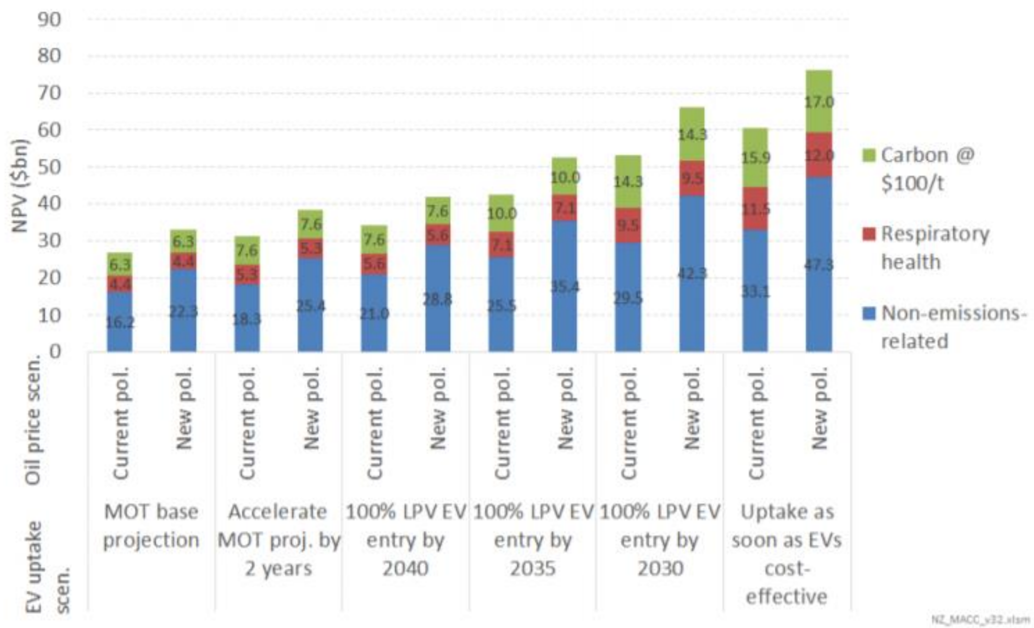


Figure 270

https://www.oriongroup.co.nz/assets/Value-of-EVs-to-NZ-Concept-Consulting-August-2019.pdf

The benefit is distinguished between:

- Non-emissions-related benefits – i.e. the net effect of capital costs, fuel costs, maintenance costs, and other (non-emissions) costs.
- Respiratory health benefits
- Carbon costs, with carbon emissions notionally evaluated at $100/tCO2e, being in the lower half of a survey of estimates of carbon prices necessary to meet New Zealand's net-zero-by-2050 emissions target.

This analysis suggests that EV uptake at the rate projected by MoT (Ministry of Transport) in its Base scenario will deliver approximately $30bn in benefits to New Zealand, with approximately $19bn of those being from reduced oil purchase costs and $11bn being from reduced costs associated with emissions.

14 APPENDIX- B OVERVIEW OF ELECTRICITY GENERATION IN NEW ZEALAND

New Zealand is well-positioned to lead the world in decarbonisation through electrification and renewable generation investment. The key points underpinning New Zealand's energy future are:

- With approximately 80 per cent of electricity already generated from renewable sources, and with a wealth of future renewable options, New Zealand is well-positioned to lead the world in decarbonisation through electrification and renewable generation investment.
- Assuming adequate policy settings, by 2050 two thirds of New Zealand's transport energy requirements could be powered by electricity.
- Future power stations will be increasingly renewable, with new technologies and improving economics for renewables seeing 95 per cent of New Zealand's electricity generation mix renewable by 2035 and 100 per cent by 2050 in a normal year – up from approximately 80 per cent today.
- The average household energy bill – including transport fuels – is estimated to decline by approximately 27 per cent in real terms by 2035.
- The New Zealand electricity market has generally worked well over the past 20 years. It has evolved significantly over that time and is likely to continue to evolve to reflect and support New Zealand's energy transition.

New Zealand has two principal climate change commitments:

- ***Paris commitment***: A 30 per cent reduction of gross greenhouse gas emissions below 2005 levels (or 11 per cent below 1990 levels) for the period 2021-2030.
- ***Domestic 'net zero' commitment:*** Net zero emissions of all greenhouse gases other than biogenic methane by 2050.

The main components of costs for delivering electricity to fuel electric vehicles are:

- Generation costs
- Network costs
- Charging infrastructure

14.1.1.1 gross energy demand:

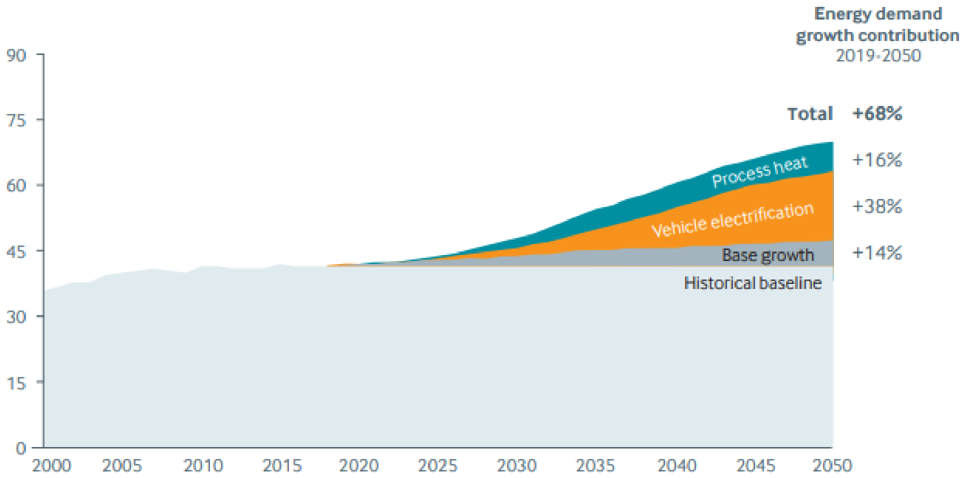


Figure 11

[WHAKAMANA i Te MAURI HIKO – EMPOWERING OUR ENERGY FUTURE // MARCH 2020]

The ramp in energy demand is slow in the five years between 2020 and 2025, from 42 to 44 TWh, but materially grows in the 2025–2030 period, in which total energy demand increases by approximately 10 per cent from 44 to 48 TWh. The Accelerated Electrification base case estimates sustained, strong growth in electricity demand between 2025 and 2050, driven primarily by transport electrification and then the electrification of process heat. New Zealand will do more with energy in 2050 but will also require less fuel to do it. Technology already allows electrical energy to be converted into heat and transport energy with much greater efficiency than technologies requiring the burning of fossil fuels.

By way of a current example, a typical car with a two litre internal combustion engine requires 77 kWh of petrol to drive 100 kilometres, while a Nissan Leaf electric vehicle (EV) requires only 16 kWh of electricity to cover the same distance – it's nearly five times as energy efficient (Transpower, 2020).

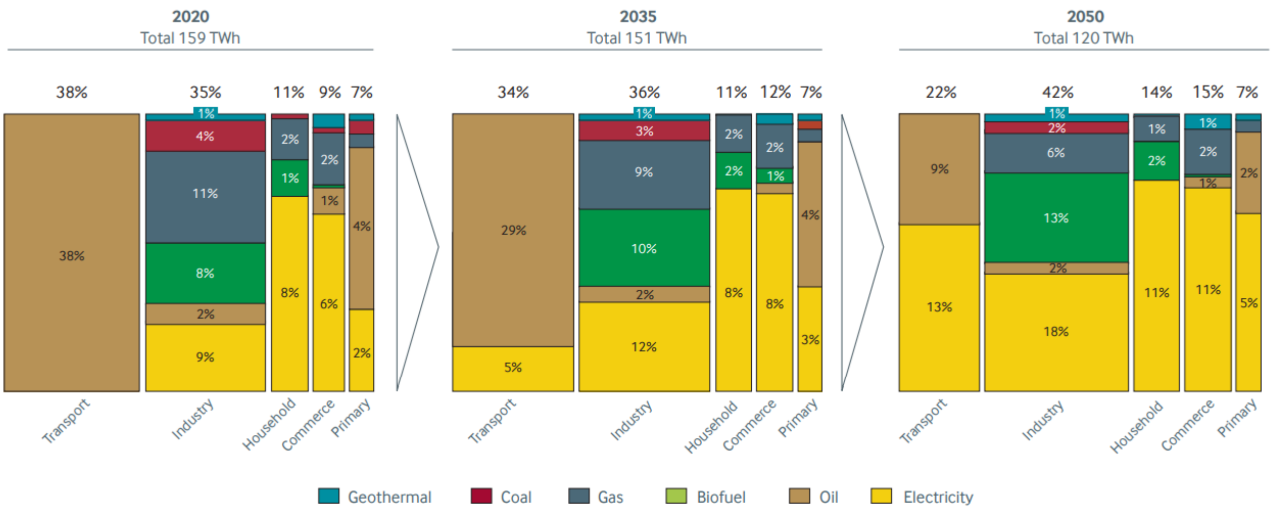


Figure 12

Figure (12) shows how New Zealand's energy mix could be electrified by 2050. Electricity demand as a proportion of total delivered energy demand is estimated to increase from 25 per cent today to 58 per cent by 2050. Note, other fuel switching possibilities such as coal to gas, gas to hydrogen, and the use of biomass/ biofuel have not been considered in this analysis but will have a role to play in the displacement of fossil fuels out to 2050. Efficiency improvements in the use of fossil fuels such as hybrid vehicles and the use of waste heat recovery all have contributions to make in meeting our emissions targets (Transpower, 2020).

14.1.1.2 Electrification of transport in nz:

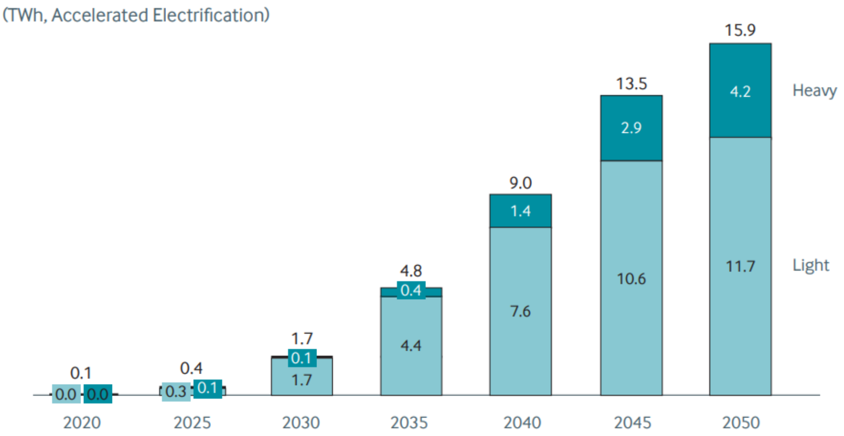


Figure 13

WHAKAMANA i Te MAURI HIKO – EMPOWERING OUR ENERGY FUTURE // MARCH 2020

Transport is currently dominated by fossil fuels and accounts for approximately 40 per cent of all the delivered energy in New Zealand. It is also estimated that electrification of light land and heavy transport has the potential to increase electricity demand by 5 TWh by 2035 and 16 TWh by 2050.

The electrification of light vehicles is already underway but is expected to ramp up in earnest in the late 2020s and early 2030s, requiring an additional 4 TWh of electricity by 2035 and 12 TWh by 2050. The estimated growth in energy demand is driven by the total light vehicle kilometres travelled (VKT), the improving market share of EVs and the fuel efficiency of EVs.

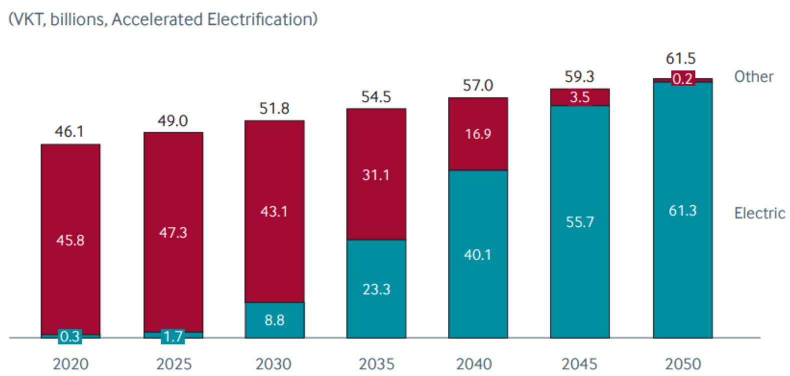


Figure 14

- EVs already, or will soon, outperform ICE vehicles on operating costs, emissions, reliability, acceleration and sticker price, and will be comparable on many other important factors, including range and safety.
- Further, the ability for EVs to reduce transport carbon emissions are assumed to be increasingly seen as an attractive opportunity for policy makers to achieve emissions reduction targets.
- EV fuel efficiency has been assumed to improve over time, partially offset by the current trend towards larger, heavier vehicles as the fleet begins to convert.

14.1.1.3 Infrastructure:

- Over 85 per cent of homes have garages with a power outlet suitable for overnight EV charging.
- Charging a car for 160 km takes 12 hours in a regular power point (2.3kW) or six hours using a charger connected to the main switchboard (5kW).
- Most electricity retailers offer lower tariffs during off-peak times or at night, which will help to minimise charging costs.
- At a national level, Transpower – which owns the main electricity transmission system – has confirmed that the electricity grid is able to accommodate substantial EV capacity (Ross, 2018).

14.1.1.4 Electricity supply growth:

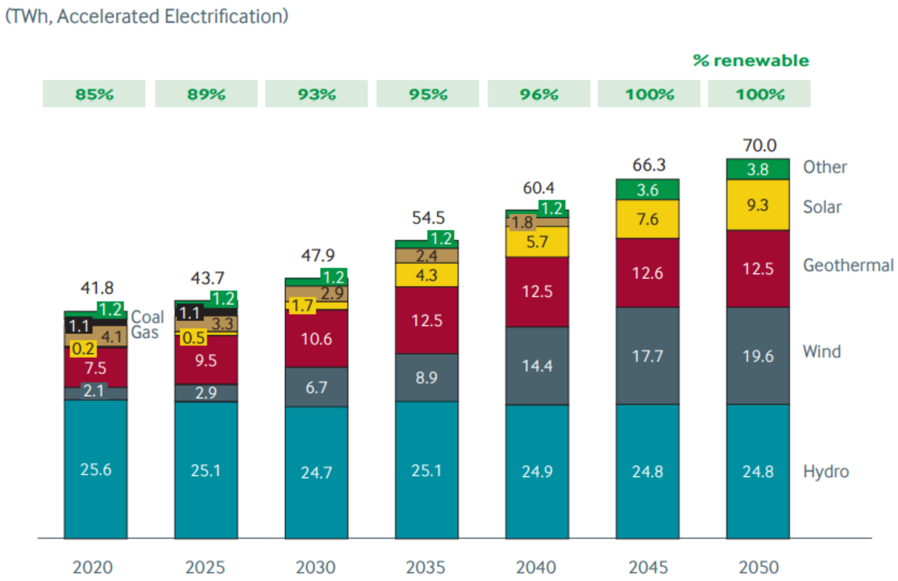


Figure 15

[WHAKAMANA i Te MAURI HIKO – EMPOWERING OUR ENERGY FUTURE // MARCH 2020]

New Zealand's electricity mix will become much more diverse. Without considering possible hydrology changes because of climate change, hydro generation is set to stay largely static out to 2050. In the context of a growing overall market, hydro is estimated to drop to 36 per cent of New Zealand's electricity mix, increasing its value in meeting peak demand.

Geothermal generation increases incrementally to 18 per cent, wind generation grows rapidly to comprise 28 per cent, solar makes up 13 per cent of the market and five per cent comes from other 'on demand' sources (assumed to be a mix of biomass, hydrogen, cogeneration, or other renewables with pumped hydro energy storage). Gas generation using carbon capture and storage is not an assumption in the modelling but is a possible option for emissions reduction out to 2050 (Transpower, 2020).

15 APPENDIX- C CARBON PRICING & CHARGING

With New Zealand's predominantly renewable electricity, GHGs per vehicle kilometre travelled (VKT) are, on average, 86 per cent lower for EVs. EVs generate 21 grams of CO2e per VKT, compared to 152 grams of CO2e for petrol. New Zealand has a goal of 90 per cent renewable electricity by 2025 and, as renewable energy replaces aging thermal plant, EV emissions will be cut even further. Therefore, the life-cycle CO2e benefits of EVs in New Zealand could be significant on a net global basis.

Transport energy consumption and transport emissions drop significantly throughout the period to 2040 due to a higher carbon price and lower economic activity and population growth. This is underpinned by business and consumers early adoption of low emission technology in the transport sector (BusinessNZ, 2020).

By 2030 the difference between the carbon price in Kea and Tūī is $65/tCO2 -e with Kea [4]at $105/tCO2 -e and Tūī [5]at $40/tCO2 -e. That spread widens to $100/tCO2 -e by 2060. The emissions outcome shown reflects the carbon price model inputs and all the behaviours reflected in the narratives.

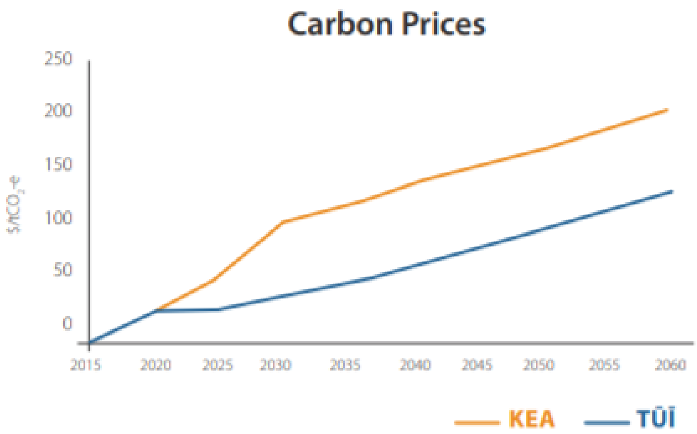


Figure 16

Under Kea, the economy is mostly decarbonised by 2040. Under Tūī progress to decarbonise the economy is slower, with energy sector emissions 50% higher than in Kea by 2040.

[4] **KEA**- Kea are collaborative, curious and innovative. Kea represents a future in which climate change is seen as the most pressing issue.

[5] **Tūī** - Tūī are territorial and competitive, resulting in a lively and vibrant forest environment. Tūī represent a future in which global communities, businesses and governments believe that climate change is only one of several competing priorities.

15.1.1.1 Emission reduction by sector:

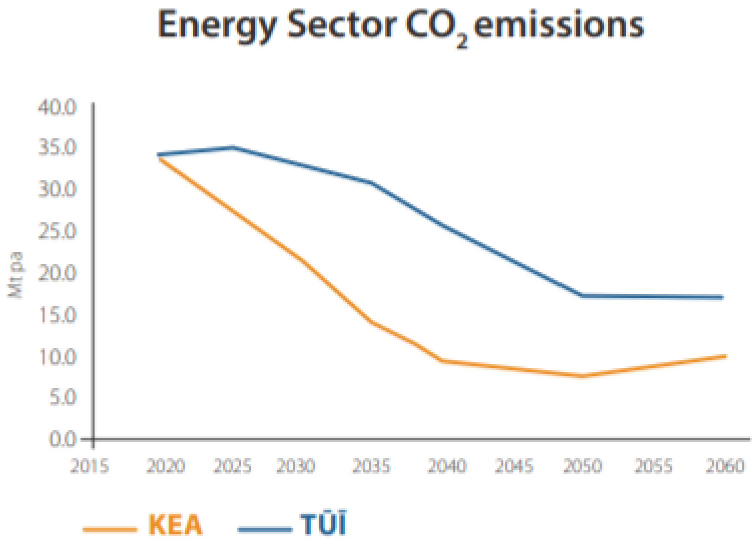


Figure 17

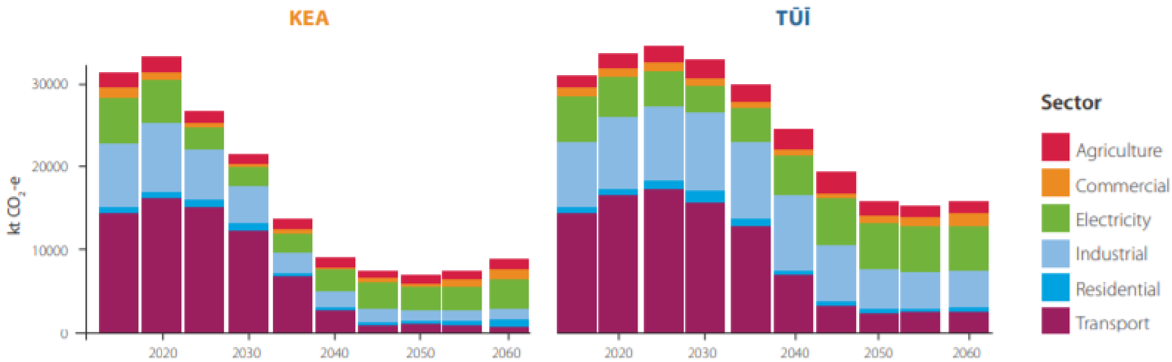


Figure 18

https://www.bec2060.org.nz/__data/assets/pdf_file/0017/182231/Carbon-FactSheet.pdf

A $90/tCO2 -e difference between the two carbon price paths after 2030 (in combination with accompanying policy settings) delivers a significantly different emissions profile between the two scenarios – Kea and Tūī. In transport, the introduction of electric vehicles significantly reduces emissions for both scenarios in the long term. Kea's focus and prioritisation on removing emissions from New Zealand's economy can be driven from 34mt pa in 2020 to 10mt pa by 2040. However, some "sticky emissions" remain from natural gas usage in the food product and other manufacturing sectors as well as geothermal use in the electricity sector and make a full decarbonisation of the energy sector difficult. In Tūī, New Zealand takes more of a follower approach to addressing its CO2 -e emissions profile, CO2 -e emissions fall from 34mt pa in 2020 to 16mt pa by 2050 (BusinessNZ, 2020).

The monetary benefits from CO2 savings depend on the social cost of carbon that is used to convert the estimated impacts from tonnes to dollar values. In this analysis, the carbon price has been used as a proxy and was taken from New Zealand's Seventh National Communication to the UNFCCC as shown in below table. A linear extrapolation was used to obtain figures for the interim years while for post 2030, the price was maintained at $25/tCO2e.

Year	$ per tCO2e
2010	19.50
2015	15.21
2016	17.15
2020	19.57
2025	22.58
2030	25.00

15.1.1.2 GHG Mitigation Costs

An important measure for deciding and prioritising climate change measures is the cost per unit of CO2e offset. On the economic analysis above:

- At 8,000 km, an EV saves 1.05 tonnes of CO2e per annum, at $317 per tonne.
- At 12,000 km, an EV saves 1.57 tonnes of CO2e per annum, at $168 per tonne.
- At 20,000 km, at EV saves 2.62 tonnes of CO2 per annum, at $12 per tonne.
- Greater than 20,000 km, the cost per tonne is negative (Ross, 2018).

15.1.1.3 Charging the electric vehicle

- According to the Ministry of Transport (MOT), 92% of light vehicles are parked at a residential property overnight and over 80% use private off-street parking. On average New Zealand EV drivers travel 41km per day, and 95% of day journeys are less than 125km.
- The majority (77%) of the current EV fleet supports up to 3.7 kW AC charging rate. Used Nissan Leafs from Japan (the mainstay of the fleet) have a maximum 3.6 kW charging capacity. PHEVs generally have a maximum 3.7kW AC charging capacity and a small battery size to fit space and cost constraints.
- This charging load can be accommodated within the unused mains capacity of most homes in New Zealand. Charging up to 3.7 kW rate can be achieved with a Mode 2 charging cable, which is typically supplied with vehicles at purchase. For average daily use, such 'trickle charge' overnight is sufficient for 1- 2 days' travel.
- Until 2023, 70-80% of the EV fleet will consist of vehicles with a maximum AC charging rate less than 3.7kW. In the next decade, the number of EV's is expected to increase above 600,000 and a growing share will support faster charging at home. This may cause electricity load balancing issues at the home and network level.
- Managed charging, via smart chargers can reduce the future impact of EV's on the electricity system. Ideally, NZ will take advantage of the next few years to develop and implement systems and policies that incentivise and make effective use of smart

charging technology to avoid increasing network peaks and resulting network reinforcement from the uptake of electric vehicles.

15.1.1.4 Rate of charging

For EV owners with access to off-street parking with a power point, charging at home overnight is expected to be the simplest way to charge. Assuming a residential off-peak electricity rate of 24c implies EV charging costs are equivalent to approximately 61c a litre of fuel. The cheapest way to charge an EV is by charging during off peak hours, typically between the hours of 11pm and 7am. Charging at fast public charging stations can potentially cost upto $10 per 100km (equivalent to $1.4 a litre of fuel). The network of fast public chargers is growing in New Zealand (EECA, Electric Vehicle Charging, 2019).

Charging speed	Typical location	Illustrative metrics
Trickle charging	Home	• 3kW (15-18km/hr of charging) • 13 hours for 80% of full charge
Slow charging	Home, Work	• ~7kW (30-40 km/ hr of charging) • 6 hours for 80% of full charge
Medium charging	Home, Work	• ~22kW (70-80 km/ hr of charging) • 3 hours for 80% of full charge
Fast charging	Work, Public	• ~43kW (140-160km/ hr of charging) • 1.5 hours 80% of full charge
Rapid charging	Public, Corridor	• 50 - 75kW (200-250 km/hr of charging) • <1 hour for 80% of full charge
High power charging	corridors only	• 145+ kW (300-500 km/hr of charging) • <30 min for 80% of full charge

EV chargers draw a relatively large electrical load, between 2.2 kW and 22 kW based on current technologies. These additional loads may exceed the design capacities of the electrical networks at home and on the distribution networks.

15.1.1.5 Home level

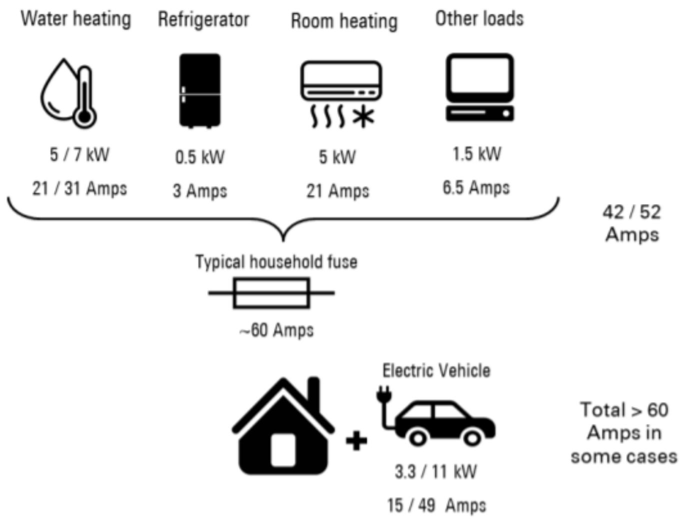


Figure 19

https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/EV-Charging-NZ.pdf

- The household mains in New Zealand are usually sized at 60 amps. EVs can place a considerable additional load on a household electrical network. Load levels of existing appliances will have an impact on the rate at which an EV can charge without overloading the household fuse.
- Smart EV chargers are required which can dynamically vary the charging load based on loading from other appliances or from external market linked signals.

15.1.1.6 Network Level:

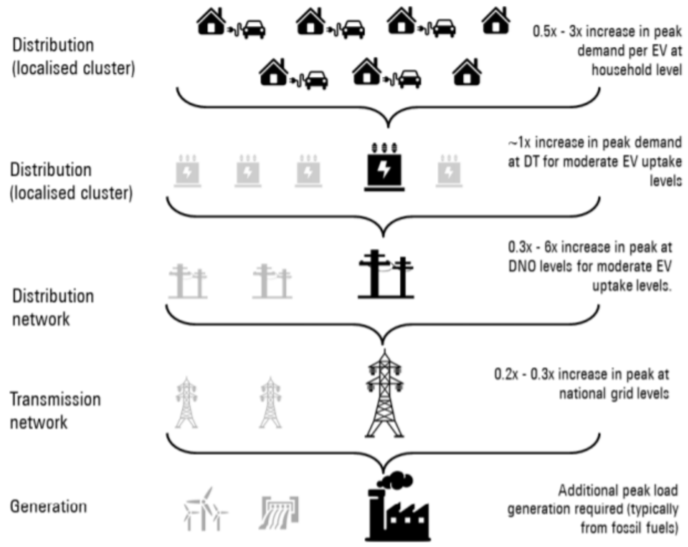


Figure 280

https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/EV-Charging-NZ.pdf

- The power level, time and location of EV charging could have significant implications for the electricity system. EV loading on the local grid is a critical issue for network companies, especially in areas with higher EV concentration.

- Growing EV numbers and clustering in particular suburbs mean that EV charging will impact low voltage distribution networks.
- Customers using 7kW home chargers will surpass network capacity during evening peak hours, even at 20% EV penetration level. The relative capacity in the network is higher in the case of slower chargers (EECA, Electric Vehicle Charging, 2019).

15.1.1.7 EV charger market in new zealand

New Zealand EV users have a choice of about 65 charger models across a range of price points, manufacturers and features. Costs can range from about $500 to over $10,000 including installation.

Overview of the New Zealand charger market

	Charging cables	3.7-7.4 kW wall mounted chargers	11 – 22 kW wall mounted chargers
Number of models available	– 12 base models with variations	– 31 base models with variations	– 22 base models with variations
New Zealand suppliers, distributors	– OEM Audio, Blue Cars, Chargesmart., Transnet	– Chargemaster, Chargenet, Echarge, Juicenet, Plugndrive New Zealand, Schider Electric, Blue cars, Transnet, YHI, Embrium, Evnex,	– Blue cars, Chargemaster, Chargenet, Echarge, Juicenet, Schider Electric, Transnet, YHI, OEM Audio, Embrium, EVnex
Key differences	– Pricing variations with cable length, on in-cable control features (delay, screen) and place of manufacture	– Aesthetics and design, built in RCD type, charge level, manual variation in charging limit, smart features and cable length	

Figure 22

https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/EV-Charging-NZ.pdf

16 APPENDIX- D LEGAL REQUIREMENTS OF LIGHT TRAILERS IN NEW ZEALAND

This factsheet describes the legal dimension requirements in Land Transport Rule: Vehicle Dimensions and Mass 2016 of the dimension limits for light trailers. Please refer to factsheet 13 for general dimension and mass limits and towing requirements.

For definitions of dimension and axle terms see factsheet 13.

What is a light trailer?

Light trailers are vehicles:

- without motive power (ie they don't have pedals or a motor to drive the wheels)
- with a maximum gross vehicle mass (GVM), usually specified by the manufacturer, of 3500 kilograms or less. (The GVM includes the maximum load that the trailer can carry.)

Light trailers includes class TA trailers (GVM up to 0.75 tonnes) and class TB trailers (GVM from 0.75 tonnes to 3.5 tonnes).

What is a light simple trailer?

A simple trailer has one, two or three axles arranged close together in an axle set. This is attached to the towing vehicle behind the axle closest to the rear of the towing vehicle.
A simple trailer is the most common type of light trailer. Most boat trailers, caravans, and garden trailers are simple trailers.

How are other types of light trailer classified?

Some boat trailers, caravans or garden trailers cannot be classified as simple trailers. Their design, or the points of attachment to the towing vehicle, is closer to the design described for heavy trailers in factsheet 13c Heavy combination vehicles. For details on other types of trailer, read this information on full, semi, simple and pole trailers, as well as A- and B-train combinations.

All the dimension requirements for heavy trailers in factsheet 13c apply to light trailers of equivalent design, except that:

- light trailers have no minimum ground clearance
- vehicles towing light trailers don't have to meet the tow coupling positions specified for heavy trailers
- the maximum rear overhang for light trailers is four metres.

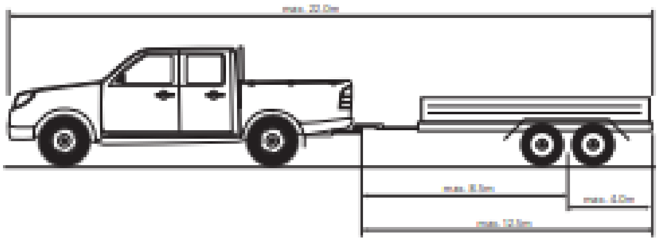
Light simple trailer dimension limits

Maximum width

The maximum width for a light simple trailer (including its load) is 2.55 metres (excluding side marker lights and direction indicators and the bulge towards the bottom of the tyre).

Maximum length

The maximum length for a light simple trailer (including drawbar and load) is 12.5 metres. For a towing vehicle and simple trailer combination (including load, but excluding collapsible mirrors), the maximum overall length is 22 metres.



Maximum height

The maximum height for a light simple trailer (including load) is 4.3 metres.

All vehicles must be loaded in a safe manner, with a height appropriate to the type of load.

Maximum forward distance

For a simple trailer, forward distance means the distance from the rear axis of the trailer to the centre of the point of attachment on the towing vehicle. For definitions of rear axis see factsheet 13.

The maximum forward distance is 8.5 metres.

Maximum rear overhang

For a simple trailer, rear overhang means the distance from the rear axis to the rear of the vehicle or its load, whichever is greater. For definitions of rear axis see factsheet 13.

The maximum for all light trailers is four metres.

Minimum ground clearance

There are no minimum ground clearance requirements for light trailers.

Maximum front overhang

For simple trailers, front overhang means the distance from the centre of the tow coupling to the foremost point of the vehicle (trailer, including its load). The maximum for light simple trailers is 2.04 metre radius arc ahead of the tow coupling.

Outside turning circle

The combination rigid vehicle and trailer or trailers (excluding collapsible mirrors) must be able to complete a 360-degree turn, to the left and to the right, within a circle of 25 metres diameter (kerb to kerb).

No part of a vehicle in a combination, other than its tow coupling, may come into contact with another vehicle in the combination.

What are the tow coupling requirements?

It is the driver's legal responsibility to ensure the trailer is safely and securely attached to the towing vehicle by an adequate tow coupling.

For a vehicle towing a light simple trailer, the tow coupling position can't be more than the maximum rear overhang allowed for that type of towing vehicle (for more information about towing see factsheet 13c).

Please note that the maximum allowable length and forward distance of a rigid motor vehicle is less if it is towing a trailer.

Loading and towing a light simple trailer

Loading your trailer safely

If you tow a simple trailer, you need to be aware that the trailer can impose a large weight on the rear of your vehicle. This weight can, by lever action through the chassis of the vehicle, reduce the effective mass bearing on the front axle(s) of your vehicle. It is important, therefore, that you load your trailer carefully so the load is distributed centrally over the axle(s) of the trailer. This will allow your vehicle to maintain front-wheel grip on the road, so you can continue to steer it safely.

Note: There needs to be a downward force, of approximately 10 percent of the weight of the trailer and its load, on the tow coupling of a simple trailer, to ensure it remains stable while being towed.

The number of trailers you can tow

A light rigid vehicle may tow only one trailer.

Light tractors may tow two light trailers if the manufacturer's rating on the tractor allows this, and if the tractor doesn't exceed 50km/h.

A heavy rigid vehicle (but not a bus) may tow two trailers under certain conditions. See factsheet 13c for more information on towing two trailers with a rigid heavy vehicle.

Intervehicle spacing

Intervehicle spacing means the distance between the towing vehicle (excluding the tow coupling shroud) and the trailer (excluding the drawbar but including the load). The maximum for light simple trailers is four metres.

There's no minimum spacing. The trailer (or its load) can overhang the towing vehicle.

Requirements for passenger service vehicles towing a trailer
A heavy passenger service vehicle (eg a bus) may tow only one light trailer (ie only one trailer with a gross vehicle mass up to 3.5 tonnes).

A light passenger service vehicle (eg a van or taxi) may tow only one light trailer with a gross vehicle less than two tonnes.

An articulated bus may not tow a trailer.

What speeds are allowed for vehicles towing simple trailers?

- A light vehicle towing a trailer is limited to a maximum open-road speed of 90km/h.
- A heavy vehicle towing a trailer is limited to a maximum open-road speed of 90km/h.
- School buses towing a trailer are limited to maximum open road speed of 80km/h.

Drivers also need to obey any lower speed limits that apply on particular roads.

What are the limits for projecting loads?

Vehicles may carry loads that are higher, longer or wider than the vehicle itself, provided the load doesn't exceed the maximum permitted dimensions for that class and type of vehicle, and provided the vehicle can be moved safely when loaded. It's the operator's responsibility to ensure the load is properly secured to the vehicle so the vehicle remains stable at all times.

You need to read factsheet 53a *Overdimension vehicles and loads* if the load exceeds any of the standard dimension limits.

Loads that overhang the outside of the body or deck of the vehicle by more than 1m to the front or rear, or more than 200 millimetres to the left or right side, need to carry special warning devices attached to the overhanging end(s) of the load, see factsheet 13.

During the *hours of daylight*, there must be either:

- a clean white, or fluorescent red, orange or yellow flag, at least 400 millimetres long by 300 millimetres wide, or
- a hazard warning panel, at least 400 millimetres long by 300 millimetres wide, showing an orange diagonal stripe (200 millimetres wide) against a yellow green background, facing forwards or rearwards, or
- a hazard warning panel, at least 300 millimetres long by 400 millimetres wide showing an orange diagonal stripe (200 millimetres wide) against a yellow-green background, facing forwards or rearwards, or
- a hazard warning panel, at least 600 millimetres high by 200 millimetres wide showing an orange diagonal stripe (300 millimetres wide) against a yellow/green background facing forwards or rearwards.

Note: Hazard warning panels that extend beyond the edge of the vehicle must be frangible (breakable or readily deformable).

During the *hours of darkness*, the flags or hazard panels may be displayed and lights must be attached to the load as follows.

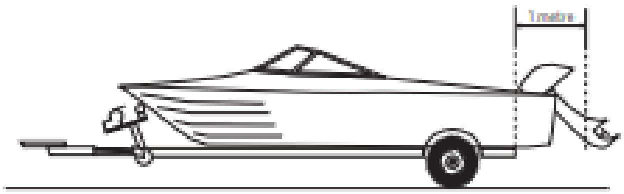
- Loads more than one metre wide and extending more than one metre from the rear of the vehicle must have one red lamp (facing toward the rear) on each side of load. Loads up to one metre wide and extending more than one metre from the rear of the vehicle must have one red lamp (facing toward the rear) at the centre of load.
- Loads more than one metre wide and extending from the front of the vehicle must have one white or amber lamp

(facing toward the front) on each side of load.

- Loads up to one metre wide and extending more than one metre from the front of the vehicle must have one white or amber lamp (facing toward the front) at the centre of load.
- Loads extending more than 200 millimetres beyond the side of the body of the vehicle must have one red lamp (facing toward the rear) on each side of the load at the rear and one white or amber lamp (facing toward the front) on each side of the load at the front.

These lights need to be clearly visible in clear weather at a distance of at least 200 metres during the hours of darkness.

Displaying these lights at night is an operating requirement that applies to all vehicles, regardless of when they were first registered.



In the diagram above, the boat is the load on the trailer. It has a raised outboard motor that projects more than one metre behind the rear of the trailer.

If the distance from the rear of the trailer to the most rearward point of the load is more than one metre (and the projecting part is less than one metre wide), one warning device must be attached to the centre of the projecting part of the load:

- In daylight, this may be a flag or hazard panel (facing backwards).
- During the legal hours of darkness, this must be a red light visible from at least 200 metres away. The flags or hazard panels may also be displayed.

Where can I find more information on towing and loading?

Refer to the NZ Transport Agency's publication *Guide to safe loading and towing for light vehicles*.

Where can I find out more?

- Factsheet 13 *Vehicle dimensions and mass: guide to the factsheet 13 series*
- Factsheet 13a *Heavy rigid vehicles*
- Factsheet 13b *Light rigid vehicles*
- Factsheet 13c *Heavy trailers and combination vehicles*
- Factsheet 13e *Static roll thresholds*
- Factsheet 13f *Heavy buses*
- Factsheet 13g *High Productivity motor vehicles*
- Factsheet 13h *Specialist vehicles*
- Factsheet 53a *Overdimension vehicles and loads*
- Factsheet 53b *Overdimension roles and responsibilities*
- Land Transport Rule 41001: Vehicle Dimensions and Mass 2016.

17 APPENDIX-E RUC RATES FOR UNPOWERED VEHICLES

le type num ber	Description	Weight bands	RUC rate ($ per 1,000km	RUC rate
			GST inclusive)	($ per 1,000km GST inclusive)
			up to 30 Jun 2020	as of 1 Jul 2020
24	Unpowered vehicles with one axle	All RUC weights	120	126
28	Unpowered vehicles with two axles (except vehicle types 29, 30 and 929)	Not more than 10 tonnes	46	48
		Any RUC weight more than 10 tonnes	295	311
29	Unpowered vehicles with two twin-tyred, or single large-tyred close axles, (except vehicle type 929)	Not more than 10 tonnes	39	41
		Any RUC weight more than 10 tonnes	132	139
30	Unpowered vehicles with two twin-tyred spaced axles	Not more than 10 tonnes	39	41
		Any RUC weight more than 10 tonnes	222	234
33	Unpowered vehicles with three twin-tyred, or single large-tyred, close axles (except vehicle type 939)	All RUC weights	177	186
37	Unpowered vehicles with three axles, (except vehicle types 33 and 939)	Not more than 10 tonnes	42	44
		Any RUC weight more than 10 tonnes	302	318

43	Unpowered vehicles with four axles	All RUC weights	226	238
951	Unpowered vehicles with five or more axles	All RUC weights	170	179
929	Leading trailer with two twin-tyred, or single large-tyred, close axles	All RUC weights	96	101
939	Leading trailer with three twin-tyred, or single large-tyred, close axles	All RUC weights	64	6

18 Appendix- F Cost Analysis

18.1 Target Market Calculation

Year	EV sales	% increase in EVs	1.15% trailers	Market size ($)
2020	17,831	1.4%	205	$ 2,455,347
2021	18,098	1.5%	208	$ 2,492,177
2022	18,388	1.6%	211	$ 2,532,052
2023	18,719	1.8%	215	$ 2,577,628
2024	19,093	2.0%	220	$ 2,629,181
2025	19,533	2.3%	**225**	$ 2,689,652
			1.50% trailers	**Market size ($)**
2020	17,831	1.4%	267	$ 3,202,626
2021	18,098	1.5%	271	$ 3,247,463
2022	18,388	1.6%	276	$ 3,299,422
2023	18,719	1.8%	281	$ 3,358,812
2024	19,093	2.0%	286	$ 3,425,988
2025	19,533	2.3%	**293**	$ 3,504,786
			2% trailers	**Market size ($)**
2020	17,831	1.4%	357	4,270,168
2021	18,098	1.5%	362	4,329,950
2022	18,388	1.6%	367	4,399,229
2023	18,719	1.8%	374	4,478,416
2024	19,093	2.0%	381	4,567,984
2025	19,533	2.3%	**390**	4,673,048

18.2 Sensitivity Analysis on Battery Price

Year	Decrease by 18%	Decrease by 10%	Decrease by 5%	Increase by 4%
2020	$176	$176	$176	$176
2021	$144	$158	$167	$183
2022	$118	$143	$159	$190
2023	$97	$128	$151	$198
2024	$80	$115	$143	$206
2025	$65	$104	$136	$214
2026	$54	$94	$129	$223
2027	$44	$84	$123	$232
2028	$36	$76	$117	$241
2029	$30	$68	$111	$251
2030	$24	$61	$105	$261
Cost of Battery for 20kWh	$756	$1,918	$3,293	$8,141
Cost of EAUT	$ 11,429.19	$ 12,903.84	$ 14,633.69	$ 20,738.19
USD	$460	$1,227	$2,108	$5,210
NZD	$650	$1,667	$2,860	$7,070

18.3 Sensitivity Analysis on NPV

Year	Current price, 176kWH	4% increase, 185kWh	18% decrease, 16kWh
Y0	-$4,046	-$3,955	-$6,198
Y1	-$61,537	-$60,365	-$88,383
Y2	-$56,815	-$55,526	-$86,345
Y3	-$51,455	-$50,037	-$83,939
Y16	$97,025	$101,039	$5,069
Y17	$117,982	$122,398	$16,830
Y18	$141,217	$146,074	$29,950
Y19	$166,961	$172,303	$44,567

18.4 Trailer to Cars Ratio Calculation

Year	Trailer	Cars	% Ratio
2000	17902	2,147,664	0.83%
2001	15323	2,213,664	0.69%
2002	16625	2,292,318	0.73%
2003	18269	2,395,126	0.76%
2004	21380	2,490,896	0.86%
2005	23478	2,578,588	0.91%
2006	22894	2,631,666	0.87%
2007	25779	2,679,389	0.96%
2008	24006	2,692,979	0.89%
2009	18625	2,684,822	0.69%
2010	19874	2,705,374	0.73%
2011	19023	2,698,463	0.70%
2012	20975	2,736,627	0.77%
2013	23331	2,794,837	0.83%
2014	26262	2,884,236	0.91%
2015	29970	2,979,180	1.01%
2016	33187	3,091,162	1.07%
2017	35684	3,202,353	1.11%
2018	38291	3,284,122	1.17%
2019	38549	3,362,819	1.15%

18.5 Total Trailers Registered in New Zealand

Year	Trailers
2000	17902
2001	15323
2002	16625
2003	18269
2004	21380
2005	23478
2006	22894
2007	25779
2008	24006
2009	18625
2010	19874
2011	19023
2012	20975
2013	23331
2014	26262
2015	29970
2016	33187
2017	35684
2018	38291
2019	38549

18.6 Region wise Trailer Registration

Cities	Total Trailers Registered
Auckland	103082
Christchurch City	38222
Dunedin City	12356
Hamilton City	18889
Invercargill City	8698
Lower Hutt City	5389
Napier City	6641
Nelson City	5824
Palmerston City	8997
Porirua City	3136
Queenstown	7199
Tauranga	19044
Upper Hutt City	3188
Wellington city	8149

18.7 Revenue and expenses

	MONTHS (Y0)												Year				
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	Y1	Y2	Y3	Y4	Y5
Revenue																	
Trailer Kit	1,655	1,655	1,655	3,310	3,310	4,966	6,621	6,621	8,276	9,931	13,241	16,552	77,794	85,573	94,130	103,543	113,898
Grand Total	**1,655**	**1,655**	**1,655**	**3,310**	**3,310**	**4,966**	**6,621**	**6,621**	**8,276**	**9,931**	**13,241**	**16,552**	**77,794**	**85,573**	**94,130**	**103,543**	**113,898**
Expenses																	
Fixed expense ($)																	
Salaries ($)																	
Labour Cost @2 people full time	7,798	7,798	7,798	7,798	7,798	7,798	7,798	7,798	7,798	7,798	7,798	7,798	93,581	95,452	97,361	99,309	101,295
Total salary	**7,798**	**7,798**	**7,798**	**7,798**	**7,798**	**7,798**	**7,798**	**7,798**	**7,798**	**7,798**	**7,798**	**7,798**	**93,581**	**95,452**	**97,361**	**99,309**	**101,295**
Workshop rent 500sqft-CHC	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	25,200	25,200	25,200	25,200	25,200
Variable expense $																	
Electricity	400	400	400	400	400	400	400	400	400	400	400	400	4,800	4,896	4,994	5,094	5,196
Material transport	33	33	33	66	66	99	132	132	166	199	265	331	1,556	1,711	1,883	2,071	2,278
Branding & Marketing	33	33	33	66	66	99	132	132	166	199	265	331	1,556	1,711	1,883	2,071	2,278
Consumables (Materials) + Workshop miscel	33	33	33	66	66	99	132	132	166	199	265	331	1,556	1,711	1,883	2,071	2,278
Total Operational expenses	**2,599**	**2,599**	**2,599**	**2,699**	**2,699**	**2,798**	**2,897**	**2,897**	**2,997**	**3,096**	**3,294**	**3,493**	**34,668**	**35,230**	**35,842**	**36,506**	**37,230**
Total expenses	10,398	10,398	10,398	10,497	10,497	10,596	10,696	10,696	10,795	10,894	11,093	11,292	128,248	130,683	133,203	135,815	138,524
Gross Profit																	
Finance charges	-																
OH @ 12%													15,390	15,682	15,984	16,298	16,623
Grand total expense	**10,398**	**10,398**	**10,398**	**10,497**	**10,497**	**10,596**	**10,696**	**10,696**	**10,795**	**10,894**	**11,093**	**11,292**	**143,638**	**146,365**	**149,188**	**152,113**	**155,147**
Profit/loss																	
EBTA ($)	(8,743)	(8,743)	(8,743)	(7,187)	(7,187)	(5,631)	(4,075)	(4,075)	(2,519)	(963)	2,149	5,260	(65,844)	(60,792)	(55,057)	(48,569)	(41,250)
Profit/loss%	-528%	-528%	-528%	-217%	-217%	-113%	-62%	-62%	-30%	-10%	16%	32%	-85%	-71%	-58%	-47%	-36%
Tax @ 18% ($)	0	0	0	0	0	0	0	0	0	0	387	947	0	0	0	0	0
PAT ($)	-8743	-8743	-8743	-7187	-7187	-5631	-4075	-4075	-2519	-963	1762	4313	- 65,844	- 60,792	- 55,057	- 48,569	- 41,250
NPV @5% ($)	-8326	-8171	-8171	-6716	-6716	-5262	-3808	-3808	-2354	-900	1647	4031	-61537	-56815	-51455	-45392	-38551