LIGHT DUTY ELECTRIC VEHICLE PROLIFERATION IN MALAYSIA

Dec. 2023

This report was funded through the German International Climate Initiative (IKI). The development of this report has been supported by the UNEP Global Electric Mobility Programme.

DISCLAIMER

All findings, interpretations, and conclusions presented in this document are based on information gathered by the authors, who assume full responsibility for any errors or omissions.

COPYRIGHT

ACKNOWLEDGEMENTS

The authors would like to extend their appreciation to all those who contributed to this report, including the Ministry of Transport (MOT), the Economic Planning Unit (EPU), the Land Public Transport Commission (SPAD), the Ministry of Finance (MOF), the Ministry of Urban Wellbeing, Housing and Local Government (KPKT), the Ministry of Energy, Green Technology and Water (KeTTHA), the Ministry of Natural Resources and Environment (NRE), the Ministry of International Trade and Industry (MITI), the Road Transport Department (JPJ), the Malaysia Productivity Corporation (MPC), the Technology Depository Agency (TDA), the Sustainable Energy Development Authority Malaysia (SEDA), and the dedicated staff from UNEP and Focus Applied Technologies. Special thanks are also extended to the staff of the Malaysian Green Technology Corporation (MGTC) for their invaluable support throughout the development of this publication. Lastly, this work would not have been possible without the generous support of the International Climate Initiative (IKI), who funded this study.

LIGHT DUTY ELECTRIC VEHICLE PROLIFERATION IN MALAYSIA

A Study on the State of Electric 2- and 3- Wheelers, Government Policy, Proliferation Obstacles and Emissions Reduction Opportunities

Dr. Horizon Gitano-Briggs
Chief Technology Officer
Focus Applied Technologies

Nurul Shafina Khairudin
Financial Analyst
Focus Applied Technologies

PROJECT CONTEXT

The United Nations Environment Program (UNEP) is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system and serves as an authoritative advocate for the global environment. Its mandate is to coordinate the development of environmental policy consensus by keeping the global environment under review and bringing emerging issues to the attention of governments and the international community for action.

The Sustainable Mobility Unit, under UNEP's Industry and Economy Division, promotes sustainable, low and zero emissions transport. UNEP is implementing the Global Electric Mobility Program, supporting over 60 low and middle-income countries to shift to electric mobility for improved air quality and climate change mitigation. We do so via various Programs and projects like the Used Vehicles Project, the Global Fuel Economy Initiative, the Electric Mobility Program, Non-motorized Transportation Program, and the Partnership for Clean Fuels and Vehicles project etc.

The purpose of this study is to assess the current condition of electric 2- and 3-wheelers in Malaysia, analyze the related governmental policies, and, together with various government representatives, develop a set of progressive policy measures to maximize the utilization of electric 2- and 3-wheelers in the future. Key to this is an assessment of the CO_2 impact of various levels of electric vehicle adoption, which helps serve to emphasize the importance of taking concrete, long-term actions to maximize the benefits of this clean, efficient technology.

CONTENTS

INTRODUCTION

This work, conducted in 2023 as part of the UNEP Global Electric Mobility Program, aimed to assess the current state of Electric 2- and 3-Wheelers (E2/3W) in Malaysia. The study examines existing government policies, the status of manufacturers, and the challenges and barriers to widespread adoption of E2/3W vehicles. Additionally, the report offers "progressive" policy recommendations designed to promote E2/3W adoption in the market. Various adoption scenarios are modeled, providing estimates of their potential CO_2 impact compared to the business-as-usual scenario.

BACKGROUND

Electric Vehicles (EVs) have been around since the 1890s and gained considerable popularity in the early 1900s due to their low vibrations, minimal noise, lack of odor, and ease of operation compared to Internal Combustion Engine (ICE) vehicles of the time. However, their popularity waned as the development of highways in the early 20th century revealed the limited range of EVs, which could not meet the growing demand for long-distance travel. At the same time, advances in ICE technology, coupled with the low cost of petroleum and the widespread availability of petrol stations, made ICE vehicles more affordable and convenient, further contributing to the decline of EVs.

The extensive use of fossil fuels over the past century has led to significant environmental consequences, including local air quality degradation, rising global CO_2 levels, and the depletion of petroleum reserves. A crucial step toward mitigating these impacts is transitioning from ICE vehicles to EVs. EVs are generally more efficient (well-to-wheels) than ICE vehicles and are compatible with low-carbon energy sources such as solar, wind, hydro, geothermal, and nuclear power.

In response, the United Nations Environment Programme (UNEP) has launched a study on electric two- and three-wheelers (E2/3W) across Southeast Asia to identify factors and challenges that could help expand the EV market in these countries. In Malaysia, awareness of the importance of EVs has grown since the government committed to a 45% reduction in greenhouse gas emissions by 2030, in line with the Paris Climate Accords. However, the adoption of EVs remains limited, partly due to the subsidized low cost of automotive fuels.

The high purchase price of EVs, low range per charge and long charging duration are the biggest concerns for EV owners. Despite government tax breaks and other incentives most of the EVs on the market are still expensive, and users generally consider EVs only suitable for short-distance trips due to their limited range[1,2]. Additionally charging facilities in Malaysia, including home charging facilities and charging along highways, is currently insufficient to meet the larger EV demand[3].

ELECTRIC – ICE COMPARISON AT A GLANCE

Compared to conventional engine powered vehicles EVs have some unique advantages, and several disadvantages:

EV ADVANTAGES

- Zero "tail pipe" emissions
- Lower maintenance costs
- Better lifetime cost*

EV DISADVANTAGES

- Higher purchase cost
- Limited Range
- Range degradation with age
- Longer re-charge time

* Depends on fuel price

Putting the negatives aside, electric vehicles can still provide substantial benefits. EVs cost significantly less to operate than ICEs due to the cost of fuel and maintenance. Additionally, EVs can be charged almost anywhere where there is electrical power and are not limited to charging stations. Although the range of current EVs is still limited, progress in battery technology is constantly improving, reducing battery cost and charging time. With larger numbers of EVs on the market, the investment in charging infrastructure makes more and more sense, and vehicle costs should come down with increased sales volumes. Current EVs are already suitable for shorter trips, such as urban commuting and first/last mile connectivity to public transport systems. Increasing the number of EVs in Malaysia could significantly help the government attain its CO_2 emissions reduction target.

The goal of this work to propose revisions of policy and regulations to help aid the proliferation of 2- and 3-wheeled electric vehicles in Malaysia to reduce environmental impact, improve energy efficiency and improve the quality of life, especially for those of modest economic means, which are disproportionately dependent on small 2-wheeled vehicles.

[1] Noel, L., de Rubens, G. Z., Kester, J., & Sovacool, B. K. (2020). Understanding the socio-technical nexus of Nordic electric vehicle (EV) barriers: A qualitative discussion of range, price, charging and knowledge. Energy Policy, 138, 111292. https://doi.org/10.1016/j.enpol.2020.111292

[2] Zhu, J. (2016). Analysis of the New Zealand specific electric vehicle adoption barriers and government policy. http://hdl.handle.net/10063/6190

[3] https://www.eco-business.com/news/electric-dreams-what-is-needed-to-accelerate-ev-growth-in-malaysia/#:~:text=According%20to%20Datuk%20Hanafi%20Sakri,much%20smaller%20population%20and%20size

EXECUTIVE SUMMARY

The first and most important thing to keep in mind when discussing small electric vehicles is that these are, by far, the most efficient form of individual powered transportation. That is the motivation for the UNEP encouraging their usage. A simple comparison between a combustion motorcycle and a passenger car helps emphasize the case: a motorcycle may get 60km per liter, whereas the car gets around 15km/liter, making the motorcycle four times as efficient per passenger kilometer. The small electric 2-wheelers prevalent in Malaysia are even more efficient, getting around 90km per liter equivalent from electricity. At this rate it is more efficient for six people to drive six electric 2-wheelers than to ride in one car. Electric 2-wheelers are exceptionally efficient.

Malaysia, consistent with other ASEAN countries, classifies Electric 2-Wheelers (E2W) into 3 categories:

Class	Top Speed
Bicycle	Less than 25 kph
Scooters	Between 25 and 50 kph
Motorcycle	Exceeding 50 kph

Malaysia has very advanced standards addressing the safety and performance and compatibility requirements of each category.

MARKET OVERVIEW

Malaysia has four domestic manufacturers of electric 2-wheelers: Eclimo, Roda Prestasi, Legatus, and Voltron. The first three focus primarily on producing e-motorcycles (with top speeds exceeding 50 kph) for the domestic market, while Voltron concentrates on exporting e-bikes and scooters. In addition, several legitimate importers—AZ Bikes, Treelectric, Zesparii, and Blue Shark—source products from China for sale in Malaysia, focusing mainly on e-motorcycles.

Currently, the electric 2-wheeler (E2W) fleet in Malaysia consists of approximately 150,000 units, growing at an annual rate of about 8%. The majority of these (90%) are e-scooters, with a smaller proportion (8%) being bicycles, and very few are classified as e-motorcycles. Domestically produced vehicles account for only about 1,000 units, while the remainder are imported, predominantly from China. Although local manufacturers and legitimate importers comply with the relevant standards, many directly imported models do not. Some importers bypass regulations by certifying scooters as bicycles to evade stricter compliance requirements. A simple online search for "electric motorcycle sales Malaysia" reveals dozens of models priced between RM 700 and RM 3,000.

Significantly, the models succeeding in the field are *not* comparable to conventional motorcycles in terms of performance: the E-scooter class which is selling relatively well typically has a top speed of around 40kph and a maximum range of 30 to 60 kilometers. It is used more like a bicycle than a motorcycle, and accumulates around 1,500 km per year on average, as opposed to conventional motorcycles which attain around 9,000km per year.

OBSTACLES TO GREATER PROLIFERATION

While the scooter class electric 2-wheelers are selling moderately well, the motorcycle class vehicles, favored by local manufacturers due to the larger expected market size, are not. This is primarily because the cost of a competitive E-motorcycle, meaning one that has similar top speeds and ranges to a combustion motorcycle, is much greater (~20,000RM) than a conventional motorcycle (~5,000RM) primarily due to the cost of the battery pack. As a result, E-motorcycle manufacturers wind up selling lower spec vehicles (eg. 60 kph top speed, and ~50km achievable range) with smaller batteries for around 9,000RM. Even when customers understand that operating the electric motorcycle will cost significantly less than a petrol-powered motorcycle (charging costs of 1/5 of petrol, and EVs are virtually maintenance free), when comparing the performance, range and purchase price of a conventional motorcycle, they overwhelmingly choose the petrol vehicle. With the resulting low sales volumes, local manufacturers have a hard time justifying investment in tooling, or sourcing in volume required to bring down the price of their E-motorcycles.

Additionally, there are many unclear and/or contradictory laws which discourage the use of electric 2-wheelers. This includes, for example, the prohibition of use of the E-bicycle and E-scooter vehicles on all roads in Malaysia, even where conventional bicycles are allowed.

PROGRESSIVE STEPS FOR E2W PROLIFERATION

As a first step towards creating legislation oriented towards greater E2/3W proliferation we need to rationalize and enforce the existing regulations relating to the importation and usage of electric 2 and 3 wheelers. As the manufacturers unanimously noted it is imposable for a legitimate manufacturer, who must undergo standards compliance testing, to compete with non-compliant illegally imported products. We already have a complete set of standards covering the E-bike, Scooter and Motorcycle class vehicles, and while these may require some refining, they do need to be uniformly enforced.

E-motorcycle rules and regulations are clearly defined and closely follow customary motorcycle regulations. E-bicycles typically follow bicycle rules and regulations; however, the Ministry of Transport (MOT) recently invalidated their usage on roads, while conventional bicycles are still allowed. This obviously needs to be changed to allow E-bicycles on any roads that conventional bicycles are allowed on. The large number of E2Ws currently being used in Malaysia are not causing any major problems despite common use on lower speed roads. This de-facto road usage should be acknowledged and allowed: E-scooters are much safer for on-road operation than bicycles, as they have head and brake lights, turn indicators and can run faster than bicycles. Thus, their operation on low-speed roads, for example residential areas, *kampungs* (villages), low speed urban routes, should not cause any major problems.

Additionally, we should remove some of the "gray" areas by enforcing common sense regulations, for example E-scooters in the 25-50kph class should comply with the following:

- All riders are required to wear helmets
- They should be registered and issued "E-Skuter" plates to differentiate from motorcycles
- On-road drivers should have a valid driver's license

To encourage the use of these exceptionally efficient vehicles as first/last mile links to public transport all transport hubs should provide weatherproof parking and charging for E-bikes, scooters and motorcycles.

Charging and parking infrastructure should be enhanced to favor these vehicles especially among dense urban populations, where charging currently is not available, for example at high-density housing flats.

Manufacturers noted that financing is less available for the purchase of E-motorcycles than it is for conventional motorcycles[4]. Finance should be made available for all E-motorcycles, and perhaps extended to E-scooters as well.

One of the major obstacles to the proliferation of E-motorcycles is the low economic incentive to switch to electric propulsion caused in part by the low cost of fuel. Malaysia should remove fuel subsidies and move towards a market fuel price of 5.5RM/liter to help level the playing field and encourage purchase of more efficient vehicles. Finally, the government can help raise awareness via public education programs by extolling the advantages of electric propulsion and clarifying the rules (e.g. what roads E2/3Ws are allowed on, and helmet, licensing and registration requirements) to eliminate confusion in the minds of perspective buyers.

[4] CIMB Bank recently announced financing for some EVs: https://soyacincau.com/2023/05/09/cimb-malaysia-most-complete-sustainable-finance-solutions-insurance-unlimited-towing-ev-charger/

OVERVIEW OF OBJECTIVES

This work was broken into three main phases, namely the initial planning and information gathering, development of a technical paper detailing the specific recommendations for policy changes (ie. this document) and finally developing a demonstration project and aiding with the national policy planners. Each phase is further discussed below.

Phase 1: Planning and information gathering

- Collaboration with the UNEP Program Management Officer to identify key issues and research focus areas
- Conducting comprehensive research of the status of policies and standards regarding electric 2&3 wheelers in Malaysia, benchmarking other ASEAN countries
- Performing surveys of the current 2&3-wheeler fleet in Malaysia to determine the fleet make, model and age, annual mileage, emissions and fuel consumption characteristics
- Performing surveys of Electric 2&3 Wheeler manufacturers and importers in Malaysia, focusing on what major issues and obstacles confront them in the dissemination of Electric 2&3 Wheelers in Malaysia

Phase 2: Development of a technical paper on electric 2&3 wheelers in Malaysia

- Organizing a kick-off meeting to present initial findings on the current Malaysian 2/3-Wheeler fleet and E2/3W manufacturer's issues and review policies and standards on E2/3Ws (*performed 8-06-2023*)
- Solicit input and suggestions from the meeting participants
- Develop a research paper on the policies and standards regarding E2/3Ws in Malaysia, benchmarking other ASEAN countries, the potential of promoting E2/3Ws, analysis of the environmental and socioeconomic impact of E2/3Ws
- Organize a final stakeholder meeting, present recommendations and key findings on E2/3W policy and standards in Malaysia
- Develop a technical paper that analyzes the competitive standing of local E2/3W importers, manufacturers and businesses, vis-a-vie larger e-mobility competitors like China, with an emphasis on obstacles to the proliferation of E2/3Ws. The paper also highlights the potential impact on the ASEAN region, in terms of market regulations, policies, and standards, and suggest cooperative approaches to address these implications
- Submission of a final report, incorporating feedback from the SMU team to the Program Management Officer

Phase 3: Assistance to the national project implementing partners in designing and launching an electric 2&3 wheeler demonstration project

- Provide technical advisory support to national project partners for planning and preparing the implementation of an E2/3W demonstration project
- Present highlights of the technical and policy recommendation papers to the project stakeholders at the project launch event

GOVERNMENT POLICY REVIEW

EXISTING STANDARDS

The standards and policies applied in Malaysia were adapted largely from UNECE legislation on the World Forum for Harmonization of Vehicle Regulations to standardize policies across the globe. In Malaysia, the L-category is used to segregate the classes of two and three-wheeled road vehicles. The Light Duty Electric Vehicle (LDEV[5]) standards and basic characteristics are shown in Figure 1. Further details on L-categories are attached in Appendix A.

Category	*Speed (kph)*	*Standard*	*L-Category*
Bicycle (Pedal-Assist)	0-25	MS2514	L1, L2
Scooter	25-50	MS2688	L1, L2, L6
Motorcycle	50+	MS2413	L3, L4, L5, L7

Figure 1 : Malaysian Standard (MS) to UNECE L category cross-reference.

For electrical two and three-wheelers there are three different standards based mainly on vehicle top speed. MS2514 is for the electric power pedal-assisted bicycle with a maximum speed of 25km/h or less. For simplicity these are referred to as “E-Bicycles”. Regardless of the frame type, 2-wheeled “sit on” electric vehicles with a maximum speed of between 25kph and 50kph are covered by MS2688 and referred to as “E-Scooters”. L6 category vehicles (four-wheelers of less than 4kW power) also covered by this standard. Electric 2-wheelers with top speed of more than 50kph are covered by MS2413, however this also covers three- and four-wheel vehicles with power more than 4kW[6] but smaller than standard cars. For convenience we refer to two and three wheelers in this category as “E-Motorcycles” and most other standard motorcycle regulations also apply to this class of vehicles. These three standards cover most of the electric propulsion system safety, performance and compatibility testing, including battery specific tests, based largely on UNR 136.

While most of the items covered in the three standards are quite similar, MS2413 (the “E-Motorcycle” standard) is related more exclusively to the electric propulsion and performance items, as many of the other aspects (e.g. lighting, breaks) are covered in the standard motorcycle specification which also applies to this class (>50kph) of vehicles.

LABELING

For registration and verification purposed, all vehicles under these standards are required to have a Vehicle Identification Number (VIN), in compliance with the World Manufacturer Identifier (WMI) Codes, and motor serial number similar to the conventional two-wheelers. To help identify them as electrical vehicle each class of vehicle requires an “EV” sticker easily visible from the outside of the vehicle, as shown in Figure 2. The size of the sticker varies by vehicle class as bicycles generally don’t have large surfaces available for the bigger size sticker of the E-scooter and E-motor[7].

[5] Here we use “Light Duty” to mean anything smaller than a standard car.
[6] Consolidated Resolution on the Construction of Vehicles (R.E.3) https://unece.org/fileadmin/DAM/trans/main/wp29/wp29resolutions/ECE-TRANS-WP29-78-r2e.pdf
[7] MS 2514:2015, MS 2413-1,2,3:2015, MS2688:2018 Malaysian Standards – SIRIM

Figure 2 : A few required labels: Electric Vehicle Sticker, "High Voltage" (>60V), and non-disposable (battery). EV sticker size varies by vehicle class.

SAFETY REQUIREMENTS

All three standards highlight that the electrical parts should be safe, with circuitry to prevent fires or shocks to passengers. Many tests are required including mechanical integrity (vehicle and battery drop tests, shake and vibration tests), insulation and electrolyte leakage tests.

1. WATER RESISTANCE TEST

One unique feature of these three standards is the "tropical rain" test and "flood fording" test. These were implemented because many of the vehicles imported under these categories were designed in temperate countries which do not experience the heavy rains and flooding common in Southeast Asia, resulting in frequent failures. The rain test is an eight-hour test where the vehicle is subject to a simulated rain of 25cm/hour, and then functionally tested. The flood fording test consists of a low-speed ride through 10cm deep water for 200 meters, followed by a functional test.

2. BATTERY CYCLE TEST

A battery life cycle test, further details attached in Appendix B, is performed to ensure that the battery can withstand a reasonable minimum number of charge-discharge cycles. The battery is charged at the vehicle's highest charging current until full (according to the charging system), then drained until the battery is depleted, or the vehicles control system indicates that the battery is depleted. During discharge the battery current is measured to calculate the cycle specific charge capacity. The drain current for the battery test matches the current required by the vehicle operating in normal conditions at 80% of the maximum speed of the vehicle. The battery is considered to be at the end of its useful life when the battery capacity falls below 80% of the initial capacity.

In the standard, manufacturers may opt to declare a battery life in terms of the number of kilometers or charge-discharge cycles to battery end of life. During the test the battery must be free from electrolyte leakage, bulging or rupture, fire or explosion. The battery lifecycle test is considered failed if the number of cycles of useful battery life is less than 300 or less than the manufacturers declared life in excess of 300 cycles.

3. PERFORMANCE TEST

One of the principal performance parameters is the vehicle top speed, which defines the class the vehicle belongs to. Top speed is measured on an out-door track over several trials and averaged. Vehicles are also subject to a 20% inclined test, where they must accelerate steadily uphill without significant rollback. Range is currently tested on a basic drive cycle, but the current test cycle is lightly loaded and not representative of real-world conditions. In subsequent revisions this will be changed to the World Motorcycle Test Cycle (WMTC)[8].

4. ELECTROMAGNETIC INTERFERENCE TEST

Electromagnetic interference is the hardest section for most manufacturers to pass. The vehicles are subject to Electro-Magnetic Interference (EMI) and must continue to operate safely. Additionally, the vehicles are tested for Electro-Magnetic Compatibility (EMC) where their electro-magnetic radiation is measured to ensure that it won't cause harm or interfere with other approved devices.

EXISTING POLICY

In December 2021, the Ministry of Transport announced that mopeds, Personal Mobility Devices (PMD) and Personal Mobility Aids (PMA) were prohibited from using public roads. Conventional bicycles, however, are not covered by this act. The E-bike and E-scooter vehicles were outlawed in line with the Road Traffic (Prohibition of Use of Certain Micromobility Vehicles) Rules 2021 negatively impacting the proliferation of such vehicles.

On the other hand, in line with reduced emissions targets, the government has planned on upgrading infrastructure to support the EV uptake and revised policies to encourage users to choose EVs for daily commuting. This includes lower taxes and fees as well as incentives for users and manufacturers.

1. MANUFACTURER TAXES

Malaysian Electric Vehicle manufacturers are eligible for a range of tax breaks, including sales, excise, and import tax reductions. Additionally, users can apply for tax breaks for driving electric cars. The goal of the incentives is to encourage additional EV manufacturers to locate their production hubs in Malaysia and foster the growth of a local EV assembly sector.

The 2023 federal budget declared a complete tax exemption for producers of EV charging equipment from 2023 to 2032 and these companies are also entitled to 100% Investment Tax Allowance over a five-year timeframe, as shown in Figure 3. Additionally, companies can claim a tax reduction if they rent EVs, with a maximum eligible sum of RM 300,000. A wide range of renewable energy equipment can also apply for these same incentives.

[8] See: https://en.wikipedia.org/wiki/World_Motorcycle_Test_Cycle#:~:text=The%20World%20Motorcycle%20Test%20Cycle,29.

GREEN INCOME TAX EXEMPTION (GITE)	Selected Qualifying Activities
• *100% of statutory income from the date of application received by MIDA until 2032* *(Maximum of 5 years)*	• Renewable energy project services (design, test and commissioning) • Energy Efficiency services (consultancy, energy audit, verification, test and commissioning) • Services related to installation, maintenance and repair of EV charging equipment, infrastructure and EV charging station. • Services related to operation of the EV charging station. • Services related to maintenance, repair and overhaul of EV.
GREEN INVESTMENT TAX ALLOWANCE (GITA)	**Selected Qualifying Activities**
• ***Green Investment Tax Allowance (GITA) of 100% of qualifying capital expenditure incurred on green technology projects from the date of application received by MIDA until 2032.*** • ***> The allowance can be offset against 70% of statutory income in the year of assessment. Unutilized allowances can be carried forward until they are fully absorbed.***	• Commercial and industrial businesses undertaking generation of energy using renewable energy. • Companies investing in energy efficiency equipment or technologies and investing in energy saving equipment. • Electric motorcycle/scooter, bus, truck and EV charging equipment/system

Figure 3 : Green Investment Tax Allowances and Exemptions[9]

2. USER TAXES AND FEES

Two-wheeler importation, excise and sales taxes are detailed in Figure 4. As can be seen there is a preference for local manufacture (CKD rates lower than CBU) and electric 2-wheelers get preferential tax rates. Through 2025 imported Completely Built Up (CBU) EVs are exempt from all import and excise taxes, while locally made Completely Knocked Down (CKD) EVs are exempt from all import and excise taxes as well as sales and service taxes (SST) up until the end of 2027[10]. The government declared a personal tax exemption of up to RM 2,500 for costs related to EV charging hardware and services, including the purchase, installation, rental, and subscription fees of EV charging facilities, until the end of 2023[11].

Engine Capacity	Import Duty			Excise Duties	Sales Tax	
	CBU	CKD		CBU/CKD	CBU	CKD
	MFN	ASEAN CEPT	MFN	ASEAN CEPT	All	All
<151	30%	5%	0%	0%	20%	0%
151-200	30%	5%	0%	0%	30%	0%
201-250	30%	5%	5%	0%	30%	0%
251-500	30%	5%	5%	0%	30%	10%
>500	30%	5%	10%	0%	30%	10%
Electric	0%	0%	0%	0%	30%	0%

Figure 4 : 2-Wheeler Importation, Excise and Sales taxes

9 GUIDELINES FOR GREEN TECHNOLOGY TAX INCENTIVE, MGTC
10 https://www.mida.gov.my/mida-news/budget-2023-extension-of-ev-tax-exemptions-more-incentives/
11 https://www.aseanbriefing.com/news/electric-vehicles-in-malaysia-tax-incentives-for-owners-and-manufacturers/

The Malaysian Government has agreed to nullify the road tax for E2Ws which travel in excess of 50kph thorough December 2025. However, the E-motorcycles must still be registered and covered by insurance as per conventional vehicle.

3. VEHICLE TYPE APPROVAL (VTA)

In line with the National Automotive Policy, the government has joined the World Forum for Harmonization of Vehicle Regulations (WP29) as a member. Members of this organization are responsible for adopting the United Nations (UN) regulations as a benchmark for the quality level of automotive products marketed in their countries. The specifications checked during VTA are attached in Appendix C.

4. PUSPAKOM

One final layer of governance is vehicle inspections performed by PUSPAKOM[12]. Inspections are mandatory every 6 to 12 months for different classes of commercial vehicles including trucks, buses and taxis, and cover basic safety checks and well as a rudimentary emissions test. Testing of private cars and motorcycles is optional, except when transferring the title to another party, or re-licensing the vehicle after the annual road tax has been expired for more than three years, in which cases it is mandatory.

[12] https://www.puspakom.com.my/about-us/company-profile/

ANALYSIS OF THE CURRENT STATE OF E2/3Ws

METHODOLOGY

During this study several data collection methods were used. For initial reviews of policies and regulations we relied heavily on on-line searches, followed by discussions with the responsible government representatives during a workshop on 8-June-2023 to fill in any gaps. Some vehicle data is accessible online, such as manufacturer vehicle specifications which occasionally include fuel efficiency, top speed and cost, as well as other websites specifically devoted to "self-reporting" of things like vehicle mileage. However, we found it necessary to perform field research to validate some of the data we received, such as the total number of electric vehicles on the road (given at 426 to 4000 units in different official government statistics), which didn't agree with observations (about 150,000 units according to our estimates). The principal field work included the following:

- Traffic Surveys
- Petrol Station Surveys
- Parking Lot Surveys
- EV Owner Surveys

Traffic surveys were conducted at several locations to establish the fleet mix, especially the 2-wheeler to car/bus ratios, and ridership (e.g. number of people per motorcycle or car). This was done by counting the number and type of vehicle passing a given position on a road (typically at a stop) and counting the number of passengers. This was performed at different settings (e.g. rural, urban and state highway) and during different times of the day to get as broad a sample of traffic as possible.

Surveys were performed at petrol stations where we recorded the vehicles engine capacity, age, odometer reading and enquired about the vehicles' fuel consumption, in terms of cost per fill up and frequency of fill ups. Drivers were overwhelmingly willing to share their information and expressed interest in the study. This data was used to establish the fleet age and typical annual mileage, as well as giving us an approximate fuel consumption number.

Parking lots with large numbers of 2-wheelers were surveyed looking into the make, model and year (as estimated from the license plate number), and when available odometer reading. We were also able to assess the level of emissions compliance (2-stroke, 4-stroke carbureted, 4-stroke fuel injection) and identify any electric 2-wheelers.

When we found any EV, we endeavored to identify its owner and ask more in-depth questions about the age, cost and usage of the vehicle. From these we were able to establish typical usage patterns, motivation for buying the E2W, battery life expectancy and cost, and many other observations about the E2Ws.

In total we surveyed over 2,000 vehicles during this study. While the goal was not to get precise numbers, after all one can hardly expect a typical car owner to give a precise estimate of their fuel usage per kilometer, we wanted to get reasonable bounds on the various parameters investigated. The full data set is available in Appendix D.

RESULTS

The primary data point of interest for our study was the current number and ridership of 2- and 3-wheelers, with a particular focus on electric 2-wheelers, in comparison to cars. Notably, we found very few 3-wheelers in operation. Across all our investigations, only four 3-wheelers were identified as shown in Figure 5, indicating that as of 2023, 3-wheelers remain exceedingly rare on Malaysian roads.

Figure 5 : Despite their popularity in Southeast Asia Three wheelers are a rarity in Malaysia.
Source: Author's photo

1. FLEET MIX

In our survey of existing 2-wheelers on the road in Malaysia we found that the majority (58%) are still carbureted 4-stroke powered, as shown in **Error! Reference source not found.**. Fuel injection (EFI) has only become popular in Malaysia recently, due to stricter emissions regulations, and most new motorcycles are fuel injected but they only make up about 38% of the current fleet. Two strokes, which have not been sold for several years, still make up 2.3% of the 2-wheeler population, and electric two wheelers currently comprise about 1.5% of the 2-wheeler fleet in Malaysia.

Assuming there are approximately 10 million 2-wheelers in current use in Malaysia, this implies that there are around 150,000 electric 2-wheelers in use here. Of the E2W's surveyed all were "E-scooters" with top speeds between 25 and 50 kph, though some of them were clearly "bicycle frame" vehicles while others looked more like motorcycles (Figure 6). According to manufacturer sales numbers there are several thousand "E-motorcycles" on the roads, however we did not encounter any during our studies.

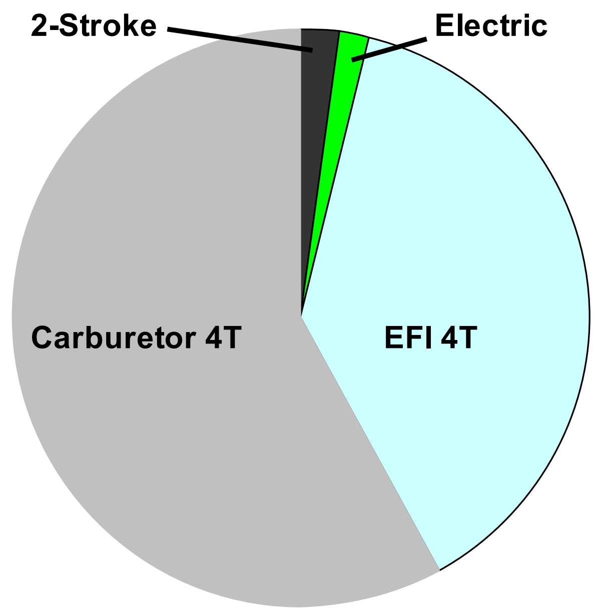

Figure 6 :Breakdown of on-road 2-wheelers in Malaysia.

Figure 7 : "E-Scooter" vehicles in Malaysia (Left). The "bicycle" has a top speed of 40kph on electric drive (Right).
Source:*Author's photo.*

A breakdown of the 2-wheeler manufacturers, Figure 8, shows that the overwhelming majority are Honda and Yamaha vehicles, which together make up over three quarters of the motorcycles sampled. Modenas (<7%), a national brand, comes behind SYM (8.5%), a fairly recent entry into the market from Taiwan.

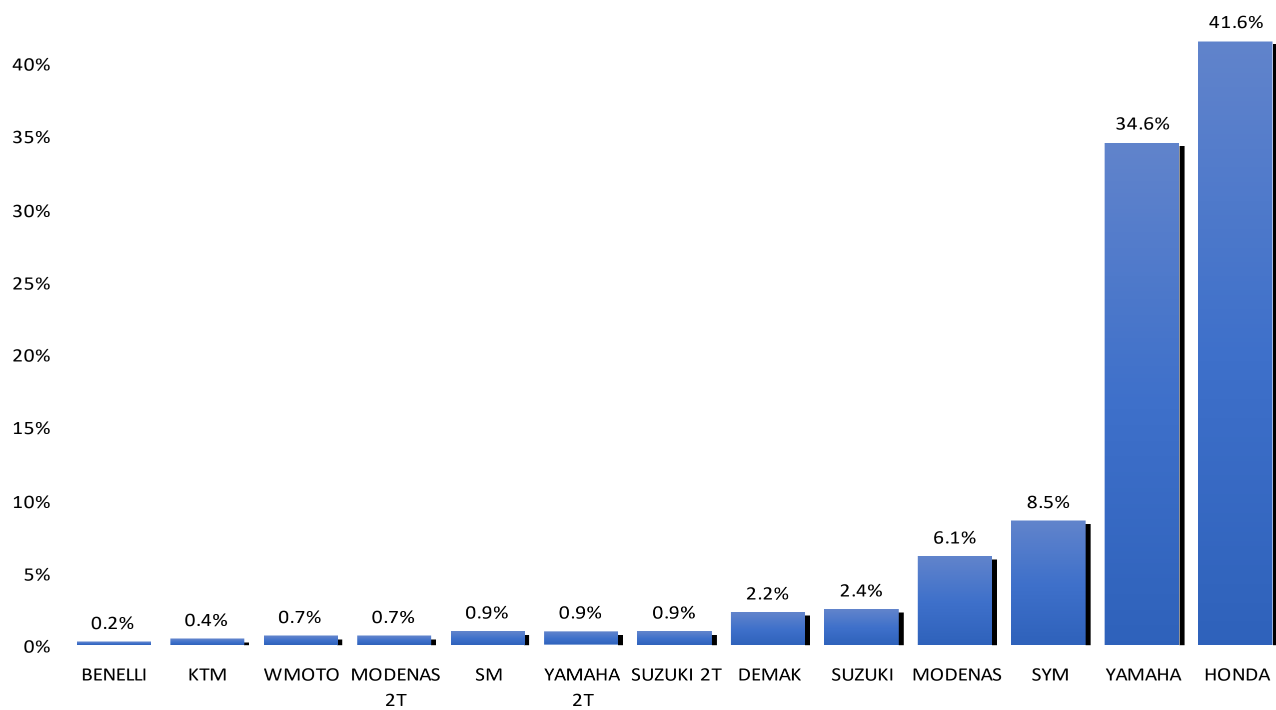

Figure 8 : Percentage of on-road motorcycles by brand and Engine type.

2. FLEET AGE

The average age of the 2-wheeler fleet was found to be 10 years, with the oldest motorcycle in the survey dating back to 1988 and a significant number of bikes from 1998 or newer. Older motorcycles were predominantly 100cc, whereas the two most popular models today are 150cc. Figure 9 illustrates the average engine displacement over time, showing an annual increase of approximately 3cc per year.

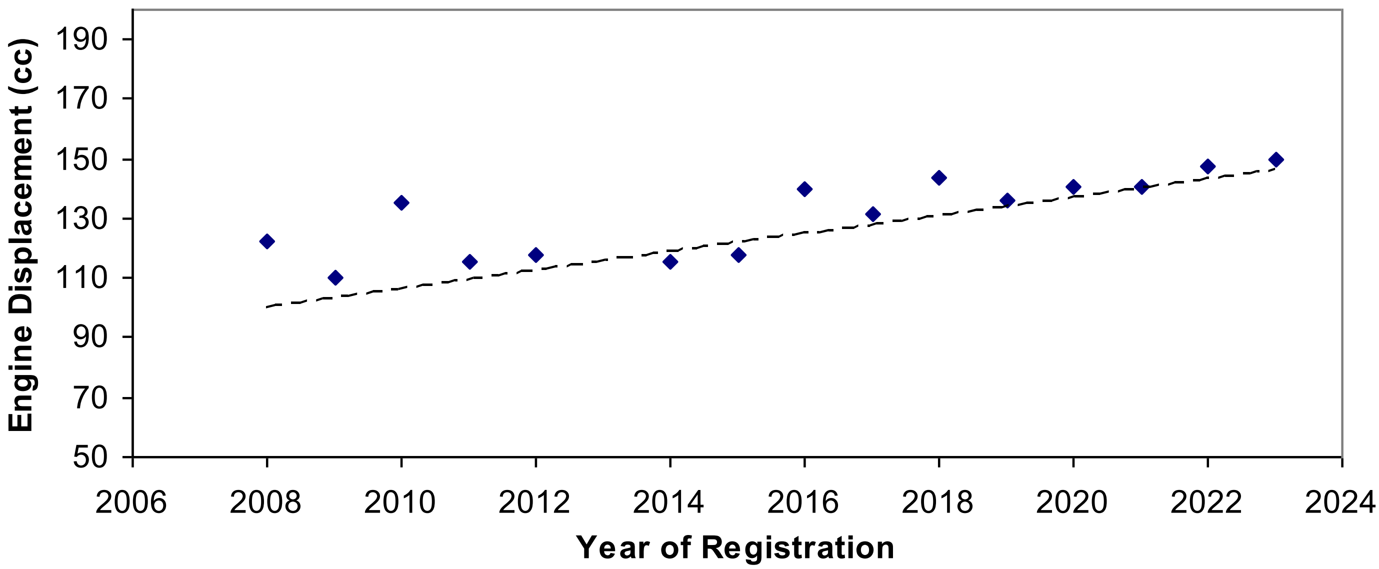

Figure 9 : Average Engine Displacement vs Year of Registration

3. ANNUAL MILEAGE

Parking lot surveys only give mileage numbers from relatively older vehicles which still have mechanical odometers, and we were unable to verify the functionality of the odometer, so petrol station surveys were carried out where we ascertained the year of the vehicle and mileage. This yielded an annual mileage of around 18,000km per car and 9,000km per motorcycle consistent with previous studies[13].

4. MILEAGE VS YEAR - POWER

From electric 2-wheeler owner surveys we know that the low power E2Ws achieve significantly lower annual mileages than conventional motorcycles due to their usage patterns. Common sense also dictates that lower speed vehicles will tend to accumulate lower mileages, so we looked at the annual mileage of the 2-wheelers as a function of age and engine power. Plotting the annual mileage (total mileage divided by vehicle age) against the vehicle's engine displacement (or equivalent for electric scooters), Figure 10, we can see that annual mileage increases significantly with engine size (and thus power), and this extends down to the lower power E2Ws encountered on the roads today.

[13] In a 2020 study for WWF we recorded 18,000 km/year for cars and 8,500km/year for motorcycles

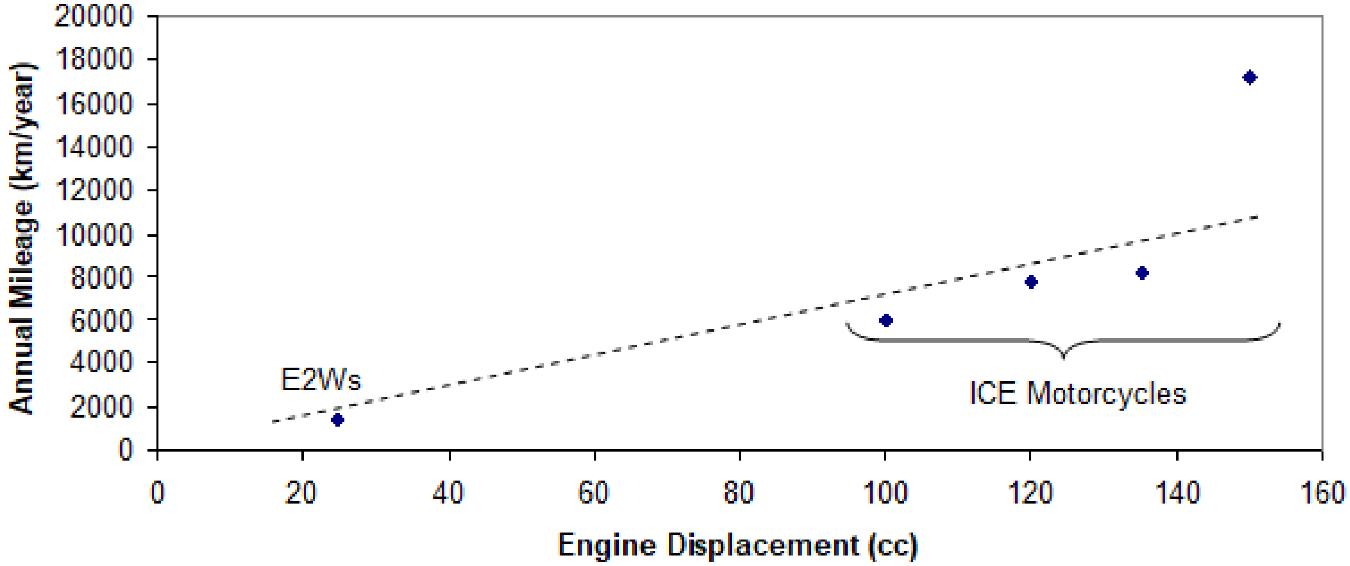

Figure 10 : Average annual mileage vs. engine displacement or equivalent

This, however, is the result of several factors, notably that newer vehicles tend to be driven more than 20-year-old vehicles for several reasons including improved fuel efficiency with newer vehicles, higher power on more recent models, as well as an increased concern for the reliability of older vehicles. To separate out the effect of power and age, we plotted the average mileage versus year for two common engine capacities an in Figure 11. In all cases there was a strong trend of decreasing mileage with vehicle age, and higher mileage accumulation on more powerful vehicles. Interestingly the mileage degradation over time of the higher power vehicles appears to be more pronounced than the lower power units. Finally, there are relatively few new 100cc motorcycles, whereas there are fewer old high-capacity motorcycles due to the increasing engine capacity trend noted earlier.

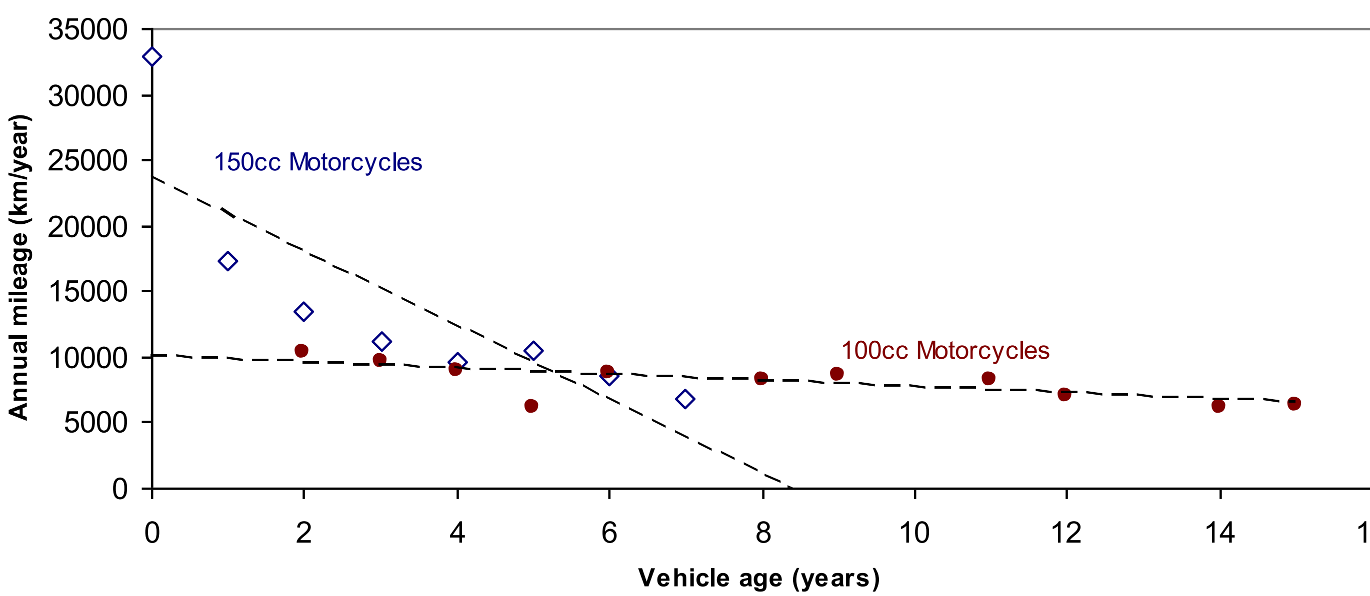

Figure 11 : Annual mileage vs. motorcycle age for 150 and 100cc motorcycles

5. ELECTRIC VEHICLE FLEET

In the course of this work, we encountered a total of 50 electric 2-wheelers. A quarter of these were counted in parking lot surveys, implying that approximately 1.5% of all 2-wheelers on the road are electric. While the total number is too small to draw many statistical conclusions about the E2Ws themselves, the characteristics of the vehicles we investigated agreed well with a MIROS survey we were involved with published in 2021 (Hamza,2021). The vehicles had top speeds of 20 to 70 kph, with an average of 40kph. The vast majority had top speeds of between 25 and 50 kph, making them “E-scooters” by law. No manufacturers have passed the relevant standard (MS2688), implying that all these E-scooters are illegal. The average travel speed was reported to be about 27 kph.

Vehicle range per charge varied from 12 to 60km, with an average of approximately 34km. Most of these vehicles were still powered by lead acid batteries. Annual mileage averaged 1455km, ranging from 50 to 5000km per year. The average purchase price of these E-bike and E-scooter vehicles was around 1660RM, ranging from 700 to 3200RM.

Apart from the survey of local manufacturers and importers, we also conducted an online investigation of electric 2- and 3-wheelers available in Malaysia, as shown in Figure 12. Many models of both 2- and 3-wheelers are available at prices starting from around 750RM. A few of the more expensive models are legitimate E-motorcycles, with valid MS2413 certification, but the overwhelming majority are uncertified E-scooter or E-motorcycle vehicles. Several of the lower cost vehicles were encountered on the roads in our study, and frequently the owners were relatively content with their performance.

65kph 8300 RM | 50kph 2000 RM | 28kph 1400 RM (3-Wheeler) | 40kph 750 RM

Figure 12 : Various E2Ws available online, with their top seed and price.

During our investigations it was noted that some manufacturers advertise “E-scooter” vehicles online while proclaiming SIRIM certification as an “E-Bicycle” class vehicle, Figure 13.

Figure 13 : Online claim of MS2514 (E-Bike) Conformity while advertising E-Scooter speed (30-40kph).

ECONOMIC ANALYSIS

To better understand the position of E2/3Ws in the market, we undertook an economic analysis of Electric 2-wheeler ownership compared with conventional ICE 2-wheelers. The model will be used to estimate the total lifetime cost of different vehicles on a cost per year, and cost per kilometer basis. Inputs to the model include the vehicle purchase price, expected life span, annual mileage, fuel or electric power efficiency, and for Electric Vehicles it includes the battery life span and cost as well. Annual expenses include road tax and insurance, maintenance costs and fuel or electric power costs. Finally, the total cost of ownership is calculated on a per year and per kilometer basis.

The model was applied to four "target" vehicles:

- A conventional 90cc "Honda cub"
- A 35kph "E-Scooter"
- A 150cc conventional motorcycle
- A 60kph "E-Motorcycle"

A few assumptions had to be made to give a realistic estimate of the actual usage. For example, from our surveys we have established that the annual mileage accumulation for motorcycles is approximately 9,000 km/year. This is applicable to the newer, higher power vehicles, but the lower power vehicles will clearly have a different annual mileage accumulation. Electric scooters, for example, are only driven at relatively low speeds, and short distances achieving annual mileage accumulations of around 1,500 km. Additionally, the different vehicles will have very different life spans. While the classic Honda Cub of the 1980's was a marvel of reliability[14], often operating for well over 20 years, most of the small, inexpensive conventional vehicles don't

[14] See for example: https://www.webbikeworld.com/honda-super-cub-history/

last as long from many years of "cost reductions". The larger displacement motorcycles are becoming more popular, with the average displacement these days running about 150cc. These machines, Honda and Yamaha being the most popular, are expected to last 20 years, while we've put the life span of a low-cost 90cc motorcycle at 15 years.

Electric 2-wheelers, by contrast, have only been around in large numbers for a short while, and have yet to establish such long lifespans. The smaller machines have been shown to have very limited life spans, mostly due to battery degradation and cheap materials (Hamza, 2021). Battery life spans on the smaller E-scooters range from 6 months to 3 years for lead acid batteries, while Li-ion batteries common on the more expensive E2Ws may claim 15-year life spans. Some small E2W owners will change the battery sets multiple times, but at some point, the vehicle is so old that it makes more sense to upgrade to a newer vehicle. Therefore, we have selected a life span of the smaller E-scooter at 8 years, including 4 battery sets (3 replacements of the battery set), while the larger E-Motorcycle and battery is assumed to have a life span of 15 years.

Vehicle fuel efficiencies were estimated from previous studies, including online fuel consumption data bases[15]. For the E2Ws "fuel efficiency" is calculated based on several factors including the vehicles average speed, battery chemistry, weight and aerodynamics and rolling resistance. Details of the calculation can be found in Appendix E.

Vehicle	ICE 90	E-Scooter	ICE 150	E-Moto	Units
Nominal Power	5	0.5	10	3	kW
Displacement/Voltage	90cc	48V	150cc	70V	
Purchase Cost	3500	2000	10000	14000	RM
Vehicle Life	15	8	20	15	Year
Battery Life		2		15	Year
Battery Cost		500			RM
Range	5500	1500	9500	8000	km/year
Fuel Efficiency	60	50	40	28.6	km/l, km/kWh
Maintenance Cost	140.75	251.67	296.00	85.00	RM/year
Annual Fees	200.00	0.00	400.00	200.00	RM/year
Fuel Cost	504.17	9.00	1306.25	84.00	RM/year
OPERATIONAL COST	844.92	260.67	2002.25	369.00	RM/year
Lifetime Range	82500	12000	190000	120000	km
Lifetime Cost	16174	4085	50045	19535	RM
COST/KM	0.196	0.340	0.263	0.163	RM/km
COST/YEAR	1078	511	2502	1302	RM/year

Figure 14 : Cost of Ownership Calculations for various 2-wheelers.

Vehicle sale prices were gleaned from various online sources and E2W Owner surveys. Maintenance costs of conventional vehicles were estimated from interviews with motorcycle owners. In general maintenance costs of the E2Ws (excluding batteries) are much lower than conventional ICE vehicles as there is no need for engine oil and filter replacement. Finally annual fees (road tax and licensing fees and mandatory insurance) were

[15] See for example: https://www.fuelly.com/motorcycle

estimated based on the vehicle's displacement. E-Motorcycles with speeds greater than 50kph are required to have registration and insurance while the E-scooters are not currently required to.

Summing up the purchase cost, annual fees, maintenance and fuel/power cost we can arrive at a total lifetime cost of ownership, neglecting end of life costs, or second-hand value of the vehicle. Taking the assumed annual mileage times the vehicle life span in years we can calculate the vehicles total distance traveled. The lifetime cost of ownership is then divided by the number of kilometers traveled for a cost per kilometer or divided by the years of ownership to get a cost per year.

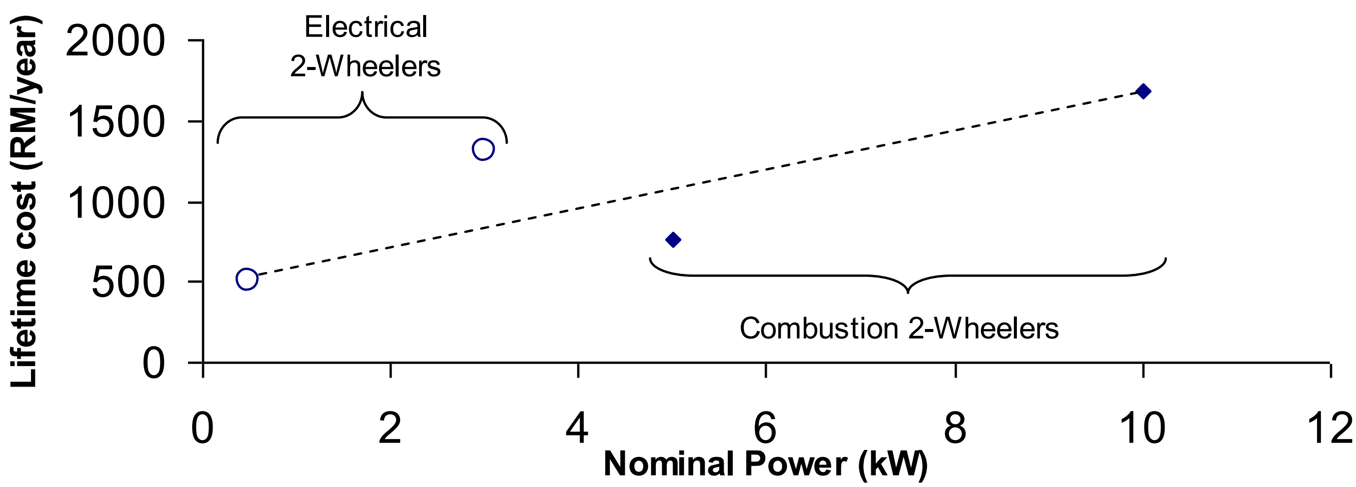

Figure 15 : Cost of ownership per year for various vehicles. E2Ws are shown as open circles.

The resulting cost of ownership per year is shown in Figure 15 with the E2W vehicle shown by open circles, and ICE vehicles by diamonds. The smaller E-scooter is clearly the lowest cost vehicle on a per year basis, while the higher power E-motorcycle comes in at a cost somewhere between the two ICE vehicles. The obvious conclusion is that for very low power, low range demands the small E-scooters are the lowest cost option. This, along with the lack of ICE competition in this low-power category, helps explain why the E-scooters are so popular: they simply cost less per year to own and operate. People are willing to spend more money on more power vehicles. The dotted line is a hypothetical price point as a function of power: vehicles below this line will be financially attractive whereas ones above the line will appear to be too expensive for the given performance. As E-motor is above this line, consumers will prefer to spend the same amount of money on a higher performance bike, thus the E-motorcycles currently remain financially unattractive.

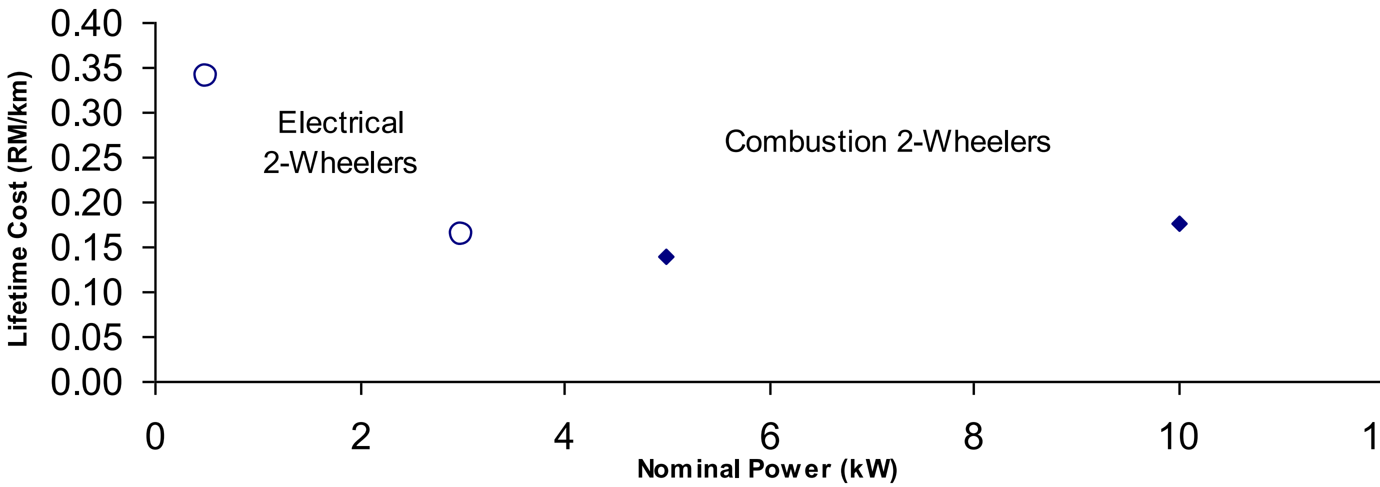

Figure 16 : Cost of ownership per kilometer. E2Ws are shown by open circles

Looking at the lifetime cost of ownership per kilometer travel we get a somewhat different picture as seen in Figure 16. The E-Scooter is now much more expensive *per kilometer* than the other forms of transport, primarily because its total lifetime range is so small. The E-motor's cost per kilometer is just above the 90cc conventional motorcycle based on our assumptions, putting it at a slight economic disadvantage. When one then considers the disadvantages of EVs, namely the limited range, and charging time, it should not be surprising that the E-motorcycles are not yet successful in the market.

While one can take issue with any of the various assumptions made above, the end results clearly show that there is a good economic reason why the smaller E-scooters are quite popular compared with the larger E-motorcycles. Given the unknowns associated with new technologies, and the relatively high up-front costs of EVs, consumers will tend to go with what they are familiar with and show a distinct preference for conventional ICE powered 2-wheelers in Malaysia.

Using the same model, we can adjust the fuel price and see how this affects the relative cost of the various 2-wheelers. In Figure 17 we can see the lifetime cost per kilometer of the same four vehicles as a function of fuel cost. The combustion vehicles costs will increase linearly with fuel price, whereas the E2Ws costs remain fixed. Again, we can see that the E-scooter still has the highest cost per kilometer, even at the ASEAN fuel price of 5.5RM/liter. Above about 3.5RM/liter the E-motorcycle starts to gain an advantage over the combustion vehicles in terms of cost per kilometer. However, it must be remembered that the Return On Investment (ROI) of buying the E-motorcycle will only be realized after about a decade, far beyond the typical user's investment horizon.

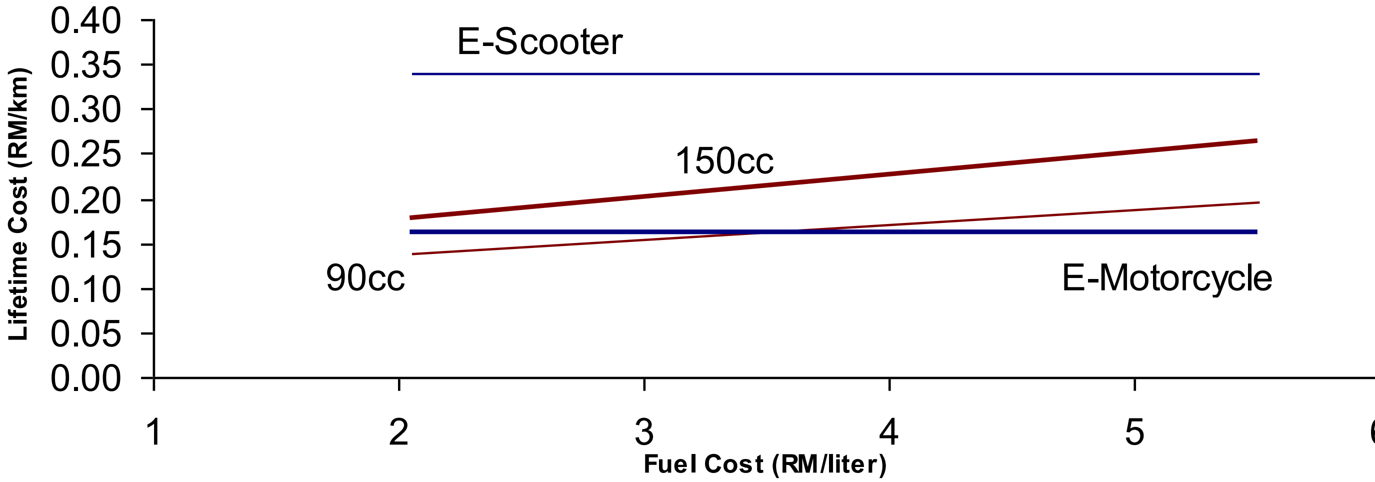

Figure 17 : Lifetime cost per kilometer of various 2-wheelers vs. fuel cost

The conclusion is that, while higher fuel prices will help the case of E2Ws, to really push consumers to prefer E2Ws more concrete measures will likely be required.

COMPARISON WITH OTHER ASEAN COUNTRIES

The ASEAN countries have in general agreed to global carbon reduction commitments. Vietnam and Malaysia have agreed to target carbon neutrality by 2050, Indonesia by 2060 and Thailand by 2065. In the transportation sector Indonesia has plans to begin phase out of combustion 2-wheelers from 2025 and is targeting 2 million EVs by 2030. Thailand is targeting 100% zero emissions vehicles from 2035, and Malaysia is targeting 100% EV/CNG/LPG or Bio-fueled vehicles by 2030. Given the high volume of 2-wheelers in Southeast Asia, E2Ws will feature heavily in these plans.

While there are many geographic, historical and climatic similarities among the SE Asian nations, there is also a wide disparity in terms of economic advancement. However, one common feature of this region is the high market share of two and three wheelers in use, with estimates of more than 150M units in SE Asia[16]. Several relevant country parameters are shown in Figure 18.

Of the surveyed countries, Malaysia is the least populous and most prosperous, which puts it at a disadvantage in terms of transportation related emissions. Since the 1970's the country has followed a petroleum, road and car-based development plan with major exploitation of petroleum resources via the national petroleum company Petronas, and developments such as the national car company Proton. While this has led to significant prosperity and massive investments in road infrastructure, it has also saddled the populace with dependency on private car ownership.

Country	Malaysia	Thailand	Indonesia	Philippians	Vietnam	Notes
Population	34,219,975	69,794,997	279,476,346	116,434,200	104,799,174	1
GDP/Pax (PPP)	25,836	17,523	11,615	7,917	9,886	2
Fuel Price	0.44	1.25	0.67	1.07	0.87	3
Cars	15,240,000	17,850,000	15,394,000	1,134,000	2,429,600	4
2-Wheelers	14,891,000	21,588,000	110,633,000	7,328,000	72,061,000	4
3-Wheelers	-	2,677	48,084	266,340	-	5
Registered E2W	4,000	60,000	60,000	22,000	2,000,000	6
Unregistered E2W	200,000	289,947	300,000	150,000		7
E2W/2W	1.37%	1.62%	0.33%	2.35%	2.78%	8
Cars / Pax	0.445	0.256	0.055	0.010	0.023	
Car/Bike	1.023	0.827	0.139	0.155	0.034	

Figure 18 : Population, GDP, Fuel price and Vehicle Registration number for selected ASEAN countries[17]

One of the most important factors in transportation emissions is the number of cars per person. Looking at the data for the selected countries the "car density" is strongly related with the available GDP per pax. Graphing this, we see the relation clearly in Figure 19. Obviously the more purchasing power someone has, the more

[16] Estimate from: https://fami-motorcycle.org/#:~:text=South%20East%20Asia%20(SEA)%2C,a%20household%20is%20extremely%20common

[17] NOTES: (1) Estimate for 2023, from CIA World Fact Book, (2) Based on 2021 Est. GDP, CIA World Fact Book, (3) From https://tradingeconomics.com/, (4) For 2020 from https://data.aseanstats.org/, (5) Estimate based on 2020 new 3W sales and estimated % of 2W Pop, (6) From ICCT Market analysis of two- and three-wheeler vehicles in key ASEAN member states and statista.com, (7) Author's estimates based on surveys (M'sia, RP, Thai) and proportionality (Indo, VN) and interviews with national representatives

likely they are to buy a car. In general, we can expect that with prosperity societies will progress further to the right of the curve, demanding ever greater numbers of cars, and generally larger, heavier vehicles.

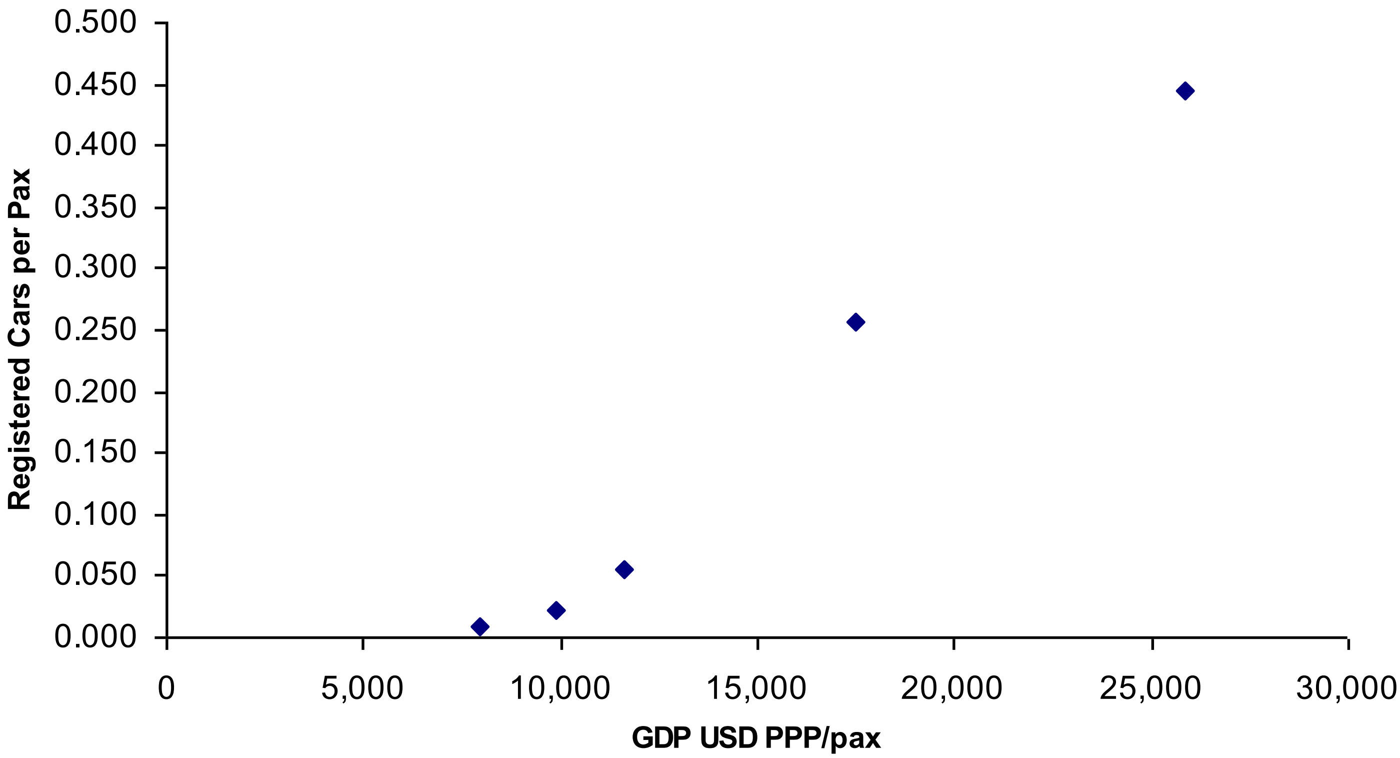

Figure 19 : Cars per person vs. GDP per person for the selected SE Asian countries.

In the last decade there has been a large increase in the usage of small E2/3Ws with several local enterprises founded to take advantage of this market. Notable successes include Vinfast of Vietnam (Figure 20) and Gesits of Indonesia which have sold 100,000 and 26,500 units to date respectively (Le 2022). Of the Malaysian entrants (Eclimo, Roda Prestasi, Legatus and Voltron) only Voltron has had significant sales of their E-bikes with around 100,000 units sold, but these sales were largely overseas, not in the ASEAN region.

One of the major factors affecting the sales of E2W's should be the price of fuel. If we plot the number of E2Ws for the various countries against the fuel cost in that country, we get the graph of Figure 21. While there is sparse data, the trend of increasing E2W share with higher fuel cost is generally discernable: higher fuel cost results in a greater share of E2Ws in the 2-wheeler fleet. Certainly, this is a factor in the success of Vinfast in Vietnam.

Figure 20 :E2W Assembly in Vietnam.
Source: VNA/VNS Photo Ngoc Ha

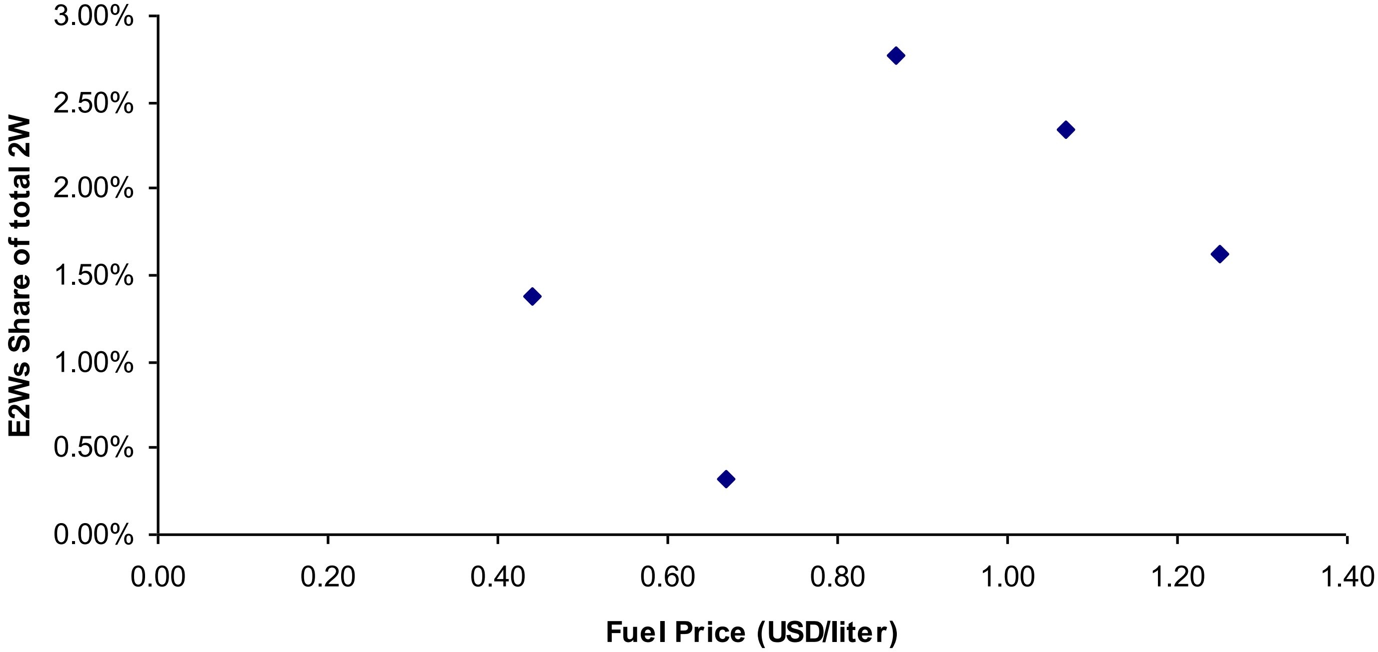

Figure 21 : Electric share of the 2-wheelers vs fuel price for the selected ASEAN countries.

Despite a few notable successes by ASEAN manufacturers, the vast majority of the product on the roads comes directly from China and consists of a wide range of small 2- and 3-wheelers. In most countries these are not registered and therefore go unreported in most analysis. The numbers in Figure 18 earlier are estimates based on surveys and proportionality to countries with better established numbers. For example, in 2023 there were approximately 4000 registered E2Ws of all classes in Malaysia, whereas our surveys have shown EVs to comprise around 1.5% of all 2-wheelers, or over 150,000 units, well over 95% of them unregistered. The same thing can be observed in Thailand, Indonesia and the Philippians where most of the small E2W (bicycle and scooter class) are unregistered.

ASEAN PROGRESSIVE POLICIES AND OBSTACLES

As many of the ASEAN countries are facing similar challenges in reducing transport related emissions, a review of the relevant policies is in order. Fortunately, this area has come under greater scrutiny lately, and several recent publications cover E2/3W related policy for several of the countries.

Figure 22 : Thailand EV Eco Sticker

Vietnam has the highest rate of registered E2Ws, and these are mostly (70%) local brands despite a lack of comprehensive supporting government policy (Le 2022-2). Most of the E2Ws have top speeds of around 50kph, with the lower power units (about 70% to the total) using lead acid batteries, the more expensive units using Li-ion batteries. Most users charge at home, but Vinfast has erected several charging and swapping stations, and even sells some models with a separate battery rental/swapping arrangement. There are plans to expand the battery charging and swapping stations to include locations such as commercial centers, gas stations, supermarkets, bus stations, public parking spaces, apartment buildings, offices, universities, etc.

While Thailand has a relatively low number of registered E2Ws, like most other ASEAN countries there are many unregistered small E2Ws on the roads. Thailand has enacted several policies supportive of E2Ws including a 18,000-baht (2,400RM) subsidy for electric motorcycles and exemption of import duties on critical EV components including batteries, BMS, motors, motor controllers, and reduction gears (Nguyen, 2022). Additionally, all vehicles are subject to a "CO_2" based excise tax, which increases taxes on less efficient vehicles regardless of the technology, and an "Eco sticker" label for vehicles including EVs as shown in Figure 22 to help customers assess the efficiency of perspective vehicles. Finally, Thailand is working on E2W battery swapping standards and promotion via various government sponsored demonstration projects[18]. A lack of charging infrastructure and high cost of EVs is cited as a significant constraint on EV proliferation, however EV sales have benefited from the relatively high price of fuel in Thailand.

The Philippines is yet another country where the unregistered small E2/3W greatly outnumber the registered E2/3W. One aspect fairly unique to the Philippians is the common use of 3-wheelers including a relatively large number of electric 3-wheelers introduced in the last few years, mostly Public Utility Vehicles (PUV) used as taxis/buses rather than private use vehicles (Ha 2021). While the Philippians has a number of EV supportive policies, such as zero importation duties on EV components and zero excise tax on EVs and various measures designed to "mainstream" EV usage, the fragmented nature of government planning makes enacting a comprehensive EV policy more difficult. The high cost of EVs, lack of charging stations, despite some government demonstration projects, Figure 23, lack of consistent policy and underdeveloped domestic EV industry are cited as reasons for the relatively low uptake of EVs in the Philippians.

Figure 23 : Metro Manila Solar E-Bike charging station. Source MMDA

Indonesia, much like Vietnam, is focusing on developing its domestic E2W production to cater to the expanding market, both within Indonesia and abroad (BCG 2022). A long-term EV policy, including focus on E2Ws has been in place for several years, and consists of zero sales tax (if local content requirement is met), easier access to loans for buying EVs, parking discounts, tax incentives for EV/component manufacturers, and discounted electrical rates for both home charging and battery charging/swapping stations. Indonesia recently announced the major step of offering a 450USD (2100RM) subsidy on the purchase of domestically produced E2Ws[19].

[18] From presentation "Shifting to Efficient and Zero Emissions Vehicles in the Global South" by Nuwong Chollacoop 2022

[19] https://techwireasia.com/2023/03/indonesia-unveils-ev-subsidies-for-consumers-and-manufacturers-heres-a-breakdown/

Two-wheeler delivery services are very common in Indonesia, and several projects have demonstrated the viability of E2Ws as delivery bike Figure 24 as well as highlighting some of their weaknesses. Indonesia has also embarked on an ICE to E2W conversion program, however results to date are fairly merge (IESR, 2023). A relatively weak residential electrical power supply has been cited as a potential obstacle to greater EV adoption, however for the low power E2Ws this is not an issue. Other problems include the lack of charging infrastructure and high cost of EVs.

Figure 24 : Delivery bikes are a major focus for electrical conversion in Indonesia.
Source: Institute for Transportation and Development Policy

RAMIFICATIONS FOR MALAYSIA

From the above summary of various ASEAN countries, we can see that while many of the challenges facing the various countries are similar, their success in implementing measures to enhance E2/3W penetration is uneven. Highly centralized governments with clear direction and fiscal authority enjoy greater success than fragmented governments. Increasing the cost of ICE vehicles relative to EVs, either via taxes, higher fuel prices or subsidies, can have a major effect on the market. A clear, comprehensive, long-term policy for E2W market expansion is required. One of the main disadvantages for Malaysia is the relatively low population compared to our immediate neighbors. This will make sustaining a local E2W industry much more difficult if it is only focused on the domestic market. The contrasting success of the local E2W manufacturers (Eclimo, Roda Prestasi, Legatus) focusing on the domestic market, with sales of ~1,000's of units, and that of Voltron, with over 100,000 units exported, helps to underscore the point: If Malaysia wishes to become a significant E2W manufacturing base we must focus not only on the domestic market, but the much larger export market. It is therefore in our best interest to champion the cause of greater ASEAN integration and standardization, especially with respect to electric 2-wheelers.

ASIAN INTEGRATION

Greater integration of the ASEAN electric 2- and 3-wheeler market is potentially advantageous, not just for Malaysia, but for ASEAN as well. Ideally ASEAN would develop harmonized standards, such that any vehicle produced in any country would comply with, and could be sold to, any of the ASEAN countries. For standards compliance testing, any certified laboratory could perform the testing, obviating the need to duplicate these expensive facilities in every country. Standardizing the vehicles will also allow manufacturers to supply components to the much greater ASEAN market rather than just their home country. Vehicle assemblers, similarly, can choose components from different countries, potentially getting a lower price, with the knowledge that they are compatible with their vehicles, and acceptable as export to other ASEAN countries. This could allow each country to focus on components that match their resources and industry, while still participating in the larger overall market. This becomes increasingly important when considering things such as EV batteries, either fixed or swapable, which require very large production scales to be economically viable.

Once vehicle and battery standardization has been harmonized, the resulting "ASEAN" produced vehicles would be better able to compete against imported product, for example from China. Importation tariffs could be applied to encourage regionally produced vehicles, while reducing capital flights from the ASEAN region.

Greater ASEAN integration of EV standards and production will also help us penetrate the global market via lower production costs and improved economies of scale[20]. Ideally the benefits of this will be shared among the various ASEAN countries, contributing to equitable economic development, and increasing regional stability[21].

[20] "Comparing EU and Asian Integration Processes: The EU a role model for Asia?", Axel Berkofsky, European Policy Centre

[21] Ibid: Such as the 1997-1998 Asian Financial Crisis

MANUFACTURERS SURVEY

Several Malaysian importers and manufacturers of E2/3W were interviewed between May and September 2023. These manufacturers and importers represent the majority of the legally produced and imported E2/3Ws, mostly with top speeds of greater than 50kph (E-Motorcycle). However, as our previous field data has shown, the vast majority of E2/3W currently on the road are the 25-50kph class “E-Scooters” imported directly from China, none of which have passed the appropriate MS2688 standard, and are thus illegal to import and sell. These importers were not included is this survey.

While the surveys were intended to be “open ended” (the basic survey form used is available in Appendix F) we specifically asked about problems encountered with licensing and permits, importation and taxes, suppliers and quality, market and customers, and enquired about separate individual vehicle components (Battery, BMS, Motor, Controller and Frame). The Vehicle Class (top speed) and number shipped to date were requested, to help put their answers in perspective. Finally, we asked for the two or three most important factors that could improve E2/3W proliferation in Malaysia. Each interview took about one hour, and in general there was enthusiasm on the part of the manufacturers to share their insights, and even to “vent” about particularly frustrating issues.

The various manufacturers were in broad agreement with their assessments of challenges facing the proliferation of E2/3Ws in Malaysia, with most of them citing the low cost of fuel, and the high cost of batteries as major issues. Their feedback is summarized below prioritized by commonality and importance (as judged by the manufacturers themselves), the most important first.

MARKET SIZE AND COMPETITION

According to manufacturers the most difficult problem with E2/3W manufacturing in Malaysia is the market and competition against ICE vehicles, and cheap Chinese imported electric scooters. With retail petrol prices of 2.05 RM/liter[22] (0.46 USD/liter) domestically, there is much less economic motivation to switch to electric propulsion compared to other markets with higher petrol prices (e.g. India: 1.29 USD/liter, Philippians: 1.16 USD/liter, Thailand: 1.27USD/liter[23]). Thus, one of the major advantages of electric propulsion, namely the lower cost of electric charging compared to petrol, is much less influential in the Malaysian market.

Another problem highlighted was the competition against cheap mass-produced E2/3W vehicles, overwhelmingly imported from China. Various models can be purchased on-line for as little as 750RM (167 USD) for a 35 kph “Electric Scooter”, with the most popular models costing up to 2000RM (about 450 USD), and resembling motorcycles, albeit slightly smaller, as shown in Figure 25. Also shown are the domestically produced Roda Prestasi Boss 2000, costing 3200RM, and the Eclimo ES-11 at 14,000RM. The China vendors generally do not comply with existing SIRIM standards, and in most cases are imported by companies which lack the appropriate Customs Approval Permit (AP)[24], whereas the local manufacturers require proper licensing and permits to do business. One manufacturer stated, “The Malaysian government is not assisting the local manufacturers who invest in product development, whilst opening the floodgates to welcome foreign brands”.

[22] Multiple on-line resources give the RON 95 petrol price of 2.05RM/liter for May 2023
[23] Downloaded from: https://www.globalpetrolprices.com/ 15-05-2023
[24] See for example: https://careta.my/article/jabatan-kastam-diraja-malaysia-gagalkan-cubaan-seludup-basikal-elektrik-e-bike
Or: https://www.sinarharian.com.my/article/257826/berita/semasa/kastam-rampas-265-basikal-elektrik-seludup-dari-china

Make	LEM (China)	RodaPrestasi (M'sia)	Daison (China)	Eclimo (M'sia)
Model	R2	Boss 2000	S3	ES-11
Range (km)	Not Stated	75	60-125	100
Speed (kph)	65 (claimed)	55	65 (claimed)	80
Image				
Price (RM)	1,999	3,200	3,400	14,000

Figure 25 : Selected imported and domestically produced electric motorcycles

As one of the manufacturers mentioned: the “Low End” (<50kph scooters) are selling, but the “High End” (>50 kph E-motorcycles where most of the manufacturers are focusing) is where the volume is, however due to competition with combustion motorcycles, sales are quite low.

A similar phenomenon can be seen with 4-wheelers. The most popular 4-wheelers in Malaysia are shown in Figure 26. Of the 10 most popular vehicles, eight are local brands (Perodua and Proton) who build local versions of international makes (Perodua builds Daihatsu and Toyota, and Proton formerly built Mitsubishi, but currently builds Geely), with Honda City and Toyota Hilux pickup making the list. The four most popular vehicles have an average sale price of about 45,000RM.

Rank	1	2	3	4	5
Make	Perodua	Perodua	Perodua	Proton	Perodua
Model	Bezza	Myvi	Axia	Saga	Alza
Image					
Price (RM)	42,280	53,200	44,050	39,800	69,000

Figure 26 : The five most popular cars in Malaysia are dominated by local brands.

For comparison a selection of the lower cost electric cars is shown in Figure 27. The average price of the four cheapest models is about 175,000RM, almost four times the cost of the most popular combustion cars. The large price differential between conventional cars and electric cars is one of the reasons that electric cars are much rarer than electric 2-wheelers: as of 2022 there were about 10,000 registered EVs in Malaysia, as opposed to well over 10,000,000 cars in active use, e.g. less than 0.1% are currently electric[25].

[25] Number of EVs from: https://paultan.org/2022/12/14/more-than-10000-evs-registered-in-malaysia-jpj/

Make	Nissan	BYD	Renault	Mazda	Tesla
Model	Leaf	Ao3	Zoe	MX30	Y
Image					
Price (RM)	168,888	159,000	171,000	199,000	243,500

Figure 27 : Selected Electric Cars sold in Malaysia.

BATTERIES

Clearly the most problematic component in the E2/3Ws is the battery. While the battery's high cost compared to a petrol tank is the biggest problem, there are other factors such as the weight, range and charge time which compare poorly with the similar factors of ICE vehicles. Manufacturers of E2Ws usually state a vehicle's top speed and range which, however, are not attained at the same operating condition. Generally, the maximum range per charge is achieved at a given constant speed, e.g. 50kph, or according to some standard "test cycle", such as the ECER-40 from Europe, or the World Motorcycle Test Cycle (WMTC). In actual usage the range per charge may be very different from the manufacturers quoted range, and depends heavily on the user's speeds and accelerations. Some manufacturers deliberately use a very low-test speed, e.g. 30kph, in order to inflate the apparent range of their E2Ws. When the actual range is compared with the manufacturer's claimed range, customers are frequently disappointed.

To further investigate the range issue, we tested an Electric Motorcycle, an Eclimo ESD-11, with a several year-old lithium battery pack. The manufacturer states a range of 100km at constant speed of 50kph. We measured the following ranges on different drive cycles:

Drive Cycle	Range (km)
30kph	150.5
ECER40	115.7
50kph	102.7
WMTC2-1	84.5

Despite the age of the pack, the vehicle still passed the manufacturer's stated range, however the achievable range varies widely from a high of 150.5km (constant 30kph) to a low of 84.5km (WMTC, a fairly realistic driving pattern), a difference of 78%. The battery pack is nominally 50V, and has a capacity of approximately 3.3kWh, giving the vehicle an energy consumption of 22Wh/km (at 30 kph) to 39Wh/km (on the WMTC). These will be used later in the emissions calculation section.

Most small conventional motorcycles get ranges of around 200km per tank, however most of the E-motorcycles offered here achieve 100km or less. For users accustomed to the larger ranges of conventional motorcycles this can lead to significant "range anxiety". The obvious fix is to provide a larger battery; however, this will significantly increase the price of the vehicle. An alternative is to increase the availability of publicly accessible charging points, in this case simply weatherproof 240V outlets, or battery swapping stations for vehicles with swappable batteries.

Battery lifetime is also acknowledged as a major issue with EVs. The low-cost E2/3Ws still predominantly use lead acid batteries, which are less expensive, but suffer from very short life spans. The lithium batteries cost much more, but they also last much longer than the lead-acid battery packs, and in the long run they are actually cheaper than lead-acid batteries. A simple way of "leveling the playing field" is to require a minimum life of charge-discharge cycles for all EVs, and test to the manufacturer's specification in the event they wish to quote a higher number. This is already in the existing E2/3W standards, it simply needs to be enforced.

1. BATTERY SWAPPING

Battery swapping is one way to overcome the range limitation of EVs, and it is much easier for E2/3Ws than for cars, as the battery packs can be relatively small, and handled by an individual. Battery swapping can also decouple the price of the battery from the price of the vehicle, thereby reducing the vehicle's initial purchase price. Additionally developing a national or regional battery swapping standard will allow E2W manufacturers to focus on their vehicle design, while leaving the battery charging/swapping up to another company that can acquire batteries in higher volumes at a lower price.

There were detractors of battery swapping among the manufacturers, however, noting that with a weight limit of 20kg the batteries would require frequent swapping (as indeed is the case with the battery swapping delivery E-motorcycles which change batteries on average 2.5 to 3 times per day[26]) which could rapidly degrade connectors. Additionally, the relatively high placement of the batteries can lead to poor weight distribution: the best placement of weight is as low as possible on a vehicles frame, especially for 2-wheelers for maneuverability reasons.

MANUFACTURING

Apart from Voltron, who mainly builds E-bicycles for the export market, the local manufacturers are all focusing on electric motorcycles, because that is where the presumed large volumes are. Currently, however, the sales volume of E-motorcycles is quite low, only a few thousand legally sold to date. At these low volumes it is difficult to justify investment in the high-volume infrastructure required to reduce the individual part cost. For example, tooling for a motorcycle frame might cost 500,000RM and can produce frames for 300RM per unit, whereas the low volume production currently in use results in frames costing 1000RM per unit. In order to justify the required infrastructure investment, volumes would have to be over 3000 units per month.

Manufacturers also mentioned that with higher volumes and investment there are several steps which they could take to improve the cost and quality of their products via the integration of controllers, chargers, BMS and display drivers. Additionally integrated manufacturing/sales/servicing, improving customer experience, can only take place if volumes are increased. Long term they have proposed to put together an online "Electric Vehicle Service" system where customers can call 24 hours a day to have a vehicle charged, or batteries serviced, similar to the many services are available 24/7 to service standard automotive batteries[27].

1. FINANCING

Tax incentives are a relatively weak enticement for manufacturers who are looking to invest millions of dollars in tooling. One thing that will help local manufacturers sell is to allow financing of E2W purchases as is commonly done for ICE vehicles. Currently, although conventional motorcycle purchasers can get bank loans,

[26] This was noted in a Gojek delivery E2W study in Indonesia in (BCG 2022), page 6

[27] See for example: https://www.thebatteryshop.my/, https://bateriku.com/, https://www.carbatterydelivery2u.com.my/

the E2Ws don't have access to financing for sales, limiting their sales to cash buyers, or forcing the manufacturers to self-finance.

Finally, a 2nd hand market in E2Ws doesn't yet exist. Although E2Ws can be more cost effective in the long run than ICE vehicles, the payback period is quite long, potentially longer than an individual owner keeps a two-wheeler, making it impossible to recuperate the value of the initial investment in the E2W before it is resold.

2. ECOSYSTEM

Currently there is a dearth of competent EV servicing technicians in Malaysia, and many motorcycle shops are at a loss to help customers with electric 2-wheelers. Stocking of spare parts will require greater volumes of more-or-less standard vehicles. Also, most 2-wheeler distributors don't sell E2Ws, thus manufacturers have no access to nationwide distributorships.

As for charging, the manufacturers also noted that there is currently no provision for charging at flats, requiring the owners to use E2Ws with removable batteries, which limits them to the smaller, lower powered units. Currently there are no existing national standards for removable/swappable batteries or battery swapping stations, an item which will come up again later. Also, there are no standards for battery charging of E2W, so customers are stuck with using a relatively "slow" 13A 240V "G" plug.

Lastly, manufacturers noted that the government should push Sustainable Development Goals (SDG) for delivery services (e.g. Grab, Food Panda, Shopee) to favor EVs. This could have a major impact on both fuel consumption and emissions as these delivery vehicles accrue much higher mileages (around 200km/day for delivery bikes compared to about 25km/day for private motorcycles) than normal vehicles. Additionally replacing parcel delivery/pickup trucks with small electric 3-wheelers could greatly decrease the resulting energy consumption. These are all the more important with the increasing tendency to use "delivered" services.

E2/3W POTENTIAL

FUEL COST

Given the limited supply of easily accessible petroleum fuel, it is unlikely that the cost of petrol will decrease in the future. In fact, as the consumption of petroleum in Malaysia continues to increase it is inevitable that eventually the price will rise even here. Given this fact, let us now investigate the effect of fuel prices on our economic model.

Taking the same 2-wheeler total lifetime cost of ownership model presented earlier and adjusting the price of fuel to reflect the situation similar to the other ASEAN countries, namely a petrol cost of 1.25USD/liter (5.5 RM/liter) we get a somewhat different story. Figure 28, the cost of ownership per year for E2Ws (open circles) and conventional ICE 2Ws (diamonds), now shows that even the E-motorcycle is now quite close to the hypothetical acceptable price line.

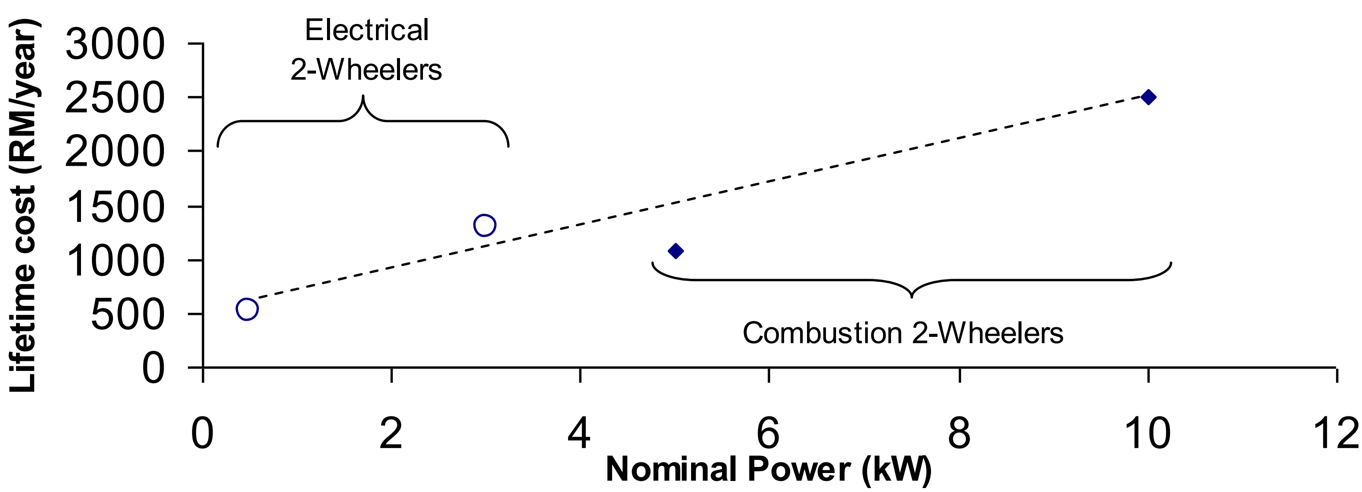

Figure 28 : Total cost of ownership of various 2-wheelers per year at a fuel cost of 5.5RM/liter

The difference is even more obvious when looking at the cost of ownership per kilometer, as shown in Figure 29.

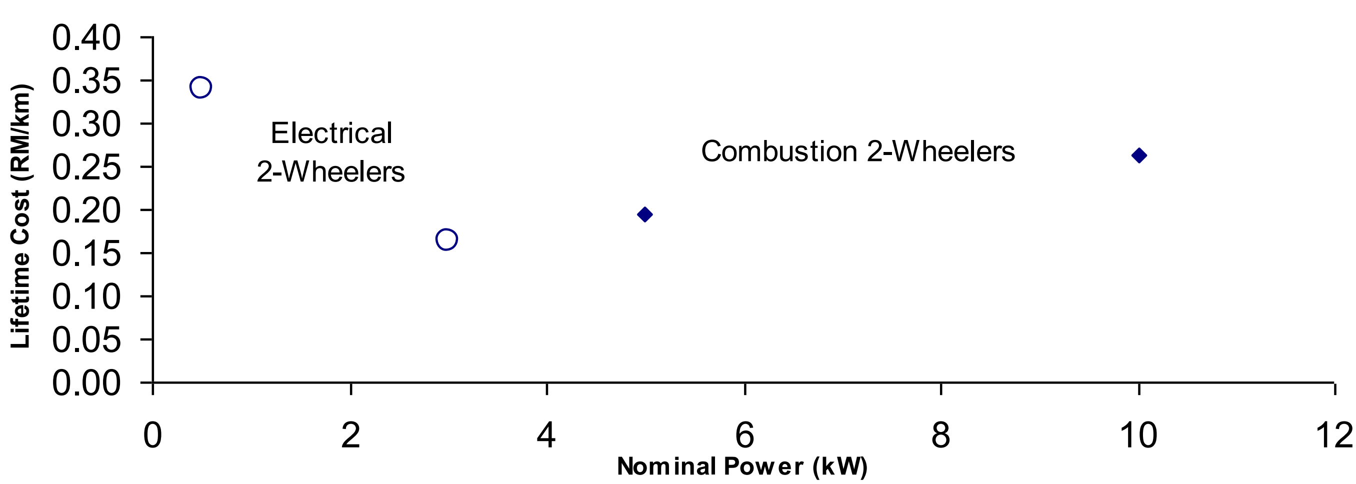

Figure 29 : Cost of ownership of E2Ws (open circles) and ICE 2Ws (diamonds) per kilometer at 5.5RM/liter

Now the higher power E-Motorcycle actually has the lowest total cost per kilometer. This will be a motivating factor for users who are interested in longer-term savings, or who anticipate accumulating a large number of kilometers over the life of a vehicle. This bodes especially well for delivery vehicles.

Another factor, often raised by E2W manufacturers, is the existence of subsidies for purchases of EVs. A 500USD (about 2,300RM) subsidy of E2Ws is often mentioned as having major potential to boost E2W sales. Indonesia recently announced a 472USD subsidy[28], and India previously announced a subsidy of 608USD per E2W[29]. This needs to be considered carefully, as the lower power E-scooters only cost around 1500-3000RM, it is unlikely that a subsidy of that same amount would be given for these small vehicles. For the E-motorcycle class vehicles, this could reduce the purchase price by around 15 to 25%, making them significantly more attractive.

For projections of E2W market share into the future, we must first start with the expected population projection[30]. Figure 30 shows historical population numbers (circles) together with a best-fit quadratic (dotted line). The population growth rate has been declining, and according to the projection the population of Malaysia will be approximately 41 million in 2050.

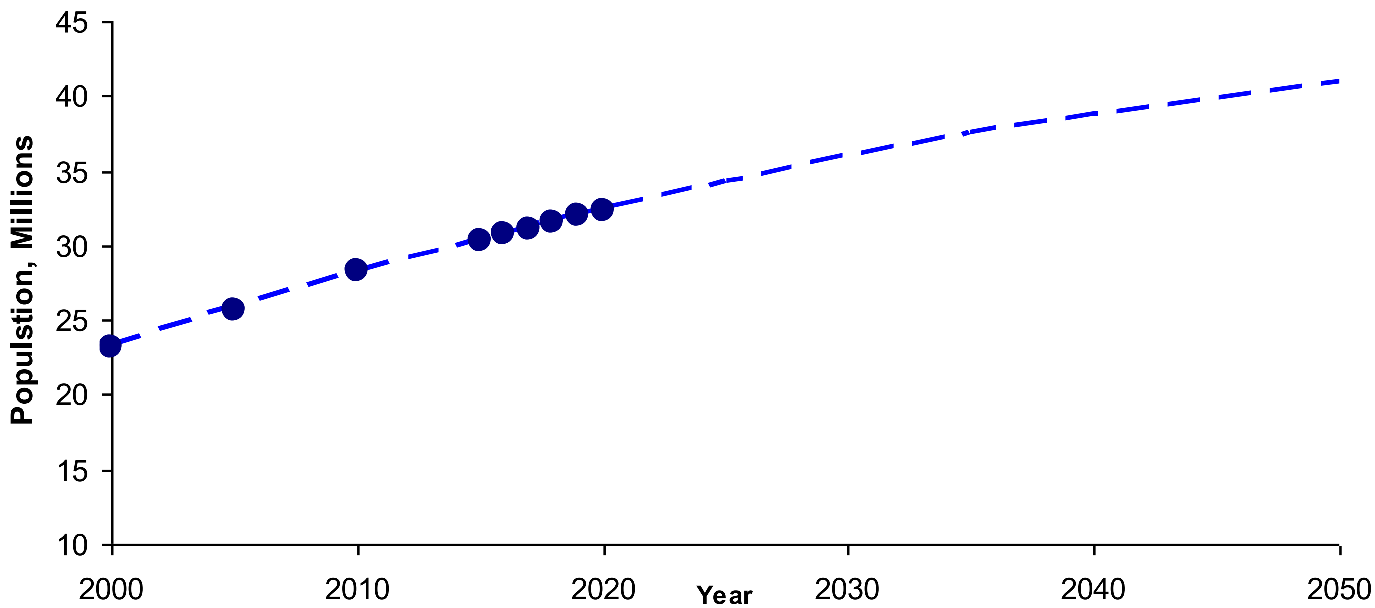

Figure 30 : Malaysian population (circles) and projection to 2050 (dotted line)

According to MOT data from 2021 the total number of active vehicles on the road in Malaysia was 22,150,000, and the inactive vehicles (i.e. those previously registered, but without current valid road tax) numbered 11,420,000[31]. This means that approximately 2/3 of the total registered vehicles are still active. The growth in the number of cumulative motorcycle registrations times the 2/3 factor is used to estimate the "active" motorcycles, as shown in Figure 31, again with a projection to 2050 when the active motorcycle population is expected to be approximately 16.9 million units.

[28] "Indonesia to Offer Incentives for Over 235,000 EVs This Year". *Bloomberg. 5 March 2023*. Retrieved 30 March 2023.
[29] "Govt plans subsidy to boost electric, hybrid vehicle sales". *Live Mint. 4 January 2013*. Retrieved 4 September 2013
[30] Data from https://www.worldometers.info/world-population/malaysia-population/
[31] Data retrieved from www.Data.Gov.My on 26-06-2023

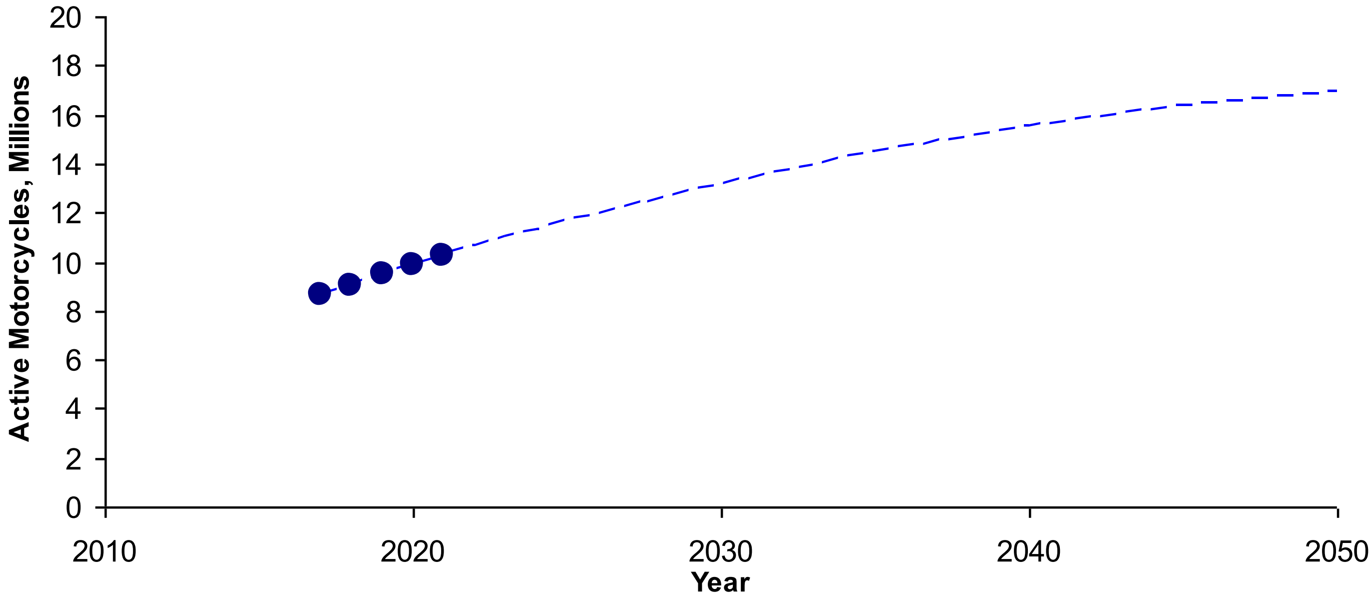

Figure 31 : Calculated "Active" motorcycles (dots) in Malaysia projected to 2050 (dotted line).

As noted in the recent survey by MIROS, only about 6% of the E2Ws were ten years or older, and according to our numbers there are approximately 150,000 units on the road today. Longevity of these low-cost, light duty E2Ws is not yet established, however from anecdotal evidence gained during interviews with E2W owners it appears that the typical period of ownership is under six years. Assuming an attrition time constant of six years, and a residual of 9000 units (ie. 6% of the current number) there would have been around 48,000 units on the road ten years ago. This then gives us an annual growth rate of about 12.2% in the number of E2Ws on the road. If we assume this trend holds in the future, we get an E2W population of over 3M units on the roads in 2050, as shown in Figure 32.

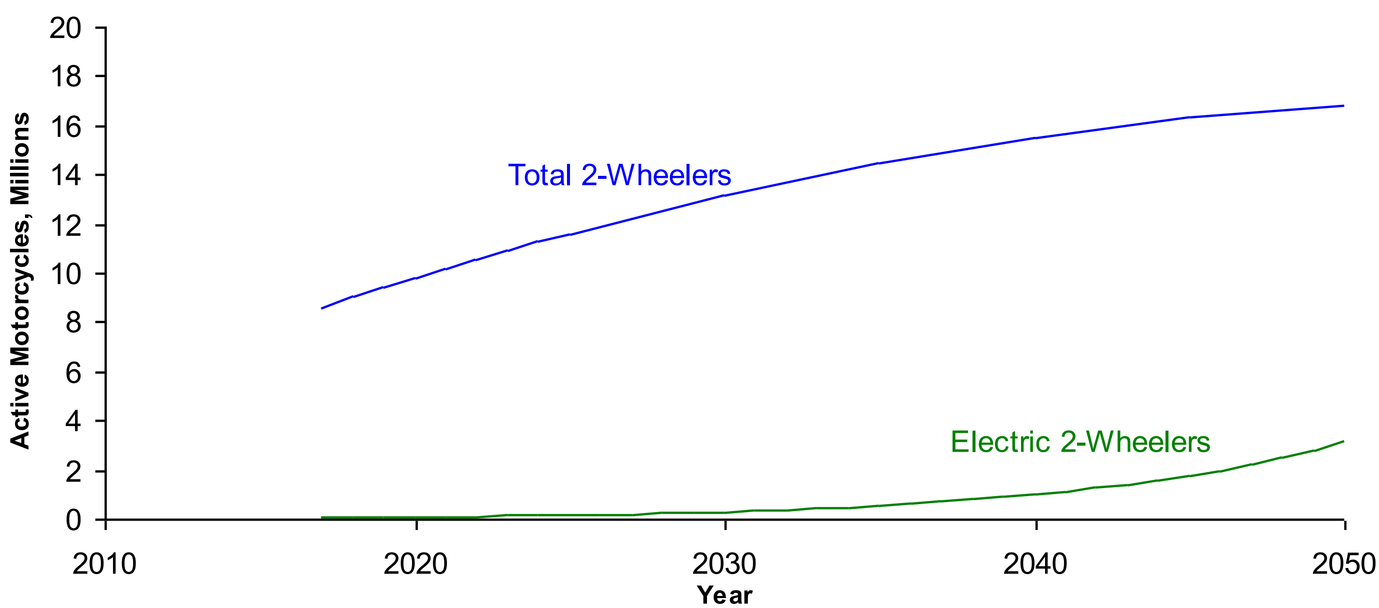

Figure 32 : Projected number of Electric 2-wheelers and Total 2-wheelers in Malaysia at current rates.

Despite an impressive growth rate of over 12% per year, this only represents only 19% of the total 2-wheeler population in 2050. We will adopt this as our Business as Usual (BAU) E2W projection later.

E2/3W OBSTACLES

This section describes in greater detail the various obstacles to E2/3W adoption uncovered during the course of this study. The problems are broken down into economic, technological and sociological barriers. The subsequent section will go into recommendations to remediate or eliminate these obstacles.

ECONOMIC

By all accounts the overwhelming economic barrier to greater EV adoption is the cost of the EVs themselves. Specifically, it is the cost of the battery versus vehicle performance and range that puts electric vehicles at a disadvantage when compared with conventional vehicles. Electric motors of the power required by E2/3W vehicles are significantly less expensive than the equivalent combustion engine. The cost of power electronics used in the motor controller and charger has come down dramatically in the last several decades and are no longer significant barriers to EV purchase[32].

The cost of an EV battery is related to both the range and the performance of the vehicle. The range is the most obvious factor to analyze at a given speed the vehicle requires a certain amount of current, and the greater the current capacity of the battery, the greater the achievable range at that speed. The relationship with vehicle performance, that is torque and top speed, is slightly more complicated, however, because although there is a strong relationship between the speed of a vehicle and its power demand, different drivers will also tend to drive at different speeds depending on the road situation and personal preference. For example, the very low power E-bicycles typically have a top speed of only 25kph, and are subsequently driven at 25kph, that is maximum power, most of the time when they are on the road. E-Scooters, having top speeds of around 35kph will tend to be operated near the top speed except in “close quarters” such as parking lots, or busy side streets. As the vehicles power increases into the E-motorcycle range, where the top speed exceeds the average speed of Malaysian motorcycle riders (e.g., around 50-60kph) the riders no longer operate the vehicle at maximum power full time. When the performance of the vehicle greatly exceeds the power, acceleration and speed of a typical user, there is no longer a strong correlation between the vehicle’s available power and the users consumed power, resulting in a “saturation” curve as shown in Figure 33.

[32] Charger cost is 7% and charger cist is 6% of the total power train where as the battery cost is 52%. Estimates from: https://interactanalysis.com/insight/which-ev-component-increased-price-the-most-in-2022/#:~:text=The%20battery%20pack%20is%20by,pack%20dominates%20over%20other%20components.

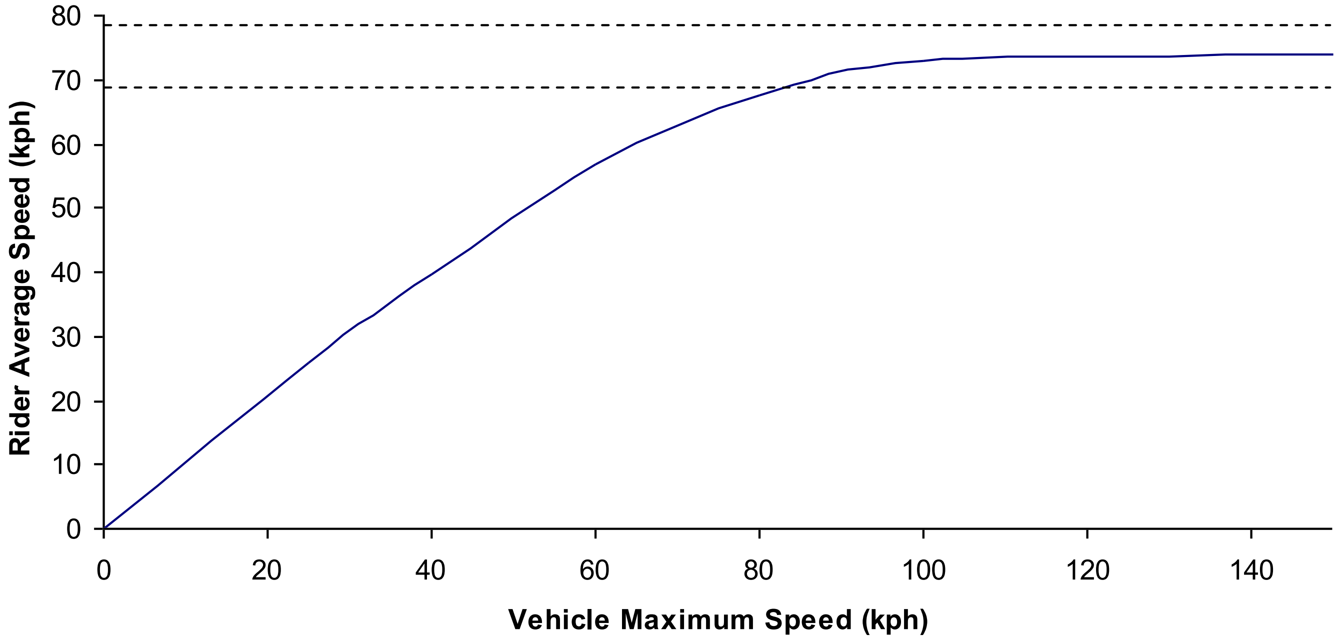

Figure 33 : Hypothetical Average Speed vs Vehicle Maximum Speed for Malaysian motorcycle riders.

In 2010, most conventional 2-wheelers in Malaysia had top speeds of 70 – 90 kph, whereas the average riding speed has been measured to be 50-60 kph (Lee 2010). This is slightly different today as newer, larger motorcycles have top speeds closer to 140 kph, however the average motorcycle speed on Malaysian roads is still only about 73 kph on expressways during light rain[33].

Conventional motorcycles in Malaysia have fuel tanks of around 4-5 liters, giving a broad range of approximately 200km under normal driving conditions. The most common motorcycles (Yamaha Y15ZR, Honda RS150) here have top speeds of around 130kph and cost about 9,000RM (a little over 2,000USD). An electric 2-wheeler with these specifications would cost over twice that[34].

This helps explain why E-motorcycles are not popular when compared with conventional motorcycles. E-scooters as shown previously, however, have a niche because their lower specs (power and range) allow them to be produced at a much lower cost. There is no equivalent ICE powered 2-wheelers in Malaysia, thus for customers looking for low speed, short hop transportation the lowest cost option is the E-scooter or an E-bike. Essentially E2W's cannot compete head-to-head against conventional 2-wheelers because they are much more expensive for the same performance and range. For manufacturers, therefore, the options are to go for the smaller, lower power niche (E-bikes and E-scooters), or perhaps for very expensive "high end" units (eg. like BMW's CE04 bike, 120kph top speed, selling for 59,500RM) which is clearly not being bought based on economic principles.

TECHNOLOGY AND INFRASTRUCTURE

As mentioned in the economic section, the battery is one of the most expensive components of an electric vehicle. Beyond the cost there are other factors that strongly affect the acceptability of EVs in general including:

[33] Development of Variable Speed Limit (VSL) System on Adverse Weather Condition in Malaysian Expressway, MIROS 2022
[34] Private conversation with Denis Chuah, head of Eclimo

- Battery Management System (BMS) Failures
- Battery Fires
- Battery Degradation

At least one of the manufacturers has had a significant number of failures (on the order of 1% of all units) of the batteries Battery Management System (BMS), which is an integral part of the battery. This causes a total failure of the vehicle, and the battery pack must be replaced. Battery packs with failed BMSs can have the BMS replaced, and either reinstalled or re-sold, however this still represents a significant inconvenience to the customer.

EV CHARGING AVAILABILITY

As a demonstration the author took a "50km range" E-motorcycle on a 40km ride to a conference at a local university. Unfortunately, one hill of about 300m altitude, depleted the battery halfway. As it was a Lead-acid battery it had to be charged overnight. No publicly accessible power outlets were to be found, so a homestay agreed to allow charging for a "mere" 10RM. On the return trip the E-moto had to be charged again, resulting in a 3 day, 80km trip which cost 20RM (about 5USD). Obviously, a lack of charging can be an issue.

While the incidence of EV battery fires is relatively rare, the concern over the possibility of battery fires is significant, fed by anecdotal evidence of burning and exploding batteries from hand-phones, laptops and electric vehicles. The concern over EV fires is largely misplaced, as indicated by a study in Sweden, which has a high population of EVs and shows that ICE vehicles are 20 times more likely to suffer a fire than EVs[35]. Additionally, the Malaysian EV standards include most of the UNR 136 regulations relating to battery safety, reducing the likelihood of fires in regulation compliant vehicles. Finally, it is quite rare for someone to get caught in a burning motorcycle, as can happen with crashed damaged cars.

The most common complaint of E2W owners was the limited battery lifetime and rapid degradation. In some cases, the batteries total failed after only a few months, well below the customers' expectations of 2 to 3 years. Again, it should be noted that all the owners surveyed were using vehicles which do not comply with the Malaysian standards, which require at least 300 charge/discharge cycles before batteries degrade to 80% of the original range. All these batteries were lead acid types, however even "cheap" lithium batteries can suffer rapid degradation if not properly treated, and lead acid batteries are capable of delivering well over 300 charge/discharge cycles if properly controlled. The problem here isn't the batteries per se, it is that the overall system over charges and/or allows over discharge of the batteries causing them to have a relatively short life. Manufacturers have the motivation to overcharge batteries as this will give the vehicle a significantly longer range per charge, but only for the first few cycles. Protection against such unscrupulous practices is precisely the reason for the charge/discharge testing in the Malaysian EV standards. The range was a concern of customers; however, they were willing to adapt to the initial range of the vehicle: most of the journeys were under 6 km, well within the range of even the cheapest E-scooter or E-bike. Figure 34 shows an E-scooter used by an elderly lady in Kedah to buy fish from a local wet market, only one kilometer from her home. For the small, low-speed vehicle the initial range wasn't so much of a problem as the range degradation

Figure 34 : Fetching fish with an E-scooter on rural state highway K906, 2023

Source: Author's photo

[35] https://www.yahoo.com/news/study-uncovers-stunning-misconception-surrounding-141500201.html

mentioned above. This is related to the fact that low-speed vehicles are typically only used for relatively short distances. As vehicle power increases, the expected range per charge will also increase, as previously shown (Figure 10), becoming more of an issue for the faster E-motorcycles.

Availability of battery charging is another area of concern. All the E2W owners surveyed had access to charging from standard 240VAC outlets at their home or apartment, but this will not be the case for those, especially B40 (lowest economic status 40% of the population) owners living in high density flats. Additionally, there is no facility for public charging, although all that is required is a publicly available weatherproof 240V AC “G-plug” with appropriate ground fault circuit breaker. As with the overall vehicle range, charging time was not highlighted as a major problem by the owners of the low-speed E-scooters, however it will likely be a greater issue with higher power units as they will be used further from the owner’s home base, and require longer periods to charge due to the increased battery capacity.

Finally, many of the chargers are not weather-proof, creating a potential electrocution hazard if charging is performed in an unprotected area. Again, this is addressed in the Malaysian EV standards, which, however, are not being properly enforced.

Additional customer complaints included the following relatively minor issues:

- Ugly: Some of the E2W designs were considered unattractive by their owners
- Spare Parts Availability: E-Scooters especially tend to have non-standard tires which are difficult to find or expensive
- Poor quality: Overall parts quality was considered too low, resulting in rapid rusting of metal parts, or fading and cracking of plastic components
- Poor breaks: Most of the scooters have bicycle-type brakes which rapidly wear out

LEGAL

Regulations for the motorcycle class E2Ws are straight forward and follow the rules of conventional motorcycles. Strictly speaking the Scooter and Bicycle class of E2Ws, however, are not allowed on roads at all, as indicated by an MOT declaration shown in Figure 35. Obviously, this precludes their use as an effective transportation mode. Additionally, it contradicts the de facto usage, where both vehicles are operated on low to medium speed roads at the shoulder or extreme left side of the lane. The prohibition of both E-bikes and E-scooters on roads is apparently never enforced. The ambiguous nature of the scooter class vehicles legality may taint potential user’s impression.

Figure 35 : MOT infographic stating that E-bikes and E-scooters (<50kph "motorcycles") are not allowed on public roads.
Source: Malaysian MOT

LEGISLATION ENFORCEMENT

While Malaysia has well established standards covering 2- and 3-wheeler EVs from bicycle to motorcycle class, the standards and other regulations are not being uniformly enforced. For example, any electric 2-wheeler with a top speed of 25 to 50 kph to be used on the roads must by law comply with MS2688 (E-Scooter). Although our data indicates that there are around 150,000 of these units on the road, not a single manufacturer or importer has ever attained MS2688 certification. Some of these "E-scooters" were imported under an "E-Bicycle" Approval Permit. This was one of the major complaints of the legitimate manufacturers we surveyed. Their point is that it is impossible to compete against cheap imported models which don't, and likely, can't meet the required standards.

SOCIOLOGICAL

Some of the obstacles to greater E2/3W adoption are sociological in nature. There are issues of lack of trust of new technologies manifesting in apprehension over EV range and disproportionate fear of things like EV Battery fires. Customer concern over battery life span and replacement cost has been repeatedly noted, and stands in stark contrast to ICE vehicles, where it is understood that a liter of petrol will deliver around 50km of travel for a typical small ICE 2-wheeler now, as well as 10 years from now.

For smaller electric vehicles with removable batteries, battery theft is a concern, especially for those living in "flats" with large communal parking areas out of view of the owner[36]. As a result, owners have to remove the batteries any time they are parked in an insecure area, as shown in Figure 36. This can be a significant burden as the owner has to remove and carry the battery, which may weight up to 20kg, in addition to any other cargo they might be carrying.

[36] A number of references cite this including: https://auto.hindustantimes.com/auto/electric-vehicles/electric-scooters-facing-battery-theft-in-this-country-41651480150541.html

Electric vehicles in general are much quieter than conventional vehicles, and this nearly silent operation can pose a hazard especially for the smaller E2/3Ws which are bound to have greater interaction with pedestrians than larger vehicles. E-bikes, for example, can be used on sidewalks and combined with walking/biking paths where other users may not hear their approach. By law they have to be equipped with a noise-making device (bell or horn), but activation of this is at the driver's discretion. This may pose a greater hazard for pedestrians and other path users and can certainly lead to "startling" as the silent E-bike whizzes by unexpectedly.

Figure 36 : Electric bicycle parked in Bandar Saujana Putra, Malaysia. Note the chained front wheel and missing battery (large open slot in frame behind seat post).

Source: Author's photo

It was noticed that the smaller E2W's are used by the elderly and women at a greater rate than conventional 2-wheelers are. When we asked about this both groups mentioned that they do not require the higher power and speed of conventional motorcycles, and they appreciated the quiet operation and ease of maneuverability of the E-scooters, and lack of kick-starting, gear shifting, and petrol tank filling associated with combustion vehicles.

A very important issue with these light duty electric vehicles is their relative vulnerability to collisions compared to passenger cars. While passenger cars are much more robust in terms of accident survivability, the crash survival of E2/3Ws is negligible in that the vehicle itself provides almost no protection. This places their users much more at risk, compared to car occupants. While it is understood that these vehicles are much lighter and more efficient, every reasonable measure must be taken to ensure that they are also used in as safe a manner as possible. This highlights one of the reasons for success of the E-scooters as compared to the E-motorcycles: there is a need for lighter, slower vehicles than conventional motorcycles currently unmet by any other powered vehicle. These advantages appear to be especially attractive to some demographic groups, namely women and the elderly.

Also, unlike cars, most of these E2/3Ws are vulnerable to weather as they have no roof or passenger cabin enclosed from the elements. This can be a major factor in reducing their potential uptake as Malaysia is a tropical country and subject to significant rain fall.

Finally, one potential problem arises ironically from their very popularity: in some locations it has been shown that the usage of E2Ws has risen to the extent that it overwhelms the existing road infrastructure, interferes with other transportation modes, and reduces the ridership of public transportation. Clearly, we do not want the usage of the E23Ws to degrade public transport ridership, rather ideally should enhance it by providing first/last mile connectivity to public transportation networks.

PROGRESSIVE POLICY RECOMMENDATIONS

The following are recommendations were gathered from our interviews with manufacturers, during a workshop with the various stake holders (Figure 37), and as a result of our investigations of electrical 2-wheeler usage in Malaysia. They are aiming at increasing the share of electric 2/3 wheelers on the roads with the goal of displacing cars or conventional motorcycle trips, and in the case of 3-wheelers, displacing some use of delivery trucks. Along with increasing the numbers of these vehicles some of the recommendations also focus on increasing the safety of the vehicles and other associated facilitations. The recommendations cover a wide range of aspects, from government policy to standards and public education. To facilitate comprehensibility, they have been separated into several categories within a given focal area.

Figure 37 : Current policy and policy recommendations were reviewed during workshops with broad government representation. Here workshop members are broken into smaller focus groups for in-depth discussions.

Source: ***Author's photo.***

As previously mentioned, most of the existing E2Ws on the roads are scooter class vehicles which have not undergone standards compliance testing. As a result, many of the electric 2-wheelers investigated showed unacceptably low quality, notably in their low battery life expectancy, and poor breaking capability. Legitimate importers and manufacturers have a hard time competing against non-compliant products; therefore, the first recommendation is to apply and rigorously enforce standards compliance to ensure better quality and safer products, and level the playing field for legitimate manufacturers. Several recommendations were made relating directly to the standards, which can be brought up to date via amending. Only new standards for compliant vehicles should be allowed on the roads. The issue of what to do with legacy vehicles is discussed further below.

1. STANDARDS AND CLASSIFICATION

The current standards (MS2514 for E-bicycles, MS2688 for E-scooters and MS2413 for E-motorcycles) are fairly clear and comprehensive; however, there are several areas where they can be improved on, and in some cases expanded to be more inclusive of the wide range of light duty electric vehicles in the market.

Currently, for the purposes of importation and taxation, most E-bikes and E-scooters are classified as “Toys”, and should be re-classified as “Vehicles”, with the relevant standards compliance required if they are to be used on the roads. This will require the coordination of JPJ, MITI and KASTAM. There will remain a possible difficulty in that both E-Bikes and E-scooters could legitimately be imported for non-road use, which would preclude them from standards compliance and obviate the need for VTA.

To reduce confusion and simplify the situation it is suggested that all E2/3W’s with speed greater than 25kph be classified as “Vehicles” and comply with the relevant standards and VTA. Exceptions could be made in special cases, however as they can potentially travel at speeds of up to 50 kph there is a much greater need to ensure their safety should they ever make it to the pavement.

Suggested changes to the existing standards include the following:

- Inclusion of “throttle” E-bikes in MS2514, and not just Pedal Assist vehicles
- Mandatory range measurements on a relatively aggressive drive cycle, e.g. WMTC. Currently the range cycle is left up to the individual manufacturer
- Enforcement of the 300 charge/discharge cycle minimum battery life limit
- Simplified certification of existing model “upgrades”, e.g. only retesting battery specific standards when recertifying an existing model with a new battery, rather than the whole vehicle recertification

As one of the major expenses and limitation of EVs is the battery, two additional areas need to be addressed in order to facilitate EV proliferation, namely generic battery standards for inter-operability between different vehicles, and battery swapping and charging station standards.

With standardized battery dimensions, weights, connectors, voltages, currents and other specifications, EV manufacturers can have access to such “standard” batteries for their machines from high volume suppliers, even if the EV manufacture is just a start up or producing vehicles in low volume. As highlighted by the E2W manufacturers, this will eliminate one of the major obstacles in the new E2W development. This could include a wide range of “standard” batteries for different sized vehicles and include different battery technologies. This “harmonization” of battery specifications should be done on an international scale, to take greater advantage of existing battery manufactures. The Swappable Batteries Motorcycle Consortium (SBMC) is an association of various vehicle, battery and component manufacturers involved in developing standards for swappable E2W batteries and chargers which could be of service to this end[37]. Additionally, several countries have recently introduced their own swappable E2W battery standards, as shown in Figure 38.

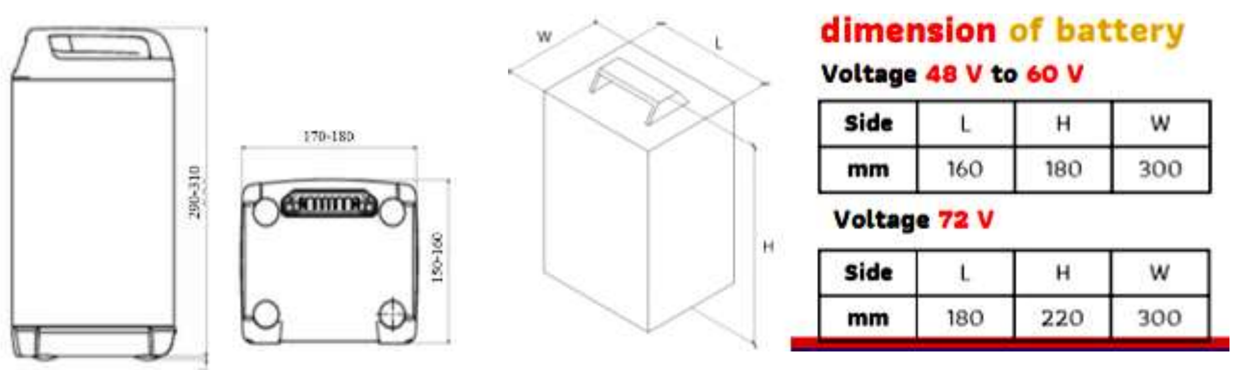

Figure 38 : Excerpts form draft Indian (left) and Thai (right) E2W removable battery standard

[37] https://www.sb-mc.net/members.html

A recommendation was made for removable/swappable batteries to be placed as low as possible on the vehicle to improve weight distribution. This may conflict with standard ergonomic practice of placing the batteries higher up in the vehicle for ease of access. Resolution of this conflict could potentially be tackled by the committee working on swappable battery standards. During the drafting of this report (late 2023) it was announced that industry players will be forming a consortium to establish national electric motorcycle battery swapping standards[38].

With non-removable batteries EV owners are forced to charge at home if they have a landed house, or a publicly accessible charging point, which currently doesn't exist. Swappable batteries, by definition are removable, thus allows owners to remove the batteries for charging inside their home or flat when a charging point doesn't exist near the vehicle. Additionally, a depleted battery can be swapped out for a fully charged one in a few minutes, rather than waiting for hours as the depleted battery is recharged. This may be conveniently done at a publicly accessible "swapping station" in a manner similar to how fuel tanks are currently refilled. This will also allow the "de-coupling" of the battery cost from the vehicle: a manufacturer can sell the EV at a much lower cost, as the battery cost is included in the incremental rate paid per swappable battery charge. A National Standards Technical Committee on Battery Swapping (NSC 05/TC 12) has been formed, and their work needs to be expedited to avoid piecemeal proliferation of multiple, incompatible swapping/charging systems.

2. BATTERY LIFE CYCLE TESTING

The biggest complaint of E2W users in Malaysia is the battery life span. The battery life span is a compromise between the battery cost, vehicle performance and range. Most low cost E2/3Ws in Malaysia still use lead acid (LAB) batteries as these are much less costly than lithium batteries (LIB), however lead acid batteries also tend to have much shorter life spans. This need not be the case, however, as well-designed LAB battery systems can have many hundreds of charge-discharge cycles before degrading to 80% of their initial charge capacity (the point where batteries are considered no longer meeting their requirement). The problem is that many manufacturers overcharge the batteries to get impressive ranges when the battery is relatively new, or allow deep discharge of the LAB, both of which drastically reduce the useful life of the battery. In some cases, "cheap" E-scooters have "failed" batteries after only four months of operation.

This emphasizes the need for Battery Life Cycle Testing for all EVs. When a customer purchases a conventional vehicle, it is understood that ten years from now it will be capable of achieving the same range as it did when new. The same is not true for EVs, thus there is a need to test EVs to insure a reasonable minimum life span, 300 cycles are currently the specification in the Malaysian standards, and confirm manufacturers claims if in excess of the minimum requirement. Additionally testing should be done to a "real-world" standard test cycle. As shown previously, an EV's range depends heavily on how it is tested. Unscrupulous manufacturers will often quote long ranges which were achieved at a constant 30kph, whereas the vehicle has a top speed of 70-90 kph, and will achieve only a fraction, perhaps less than half, of the quoted range under real world driving conditions.

Real world usage pattern Battery Life Cycle testing is not difficult, and a reasonable minimum of 300 cycles should be enforced for all road-going E2/3Ws to avoid customer disappointment.

[38] Battery Swapping Standard development referred to in *The Star*: https://www.thestar.com.my/news/nation/2023/10/31/national-battery-swapping-standard-in-store-for-electric-motorcycles

Once batteries have degraded to the point where they no longer provide sufficient range for the EV, they can be used in other "second life" applications. Genetech Technology Automation of Bangi and the Authorized Automotive Treatment Facilities (AATF) are working on Extended Producer Responsibility (EPR) guidelines to help manage batteries and facilitate their second life usage.

3. INFRASTRUCTURE

Many of the recommendations require some degree of infrastructure development. These are laid out in this section.

While separated 2-wheeler lanes are a good way of preventing car-on-motorcycle accidents, they also cost much more than motorcycle/bike lanes adjacent to, or at the extreme left side of roadways. Separate E-Scooter lanes should be attempted on lower speed urban roads, especially those connecting to transportation hubs, shopping areas, schools and residential areas to encourage safe usage of E2/3Ws.

For greater use of E2/3W some road usage rules will have to be changed. This, in turn, will require changes to the existing road usage rules, and that will require buy-in from the highest levels of government to be accomplished on a reasonable timeline. Additionally, some attention should be given to the current discrepancy in the meaning of "road shoulder" and "roadside" as used in current MOT and JKR polices.

Along with road access, E2W's will also require parking at common trip destinations, especially transportation hubs. Smaller E2Ws and their batteries may be subject to theft due to their small size and high cost, therefore "secure" parking is preferred. As these vehicles are exposed to the elements it is much more important to provide weather-proof parking areas than it is for cars which have roofs protecting the occupants from the elements. Shah Alam municipal counsel noted that bike paths there were underutilized as there was nowhere to park bike safely at bus stops. They subsequently began introducing "smart bus stops" incorporating features such as lights, information displays, rain cover, free WiFi, CCTV, a "panic button" for emergencies, helmet storage and greater transportation hub integration. This excellent work should be expanded to include E-bike/E-Scooter charging. Similar "Smart Parking" stations featuring secure E2W parking and charging should be implemented at common destinations such as government buildings, mosques, commercial centers, and especially at transportation hubs. For final destinations, including showering/changing facilities can also help encourage biking and E-biking.

Figure 39 : Weatherproof "G-plug" at a covered parking place in Kuching, Sarawak.

Source: Author's photo

Transportation hubs have also been suggested as excellent locations for bike and E2W sharing centers. A commuter exiting an MRT train could simply jump on a rental/share E-scooter and ride three or four kilometers to their desired shopping location or place of work, returning the scooter on the return trip without ever having to own it, or worrying about charging. This also goes for E2/3W battery swapping stations: Transportation hubs are a natural place to locate stations. This will have the additional knock-on benefit of encouraging the use of public transportation and reduce dependence on taxis or ride-hailing services (which are the least efficient form of transportation). Such centers could also cater to private vehicles and offer charging and maintenance services, for example changing battery or repairing tires while the owner is off on a train to their final destination.

New developments should include close-in E2/3W parking with charging. In the USA many states have implement "right to charge" laws requiring developments to include wiring for EV charging[39]. Plan Malaysia has developed guidelines for parking infrastructure which will include E2W parking. This is an excellent step and should become mandatory at some point.

It is worth restating here that E2/3W parking and charging are much less of a burden than EV car parking. E2/3Ws are much lighter and smaller than cars, and all the models on the market can be charged from a standard 240VAC, 13A "G-plug" as shown in Figure 39 as opposed to cars, which require expensive high-power charging points.

Incorporating E2/3W data collection into ongoing planning will also be important to optimize financial and manpower expenditures on transportation planning development. This will also form the basis of CO_2 emissions calculations required for prioritizing planning. Thus, the identification of E2W's will be important, and should be integrated with the existing "Smart Cities" targets for Low Emissions Vehicle, and EV Charging points (e.g. Smart City Standard MS ISO 37122:2019). This will help provide cities with incentives to integrate E2/3W infrastructure projects.

A less expensive option for new dedicated E2/3W parking is to provide on-street charging from "Smart Poles" which could include some of the "Smart Parking" station features on a single pole (e.g. E2/3W charging, lighting and CCTV for added security).

Simultaneously with the work on increasing the E2/3W charging infrastructure, work should be done on determining what tariff rate would be appropriate and incorporating the government's renewable energy goals. There exists a potential of using time-of-day based charging to help load leveling by encouraging nighttime charging, or even solar powered charging non-grid-connected bus stops.

Finally other battery charging/swapping locations should also be considered, as proposed by the Gentari-Petronas-BlueShark consortium and Yinson with battery swapping centers at existing petrol stations. As the issue of battery swapping stations is a "chicken and egg" problem, the government could help by setting goals for the number of batteries swapping stations and helping foster their dissemination.

4. FINANCIAL

One simple solution to the problem of financing E2/3W purchases is to allow financing of E2/3Ws as is currently being done for conventional motorcycles. Separate financing could be done for EV Batteries, such as renting/leasing batteries, as a service in order to decouple the cost of the battery from the cost of the vehicle, thereby reducing the initial purchase price. Due to the high mileage accumulated by delivery companies, special attention should be focused on encouraging them to convert to electric propulsion via low interest loans or other financial incentives.

[39] https://www.yahoo.com/news/charge-laws-bring-promise-evs-122322337.html Downloaded 28-06-2023

Additionally, as there is a need to increase the number of E2/3W service shops, special financial incentives should be made available for workshops or other service providers setting up or expanding into the EV area.

It was mentioned that a Total Cost of Ownership study should be performed on ICE motorcycles and contrasted with equivalent E2W or E2W with swappable batteries. This could help inform policy on financing and infrastructure development.

Beyond financing and low interest loans, more pro-active financial measures such as “fee bating” could be considered. That is partially subsidizing the purchase of E2/3Ws at the expense of a small charge added to the purchase of less efficient vehicles, for example SUVs and pickup trucks. As previously mentioned, both India and Indonesia have stated that they would be giving rebates of around 2000RM towards the purchase of electric 2/3 wheelers. As the average price of E2Ws on the road in Malaysia is only about 2000RM this could have a major impact by allowing potential E2W customers to purchase better lithium powered models, which are currently out of their reach.

The use of variable rate fee bating is preferred because, as the market shifts decisively towards E2/3Ws and away from conventional vehicles, the subsidies would be automatically reduced, thereby preventing an increasing liability for the government as direct subsidization inevitably would.

In a more general sense electric mobility should become a focal area for government research grants focusing on strategic areas such as batteries, battery refurbishing and recycling, EV Charging, EV Motor controllers and related EV technology development.

5. TECHNOLOGY

In order to evaluate new EV technologies and products, local facilities focused on EV testing should be set up and expanded to meet the requirements of evaluating newer vehicles and technologies. SIRIM will have to expand their EV component testing capabilities, including EV battery testing for both range and life expectancy. The SIRIM facilities may have to be expanded to meet the increased demand of the large number of E2W models requiring testing as the existing standards are refined and enforced.

In addition to new EVs, there is a global trend in converting existing vehicles to electric propulsion. Conversion programs targeting especially polluting vehicles, such as 2-stroke motorcycles and vehicles accumulating high mileage such as those used for deliveries, can have a significant impact on emissions. This may require more test/service centers capable of performing the conversions and repairs safely. It is recommended that EV conversion centers, and their key personnel and procedures, conform with national standards and undergo a certification process to ensure uniform and safe installations. New vehicle models or EV conversion kits may require extensive testing, similar to VTA type approval testing, on a model-by-model basis. Conversions of the approved models (donor vehicle and EV conversion kit) will only require a brief inspection and verification, similar to the current PUSPAKOM vehicle inspection when performed by certified conversion centers. Converted vehicles should carry a permanent label (such as a large oval EVC sticker, similar to existing fuel/country stickers) indicating that they are an EV conversion for accident first responders’ safety. The National Occupational Skills Standard office (NOSS) has been proposed as an organization which could help in the certification of such conversion facilities.

Apart from dedicated conversion and testing facilities, this may also require streamlined road usage approval processes for converted electric vehicles, which are currently not allowed on the roads.

In June 2022 a National Technology and Innovation Sandbox incubator (NTIS) was established to help foster innovation and technological developments. It is proposed that this be expanded to include E-mobility to provide test beds for industry to experiment with different technologies, ideas and business models to accelerate adoption and commercialization of E-mobility. The Malaysian Automotive Institute will be coordinating this together with the Ministry of Science and Technology, and Nano Malaysia.

6. DELIVERY SERVICES AND THE MISSING LINK: E3WS

Parcel delivery services such as GDex, FeDex, DHL, TNT, Lala Move, Lazada use a range of 2- and 4-wheeled conventional vehicles. Replacing the combustion 2-wheelers with electric 2-wheelers could improve the fleet emissions, but many items are too large to conveniently transport on 2-wheelers.

3-wheeled vehicles have generally been forbidden in Malaysia, however electric 3-wheelers could be an excellent option for taking some of the burden currently carried by trucks, as shown in Figure 40 E3Ws make an ideal parcel delivery vehicle with much lower emissions than cars or trucks and their use should be encouraged.

It is proposed to remove the restriction on use of 3-wheelers in general and that E3Ws should be substituted for trucks and delivery cars wherever feasible.

Figure 40 : Typical delivery truck (left) and the intended parcels in an electric 3-wheeler (right).
Source : Author's photo

7. HUMAN RESOURCE DEVELOPMENT

As noted on several occasions current motorcycle workshops are not competent to maintain electric 2-wheelers. Training of workshop technicians for EV work could be administered via the Malaysian Automotive Institute, or JPK.

It has also been proposed to identify potential areas for further development to strengthen Malaysia's electric vehicle component market globally, including talent and vendor profiling. Examples proposed include iron ore processing, Printed Circuit Board Assembly (PCBA) fabrication, motor controllers and engineering design. Businesses and individuals involved in these key areas could be matched with via Business-to-Business (B2B) connections with various EV Original Equipment Manufacturer (OEM) and service organizations.

8. PLANNING

The need for data-taking and inter-departmental, and federal-municipal cooperation is crucial to get these actions implemented as quickly and efficiently as possible. Many transportation projects, such as the previous "O-bike" sharing project[40], have failed due to poor coordination, lack of support, or, as in the case of current MOT prohibition of E2/3W on public roads, contradictory directions. Buy-in from the people targeted by the

[40] A Singapore based bicycle share service briefly operational in Malaysia, https://en.wikipedia.org/wiki/OBike

proposed policies is equally important. Currently most of the E2Ws on the road are used by people in the B40 category (MIROS 2021), and it is very important to include their input into policy planning to avoid investing effort in pursuits which won't achieve the intended outcome due to lack of popular acceptance or contradictory behaviors.
Government development approval guidelines should include incorporation of "EV Ready" provisions. This would include things like weatherproof, ground fault protected AC receptacles on the exterior of buildings for EV charging, and parking lot wiring for EV chargers.

As with any area of policy, data collection to help guide the appropriate decision-making process is critical. Tracking of EV accidents, including E2/3Ws and even micromobility devices such as "hover boards" and stand-on scooters, needs to be tracked. Currently traffic accidents are tracked via a system called POL27 which is difficult to modify to include additional data, and which does not include any electric vehicle designation[41]. This needs to be updated to allow tracking EV related accidents. In addition to updating the existing vehicle accident reporting form it was noted that while the national police force, PDRM, collects substantial traffic and accident-related data, this data is not readily to other parties involved in policy development and road safety. Any data which can be of value in developing a better transportation policy should be made readily available to all interested parties. Finally, another potential source of data are the PBTs (*Pihak Berkuasa Tempatan* or Local Authority) which collect some data at the local level, but this may require a new bureaucratic mechanism for compiling the data at the national level.

9. POLICY

Given the fragmented governmental structure, it is a good idea to start by looking at the current policy development mechanism in light of the urgent need to streamline and standardize the approach to electric mobility, and the greater question of CO_2 emissions and efficient technologies. For example, while the MOT is responsible for governing the usage of the main roads, infrastructure along the roads requires PBT's approval. MIROS helps develop guidelines for the MOT, such as proposed lane segregation, and JKR builds or extends the roadways. To expedite this, provide a unifying overall direction and emphasis there are a few options at the Prime Ministers level which could be exploited, such as the "Majlis Ekonomi Digital dan Dasar 4IR" which could produce an overall development plan white paper.

Combining the existing "EV-Solar Initiative" to reduce the cost of deploying public chargers could be done as part of the solar PV net energy metering (NEM) quotas allocated to Charge Point Operators (CPOs). This could be especially helpful for E2/3W charging points at transportation hubs where both a large roof area and the need for vehicle charging are present.

10. ENFORCEMENT

Currently most of the E-bike and E-scooter vehicles are classified as "toys" for importation. While it may be the case that some of these vehicles are actually used as "toys" or in the case of pedal assist bicycles as "sporting goods", the vast majority make their way onto public roads and should be re-classified as road vehicles.

[41] https://miros.gov.my/xs/dl.php?filename=(FA)_MRR%20No%20372_Heavy%20Commercial%20Goods%20Vehicle%20Crashes%20in%20Malaysia_V6_compressed.pdf

MITI, responsible for the Approval Permit (AP) for importation, should be involved with manufacturers and importers from the earliest stage. Currently KPDNHEP issues licenses for foreign companies, like Xiaomi, which sell a wide range of products, including E-bikes and scooters, with no separate product classification.

Bahagian Standard Kepenggunaan in KPDNHEP can issue fines for transgressions, however, they do not have the resources to address all complaints on all items, especially given the rise of on-line shopping.

It has been suggested to form a special task force on this topic, and potentially implement a "block chain" tracking methodology similar to the existing "UCustoms" on-line one-stop customs portal[42].

11. ROAD USAGE

As the objective is to reduce energy consumption and emissions, it is crucial to realize that the E2/3W vehicles should be used to displace less efficient transportation methods, namely taxis, private cars and combustion motorcycles. To accomplish this without major "motorcycle only" lane construction will require E2/3W access to existing public roadways.

Electric motorcycles are subject to the same rules and regulations as conventional motorcycles, thereby giving them access to all public roads. Currently, however, the E-bicycle and E-scooter vehicles are classified as "Micromobility" devices by the ministry of transport and are banned from all public roads.

E-Bikes are generally restricted from using roadways; however, bicycles are still allowed on some roads in Malaysia. To help expand the role of E-bikes, they should be allowed wherever bicycles are used, and potentially expanded. For example, in residential areas the road speed limit is 20kph, quite suitable for E-bicycles. Expansion of bicycle paths in urban areas connecting common travel destinations is another area to be considered. Routs running along river ways are common in many countries as this reduces the bike to motorized transportation interactions and could be further implemented here as many urban centers are crossed by rivers in Malaysia.

Electric scooters are more powerful and faster than E-bikes, and also have improved breaking and lighting, as they are designed to travel at higher speeds. With a maximum speed of 50kph, we may not want these vehicles on high-speed roadways, however they should be allowed on any roads with a speed limit of 50kph or less. For example, in built up areas road speeds are generally 30-50kph, compatible with the 50kph maximum speed of the E-scooter class vehicles.

[42] More information on UCustoms available at: http://www.customs.gov.my/en/uc

12. REGISTRATION

Many E-scooters look very much like motorcycles, while others resemble bicycles, however the road usage and other regulations of E-scooters will likely be different from those of motorcycles or bicycles. To facilitate the rapid identification of E2Ws as either E-scooters or E-bicycles it is proposed to issue a unique license plate to each class of vehicles. For E-scooters this should be in the form of a unique license plate and registration number, for example "ES-123456X" for E-Scooter number 123456, perhaps with a unique color or shape to help differentiate it from standard motorcycle plates. E-bike would have a unique, perhaps smaller design, for example in the distant past bicycles were registered with round license plates. This will also be of value in reporting and recording accidents, a requirement for further refining road usage in the future. Ongoing monitoring of accident rates and vehicle usage patterns will be critical in adapting the system to ensure the highest achievable level of safety and implementation possible.

Figure 41 : This lady uses her E-scooter to scavenge recyclables for a living. She carries more load than many pickup trucks on the road.

Source : Author's Photo.

It is further recommended that the registration process be inexpensive and easily accomplished, for example by providing proof of serial number to a local police station for a "registration permit" which could then be used to get a valid license plate made. As one of the outstanding features of these smaller E2Ws is their low cost and use by the B40, it is important to ensure that the registration process is not burdensome or expensive for the end users, such as shown in Figure 41.

Pre-existing E2Ws should be "Grandfathered" in by allowing them, in a similar manner, to receive special plate "Legacy E-Scooter XXXX" which will be good to 2029 (the expected half-life of such vehicles), after which time older "pre-registration" E2Ws would not be allowed on the roads.

Finally, some provision should be allowed for valid non-road use of E-bicycles and E-scooters as many are used only on bike paths, or rural treks by outdoor enthusiasts. Figure 42 shows a high-quality electric assist off-road "mountain bike" being used in the hills of Malaysia. Bikes like this can cost well over 30,000RM.

Figure 42 : Valid off-road use is made of electric assist "mountain bikes" like this.

Source : Author's photo.

13. DRIVER AGE AND LICENSING

It is generally agreed that road users of both E-bicycles and E-scooters should have a minimum age of 16 years, and E-scooter drivers be licensed for motorcycle riding. Additionally, all E-scooter class vehicles should require approved safety helmets for all drivers and passengers, as missing from Figure 43. Helmets for E-bicycles are recommended to be used, but use is at the rider's discretion. These recommendations need to be enshrined in the appropriate laws.

Figure 43 : Improper use can be dangerous: Underage rider and sister on a 45kph E-scooter.
Source : ***Author's photo.***

14. VEHICLE INSURANCE

To date none of the E-bikes or E-scooters are insured. Because of their lower speeds, it is unlikely that E-bikes would ever require insurance, E-scooters, however, can potentially travel up to 50 kph. Accident tracking will be necessary to determine if requiring insurance on E-scooters makes good sense or not. If insurance is required, one option would be to subsidize the insurance for E-scooters by imposing a premium on the insurance of larger vehicles, such as SUVs, pickup trucks and luxury vehicles. The intention of subsidizing the E2Ws insurance is to help maintain affordability for these lighter vehicles. As this is likely to be a contentious issue a careful evaluation of the costs and benefits of such a program is recommended.

15. ANNUAL ROAD TAX

Current taxation mandates favoring EVs are set to expire in 2025-2027. A comprehensive mandate for E2/3Ws should be developed for the long term. As E-bicycles and E-scooters are in general much lighter and used for much shorter cumulative ranges than combustion motorcycles, it is recommended that they remain exempt from annual road taxes. Road tax for E-motorcycles is currently standardized by the calculation of 1kW (electrical power) is equivalent to 20cc engine displacement.

16. VEHICLE END OF LIFE

Currently there is very sparse data on the disposal of old conventional motorcycles, much less electric 2-wheelers. Moving forwards, it is a good idea to enact a comprehensive plan for dispositioning these vehicles at the end of their useful life.

Earlier fears that EV proliferation in general could lead to "battery dumping" has not happened. This is primarily because the majority of the EVs on the road to date are smaller E2Ws with lead acid batteries which are readily scavenged for recycling. Instead of battery dumping, quite the opposite has occurred with E2Ws: old vehicle dumping. When the owner of several year-old vehicles is faced with the expense of a new battery set for an old vehicle, it is often easier to justify buying a whole new vehicle, rather than putting a large sum of money into the older vehicle. Subsequently you can see large numbers of older E2Ws abandoned at residences and workshops, as in Figure 44. While these do not present a grave environmental danger, there should be a comprehensive policy regarding the End of Life (EOL) of E2/3Ws. Currently there is a pilot program of Authorized Automotive Treatment Facilities (AATF) for proper management of reuse, recycling or disposal of EV components from EOL vehicles in four region of Malaysia which should be expanded to include 2- and 3-wheelers.

Figure 44 : Two abandoned E2Ws (left- and right-most vehicles) at a motorcycle shop in Kedah.

Source : Author's photo

A clear EOL policy for cars and motorcycles, perhaps targeting older less efficient vehicles especially, could expedite the shift to EVs in general, by removing older, less efficient and/or unfit conventional vehicles form the roads.

17. MISCELLANEOUS

The active use of E2Ws can be increased by including them in government fleets. This can be started immediately on enclosed campuses, such as universities, airports or large research campuses such as SIRIM or even between government buildings in Putrajaya. This could be associated with MOSTI's sandbox program, or directly procured by the interested department or agency. In addition to "leading by example" it could help expose civil servants and policy makers to the advantages and issues associated with light duty electric vehicles firsthand. When the heads of government departments arrive at the office on E-scooters in the rain after having waited 45 minutes for a bus connection, they will likely be very motivated to improve the transportation options of the B40.

18. PUBLIC EDUCATION – AWARENESS RAISING

Public awareness campaigns may be required to clarify the different statuses of E-bikes, E-scooters and E-motorcycles. For example, most riders currently believe that a license is not required for operating E-scooters, however this is likely to change. Malaysia Greentech Corp (MGTC) and Minister of Natural Resources, Environment and Climate Change of Malaysia could be the focal point Communication, Educational and Public Awareness (CEPA) programs via special events and conferences such as International Greentech & Eco Products Exhibition and Conference Malaysia (IGEM), auto shows, etc.

Existing competitions, such as the Low Carbon City Challenge, and other ecological platforms can be combined with initiatives on E2/3Ws, helping disseminate the mandates down to the local authorities.

19. ASEAN

One final area of interest is to coordinate the above actions within the greater ASEAN region. There are many advantages to be had by combining with the other ASEAN countries to form a homogeneous E2/3W market, allowing access to a wider range of compatible parts at lower cost, while also opening up the large ASEAN market to domestically produced products. Trans-boundary regulations harmonization is in all party's interest and could help simplify and foster inter ASEAN trade, while allowing us a better possibility of competing against larger foreign competitors, such as mainland China. This is especially true for Malaysia, which has a relatively small domestic market.

RECOMMENDATION RANKING

The proposed measures mentioned above were each assigned a "cost" ranging from low to high, and an impact, also ranging from low to high, and then given a priority based on their "score" which was a multiplication of the cost (3 for low cost, 1 for high cost) times the impact (1 for high, 3 for low). The score was then divided by three, resulting in a "priority" for each proposal ranging from 1 (for high impact/cost items) to 3 (for lower impact/cost items) as shown in Figure 45. As both the cost and impact rankings are highly subjective, the resulting "scores" are only guides intended to indicate which measures have a relatively better benefit to cost ratio for purposes of planning. The final scores were broken, somewhat arbitrarily (<2, 2-2.75 and >2.75), into three categories: High, Medium and Low priorities.

This is not to say, of course, that items in the Low Priority category should not be pursued, rather that they will require relatively more resources for somewhat more modest anticipated gains. It bears mentioning at this point that these assumptions and rankings will not remain static: overtime technology, fuel prices and economic priorities will change, which can greatly affect the results of this analysis. Additionally, we are operating under the assumption that the socio-economic, political and natural environment will remain generally well behaved, and are ignoring all external factors, such as natural disasters, wars, or political upheaval, which could completely change the balance[43].

That said, the resulting prioritized recommendations will be summarized in the conclusion section after an assessment of the total potential impact of shifting aggressively to electric 2- and 3-wheeled propulsion.

[43] For an excellent reference on the subject see Nassim Taleb's "The Black Swan: The Impact of the Highly Improbable"

Item	Measure	Cost	Impact	Score
1	Apply current standards and enforce current VTA and Standards	1	1	2.7
2	Allow inclusion of "throttle" E-bikes in MS2514	1	2	1.9
3	Mandatory range measurements on a relatively aggressive drive cycle	1	1	2.7
4	Enforcement of the 300 charge/discharge cycle minimum battery life limit	1	1	2.7
5	Battery standards for inter-operability between different vehicles	1	2	1.9
6	Battery swapping and charging station standards (NSC 05/TC 12)	1	2	1.9
7	Expand SIRIM test facilities to accommodate required testing	2	1	3.0
8	Simplify E2/3W Re-Certification for minor upgrades (eg. battery pack)	1	2	1.9
9	EV Battery 2nd Life Plan: AATF Extended Producer Responsibility (EPR) guidelines	1	1	2.7
10	Reclassify E-Scooters from Toys to Vehicles	1	1	2.7
11	Standard in KPDNHEP to use" block chain" tracking like "UCustoms"	1	1	2.7
12	Allow E-scooter on <50kph roads	1	2	1.9
13	Allow E-bikes on low speed roads (same as for bicycles)	1	2	1.9
14	Allow non-road use of E-bicycles and E-scooters, Registers as "Sporting Goods"	1	1	2.7
15	E-bicycles and E-scooters exempt from annual road taxes.	1	1	2.7
16	E-bike License plate/Registration	2	1	3.0
17	E-scooter license plate/Registration	2	1	3.0
18	Pre-existing E2Ws "Legacy E-Scooter XXXXXX" Registration	1	1	2.7
19	E-scooters require min age of 16 years + licensed	1	1	2.7
20	E-scooter require helmets for all drivers and passengers	1	1	2.7
21	Helmets for E-bicycles are at the riders discretion	1	1	2.7
22	Police EV Accident tracking	1	1	2.7
23	Local Authority Buy in/Tracking of E2/3W issues	1	1	2.7
24	E2W Access to Transport Hub, Schools, Shopping, Govt Offices	3	2	3.0
25	E2W Parking at Transport Hub, Schools, Shopping, Govt Offices	2	2	2.4
26	E2W Charging/Swap at Transport Hubs, Schools, Office and Petrol stations	2	2	2.4
27	E2W Service Centers: Training up Pax, Placement at "hubs"	2	2	2.4
28	Expand 2W paths especially to access transport hubs	3	3	2.7
29	E2W Charging included in all development plans	1	2	1.9
30	Car to E2W parking conversion	2	1	3.0
31	Smart Poles with road side E2W Charging	2	2	2.4
32	Smart charging Tariffs/Meters (lower fare at night)	2	2	2.4
33	Allow Financing of E2Ws	1	2	1.9
34	Battery rental, Batt as a service development	1	3	1.0
35	Special Financing for Delivery riders	1	2	1.9
36	Special E3W for Delivery riders / expansion to take over trucks	1	2	1.9
37	Expansion of EV training, E2/3W Shops	2	1	3.0
38	Special Financing to increase the number of E2/3W service shops	2	1	3.0
39	Fee bating on purchase price via comprehensive "Vehicle Efficiency Tax"	1	3	1.0
40	Fee bate E-scooters insurance from larger vehicles	1	1	2.7
41	EV Charging/Batteries/Motors Tech Dev Funding via NTIS "Sandbox"	3	2	3.0
42	EV Conversion Training, Testing and Approval	2	1	3.0
43	M'sian EV Products/Talent global promotion	1	1	2.7
44	Top Down "Majlis Ekonomi Digital dan Dasar 4IR" to unify approach	1	1	2.7
45	Comprehensive mandate for E2/3Ws for the long term.	1	2	1.9
46	"EV-Solar Initiative" + PV net energy metering (NEM) quotas for E2/3W Charging	1	1	2.7
47	EOL Plan for E2/3W	1	1	2.7
48	EOL Plan for ICE 2W and Cars	1	2	1.9
49	E2Ws procurement in government fleets: campuses, airports, POS, TNB	3	2	3.0
50	Public awareness E-bikes, E-scooters and E-motorcycles	1	2	1.9
51	Low Carbon City Challenge etc. to include E2/3Ws	1	1	2.7
52	ASEAN countries to form a homogeneous E2/3W market	1	1	2.7

Figure 45 : Prioritization of the proposed measures based on relative cost and anticipated impact.

CO2 EMISSIONS REDUCTION PROJECTIONS

In this section we will analyze the potential market size of electrical 2- and 3-wheelers projected into the future, and the effect of various levels of E2/3W adoption on CO_2 emissions.

The first step is to analyze the emissions of E2Ws compared with conventional ICE 2-wheelers and the other transportation modes they might replace. Combustion engine vehicles are generally graded by their fuel consumption in kilometers per liter. The actual "fuel mileage" of any vehicle depends strongly on how the vehicle is used, and the size and weight of the vehicle. For our purposes we will use average fuel mileages gathered from our surveys and online forms for conventional motorcycles, and published data for other modes of transportation. Electric Vehicles are graded by their electrical energy consumption in Watt hours per kilometer. Again the "mileage" will depend on the size of the vehicle and how it is used, with smaller "E-bikes" being the most efficient and larger "E-motorcycles" consuming more energy per kilometer traveled. Michal Sura put together an excellent summary of the energy consumption of various transportation modes, focused on small electric propulsion vehicles (Sura 2022). Based on this and our previous numbers from testing different driving cycles we have established that E-bikes consume about 10Wh/km, E-scooters consume around 20Wh/km, while E-motorcycles will require around 35Wh/km in normal operation.

ELECTRIC vs ICE EMISSIONS

While EVs have zero "tail pipe" emissions, their use still causes CO_2 emissions via two main sources:

- EV Production
- Electricity Production

In general, the amount of energy required to build an EV is similar to an ICE vehicle. EVs are fairly efficient (80-90%) "tank to wheel" compared to ICEs (10-20%), however the electricity used to charge the EV comes mostly from coal fired power plants (30% efficient) in Malaysia and there are additional line and conversion losses. In the end **EVs emit about half** the emissions of equivalent ICE vehicles, but most current E2Ws are much smaller than ICE Vehicles, so emit even less.

The emissions factor for the electricity grid depends heavily on the sources of power. Peninsular Malaysia gets it electricity predominantly from coal fired plants and has an emissions factor of 0.78 g CO_2e/Wh[44]. Taking this number times by the EV energy consumption numbers above we can calculate the emissions per kilometer, as shown in Figure 46.

2-Wheeler	Energy Consumption	Units	Emissions Factor	Units	Emissions gCO_2/km
E-Bike	10	Wh/km	0.78	gCO_2/Wh	7.8
E-Scooter	20	Wh/km	0.78		15.6
M-Moto	35	Wh/km	0.78		27.3
ICE 100cc	55	km/liter	2.416	$kgCO_2$/liter	43.9
ICE 120cc	50	km/liter	2.416		48.3
ICE 150cc	45	km/liter	2.416		53.7

Figure 46 : Emissions per kilometer for various ICE and EV 2-wheelers.

Petrol powered vehicles routinely have measured fuel consumption in kilometers per liter, or liters per 100 km. Emissions can be calculated by multiplying the fuel consumption (in liters per kilometer) times an

[44] Emission factor from: https://meih.st.gov.my/documents/10620/384e88c1-b782-49a1-8dff-74c836b3a3f7

emissions factor of 2.416 kg CO_2 /liter[45]. This is shown in Figure 46 for three different common motorcycle engine capacities, where fuel consumption numbers are from our surveys. As can be seen, the E-motorcycle results in about half of what a 150cc motorcycle emits. The smaller E-bike and E-scooters emit much less simply because they are much smaller, lighter, and generally used at lower speeds, resulting in exceptionally low energy consumption, and emissions. For reference, passenger cars emit around 192gCO_2 per kilometer, more than 12 times what an E-scooter emits[46]!

The second step in calculating the emissions impact of greater E2W usage depends on what mode of transportation is being displaced by the E2W trips. Emissions factors of various travel modes are shown in Figure 47 but it must be remembered that these numbers are highly dependent on things like vehicle rider ship: two people in a car will reduce the emissions per passenger by half, simply because there are now two passengers sharing the emissions of one vehicle with very little actual fuel consumption change[47]. Significantly it can be seen that the emissions per kilometer from the smaller E2Ws are lower than all the other transport options, except perhaps long-distance rail.

The goal, of course, will be to reduce the most carbon intensive travel forms (e.g. taxis, personal cars), and if possible "enhance" ridership of the more efficient transportation forms (e.g. electric trains) (Gitano, 2016). A recent review by Alexander Bigazzi indicated that in several markets E-bicycle trips were substituted for public transit trips 33% of the time, conventional bicycles 27%, cars 24% and walking in about 10% of the cases, however with large amounts of variation from location to location (Bigazzi, 2020). The low rate of car travel and high rate of public transit substitution is partially an artifact that many of these studies took place in areas where personal car ownership was low, and there was an established public transport system. Additionally, E-bicycles, of the kind investigated in this study, will generally only be used for very short-range trips, usually under 10km, whereas the higher power E2Ws will be used for longer trips, and thus have a greater probability of displacing trips by car. However, any analysis of the emissions benefits of E2/3W usage must consider what modes of transportation are being displaced by the E2/3W.

Mode	gCO_2/Pax km
Taxi	781
Short Flight	255
Petrol Car	192
Diesel Car	171
Bus	105
Urban Rail	41
Inter-City Rail	6

Figure 47 : Emissions per passenger kilometer for various transportation modes.

Initial projections of electric 2-wheeler market share growth were shown in **Error! Reference source not found.** assuming Business As Usual (BAU) with E2Ws taking less than a quarter of the 2-wheeler market by 2050. Many countries are announcing the intention to phase out combustion vehicles, some as early as 2030. Therefore, a modest goal might be to displace 50% of the combustion 2-wheeler market with E2Ws by 2030. After this date we are assuming that E2Ws will continue to displace conventional motorcycles, however at a diminishing rate. Displacing 100% of the combustion vehicles by 2035 is a more aggressive goal, however to really have a significant impact on emissions, we will need to replace a significant number of the combustion cars, and even delivery trucks, with E2/3Ws. Taking people out of cars and putting them on 2-wheelers will

[45] Taken from "Manual for Calculating Greenhouse Gas Benefits of Global Environment Facility Transportation Projects", reprinted in appendix G.
[46] Tiseo, I. (2021, October 4). Travel carbon footprint by transport mode, https://www.statista.com/statistics/1185559/carbon-footprint-of-travel-per-kilometer-by-mode-of-transport/ Downloaded 13-07-2023
[47] Data from UK Dept. for Business, Energy and Industrial Strategy, Taxi data from Gitano-Briggs 2016 assuming CNG powered taxis

potentially incur popular pushbacks, unless the cost of driving a car becomes prohibitively expensive, and the convenience of E2Ws is increased. However, if we are really serious about having a large impact on CO_2 emissions, we must consider limiting travel to the most efficient means possible, and that means very small electric vehicles and mass transit systems. Apart from moving away from combustion 2-wheelers we will investigate scenarios where we also shift from cars to E2Ws and even delivery trucks to E3Ws.

We therefore will focus on the following four scenarios for further emissions impact calculations:

- 50% displacement of 2-wheelers with E2Ws by 2030
- 100% displacement of 2-wheelers with E2Ws by 2035
- 100% 2W and 25% 4-wheeler displacement with E2/3Ws by 2035
- Scenario 3 plus 10% truck displacement with E2/3Ws by 2040
- Scenario 4 plus 50% replacement of Taxis/Ride Hailing with E2Ws by 2035

The emissions analysis will start with a look into the emissions of the different transportation modes, and various scenarios projected into the future. For the purposes of E2/3W projection we'll be focusing on emissions from the following modes:

- Conventional Motorcycles
- Passenger cars
- Taxis (including 4-wheeled "Ride Hailing" such as Grab)
- Light Rail
- Light duty trucks (for E3W delivery vehicles)

We expect electric 2-wheelers to capture mode share from conventional motorcycles, passenger cars, taxis, while the electric 3-wheelers will capture mode share from light duty delivery vehicles. In order to displace some cars travel it will make more sense to replace the car trip with a combination of electric motorcycle plus a light rail trip instead of just relying on the E2W for the whole trip. For example, the author frequently travels to Kuala Lumpur from Penang (around 300km) by riding an E-motorcycle 10 km to the nearest Electric Train Service (ETS) station, Figure 48, and proceeding to the destination by ETS and light rail. Therefore, in the car displacement scenario, we have assumed that the E2W will be used for 50% of the displaced car trips outright and will be a first/last mile connection accounting for 25% of a trip which is completed via urban rail (75% of the trip) for the other 50% of displaced car trips.

Figure 48 : Author's E-motorcycle, in the rain, at the train station.
Source: Author's photo

Emissions from the various modes is, and will continue to be, a "moving target" as conventional combustion propulsion is gradually replaced by EV-Hybrids, and newer more efficient technologies are introduced to bus and truck fleets. Additionally, as the population and GDP grows, both the number of private vehicles and the size of the vehicles will continue to increase. In the United States, for example, despite many years of progress in automobile efficiency improvements, the shift away from cars towards SUVs and trucks has eliminated any net significant fuel consumption improvement[48]. Furthermore, the total number of kilometers traveled by private vehicles tends to increase with time, resulting in more CO_2 emissions despite efficiency improvements[49].

Taking current data trends and projecting forward to 2050 we get the vehicle mix shown in Figure 49. We can see a similar gradual increase in the number of cars and combustion motorcycles with an approximate 1/3 increase in numbers between 2023 and 2050. The number of trucks increases relatively slowly over the same period. According to the rapid increase in E2Ws described earlier, we see the small number of electric 2-wheelers increasing to almost 4 million units by 2050.

Because we realize that both the power and number of kilometers per year will tend to increase, especially for the E2W segment, we've had to make several assumptions in assessing the emissions. Firstly, the current power of E2Ws is not equivalent to the ICE 2 wheelers they will be replacing. We've assumed that the average power, and annual mileage, of the E2W fleet will rise to match that of the ICE 2W fleet they are replacing by 2030. Secondly, as the power is increasing, the emissions per kilometer will also increase proportionally from 15 g CO_2 /km today to 30 g CO_2 /km by 2030, after which time it remains fixed.

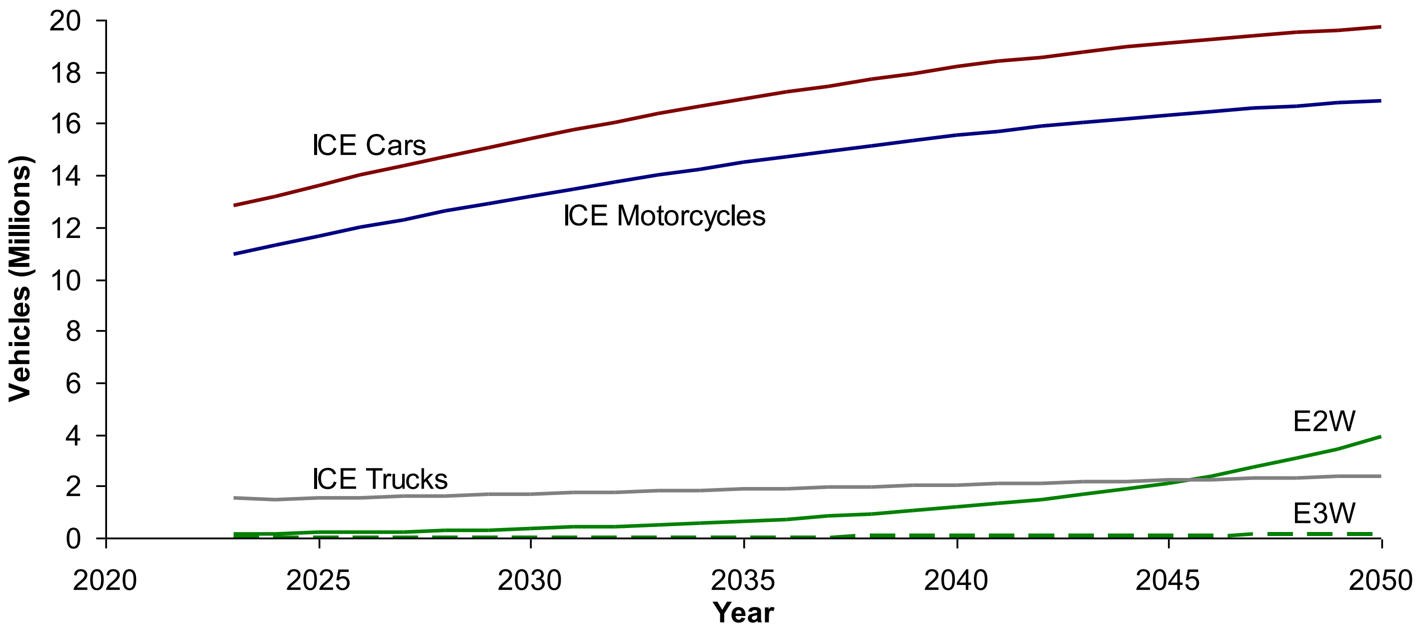

Figure 49 : Projected Fleet numbers under "Business as Usual" scenario

For cars and conventional motorcycles, we have also assumed that their annual mileage will continue to increase by approximately 1% per year, but we've chosen to fix their emissions at 50 g CO_2 and 192 g CO_2 per kilometer for the 2-wheelers and cars respectively.

CO_2 EMISSIONS

To put the emissions projections in perspective, Transportation is responsible for approximately 42% of the national energy consumption (BUR 2020), and Truck, Car and Motorcycle emissions account for about 85% of

---

48 In 1980 passenger cars made up 80% of the private vehicle fleet in the USA and got 19 miles/gallon. By 2023 they were achieving 32mpg, but had dropped to 25% of the fleet, the rest being SUV, trucks and pickups. Over the same period (1980-2023) pickup truck mileage in the US improved form 16mpg to only 19mpg. From: https://www.epa.gov/automotive-trends/highlights-automotive-trends-report

49 Miles per person per year went from 10,600 in 1970 to 12,900 in 2000 in the USA. From: https://fredblog.stlouisfed.org/2014/06/how-much-do-americans-drive/?utm_source=series_page&utm_medium=related_content&utm_term=related_resources&utm_campaign=fredblog

the transportation emissions[50]. Taking CO_2 emissions to be proportional to energy consumption then Trucks, Cars and Motorcycles are responsible for approximately 36% of the total national CO_2 emissions.

The emissions and emissions reductions projected for the various scenarios are shown in Figure 50. Following the BAU trend will result in Truck, Car and Motorcycle emissions (including the small projected E2W fleet) of 160 billion tons of CO_2 in 2050, or a cumulative emission of 3312 billion tons of CO_2 from 2023 to 2050.

Scenario	BAU	1	2	3	4	5
Cumulative Emissions (Billion tons CO_2)	3312	3216	3209	2693	2599	2569
% Reduction form BAU	-	2.9%	3.1%	18.7%	21.5%	22.4%
Incremental Reduction (%)	-	2.9%	0.2%	15.6%	2.8%	0.9%
2050 Emissions (Mton CO_2)	159974	153390	153209	111121	102670	100365
% Reduction from BAU	-	4.1%	4.2%	30.5%	35.8%	37.3%
Incremental Reduction (%)	-	4.1%	0.1%	26.3%	5.3%	1.4%

Figure 50 : Cumulative (2023-2050) year 2050 emissions and % reduction for the various scenarios

With moderately aggressive uptake of E2W's displacing 50% of the population of conventional motorcycles by 2035, shown in Figure 51, cumulative emissions will be reduced by about 2.9%, and emissions in 2050 go down by about 4.1%. After 2030 the E2W "adoption" trend is continued slowly replacing most ICE 2W's by 2050.

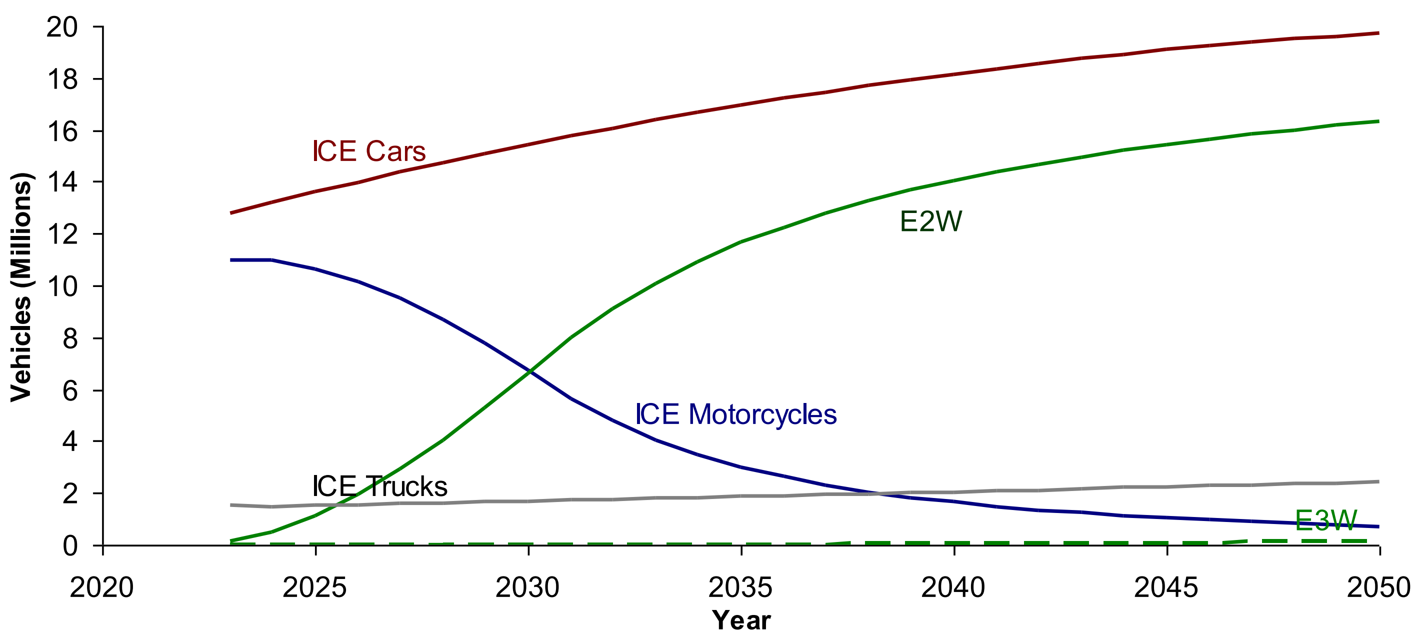

Figure 51 : Scenario 1, 50% Replacement of ICE2W by E2W by 2030

Scenario 2, shown in Figure 52, is slightly more aggressive, and results in complete replacement of the ICE2W fleet by 2035. This would require more extreme legal measures to prohibit the use of ICE 2-wheelers after 2035, and only results in slight improvements over Scenario 1: Cumulative emissions reductions go from 2.9% to 3.1%, and the 2050 emissions reduction goes from 4.1% to 4.2%.

[50] See for example: Mustapa, and Bekhet "Analysis of CO2 emissions reduction in the Malaysian transportation sector: An optimization approach", Energy Policy 89 (2016)

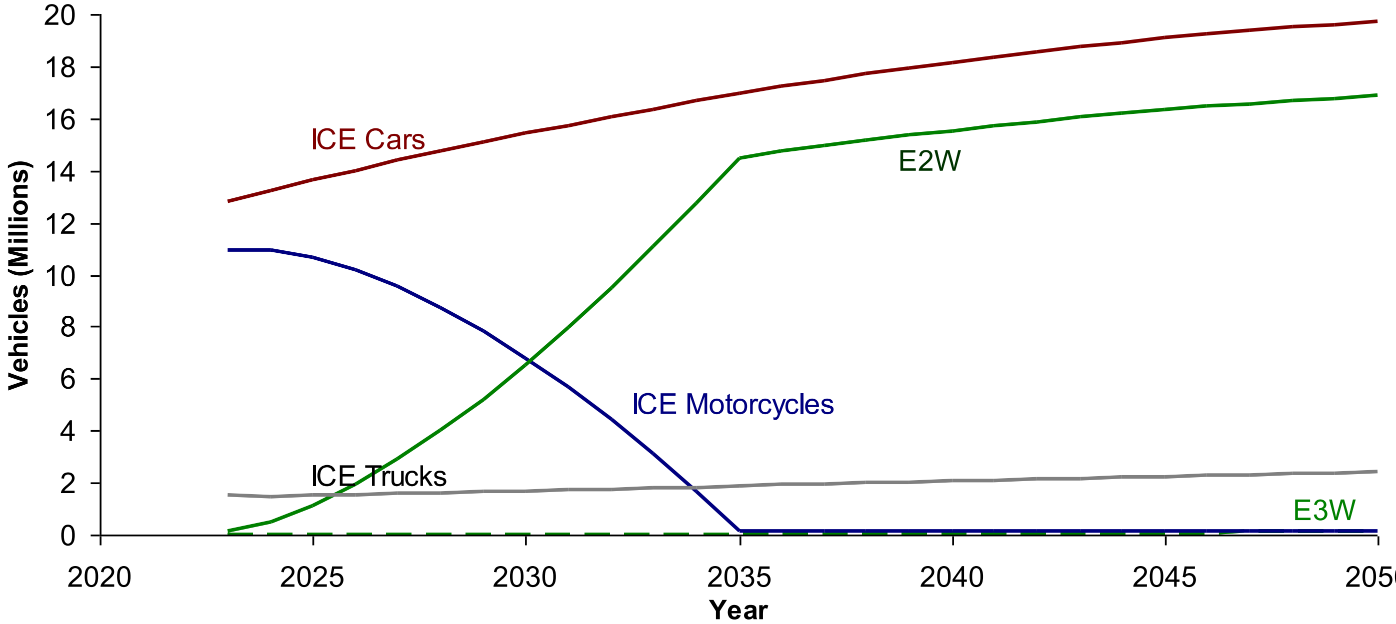

Figure 52 : Scenario 2, Total replacement of ICE2Ws with E2Ws by 2035

It is believed that this measure banning all ICE motorcycles would likely be unpopular, and it would be difficult to justify the merge improvement in emissions reductions. Scenario 3, which includes a 25% replacement of the car fleet by 2035, is shown in Figure 53. It can be seen that the car to E2W trend continued past the 2035 date resulting in an approximate 50% replacement of the car fleet with E2Ws by 2050. In this we have assumed that urban light rail has accounted for about 38% of the displaced car passenger kilometers (75% of 50%) supplementing the E2W in order to maintain the total number of kilometers traveled.

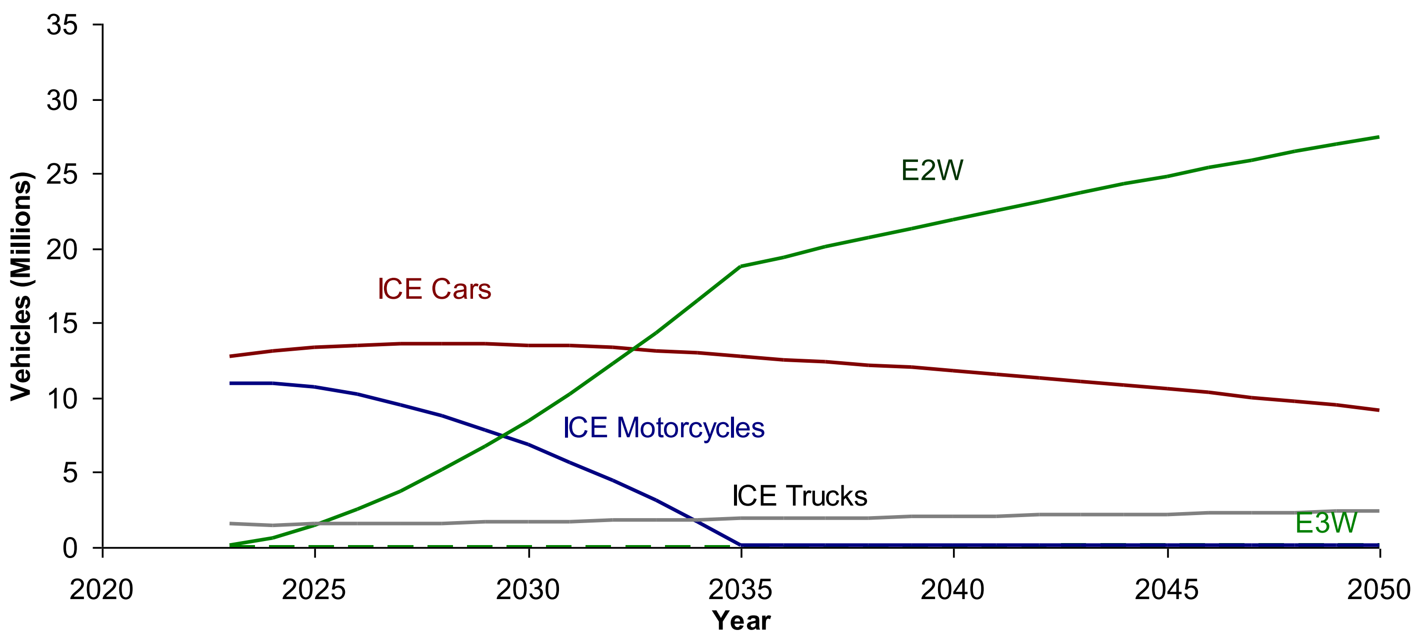

Figure 53 : Scenario 3, Total replacement of ICE2Ws by 2035 and 25% replacement of car fleet with E2Ws by 2035

The effect, however, of shifting people from cars to E2Ws is quite significant: Scenario 3 achieves a cumulative reduction of emissions of about 18.7% and a reduction of emissions by 30.5% in 2050. The effect of getting people out of cars and onto E2Ws will have a much greater impact than simply substituting E2W for combustion motorcycles.

Scenario 4, shown in Figure 54, includes replacing 10% of the trucks with E3Ws by 2035. For this scenario we've take truck emissions on the high side (307gCO_2/km), assuming these are "urban delivery trucks" which consume more per kilometer than the long-haul trucks, and the E3Ws have a relatively high emissions of 45g CO_2/km compared to the E2Ws.

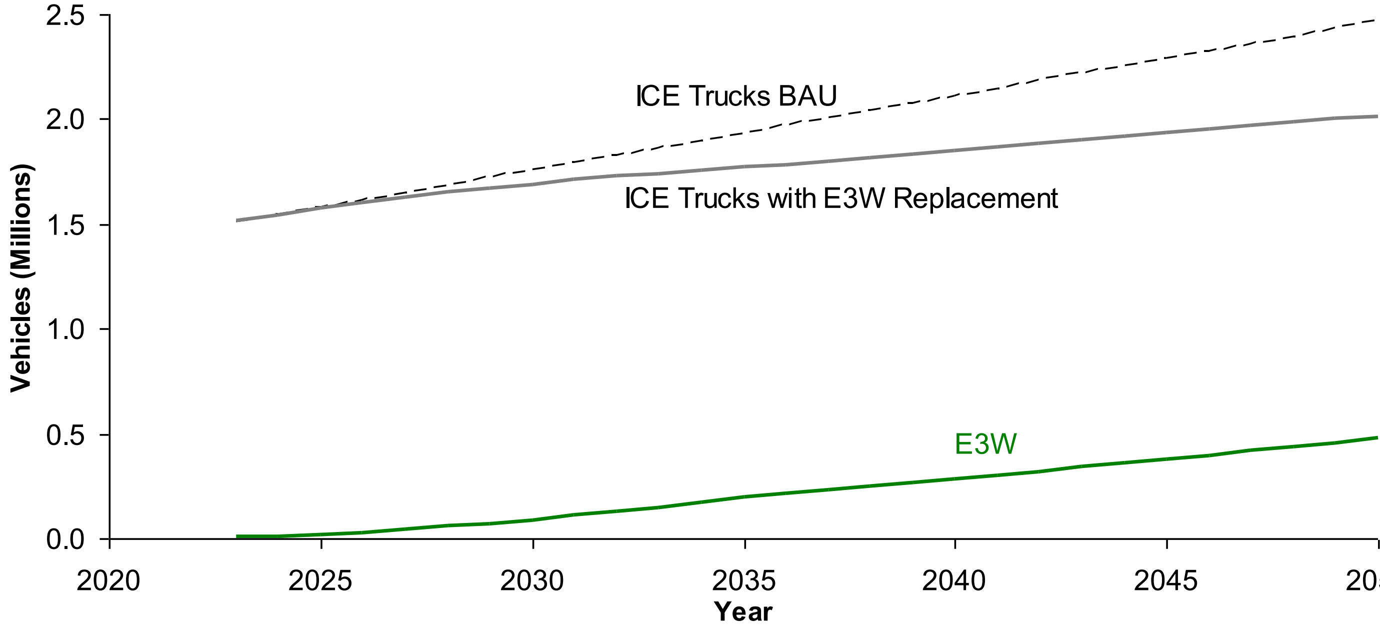

Figure 54 : Scenario 4, ICE Trucks with 10% Electric 3-wheelers substitution by 2035

Even with the substitution of E3Ws for trucks the overall number of trucks in the fleet will continue to increase well into the future. However, even this modest replacement of trucks with smaller electric delivery vehicles will result in an additional 2.8% cumulative or 5.3% (year 2050) reduction of emissions beyond Scenario 3, indicating that replacing urban delivery trucks with light electric vehicles whenever possible is approximately as important as replacing combustion motorcycles with electric ones. Additionally, this involves a much smaller number of electric vehicles and should result in significant savings for the vehicle operators, making it potentially easier to implement than the larger ICE 2W and car replacements.

Finally, as taxis have one of the highest CO_2 impacts per passenger kilometer, their replacement by E2Ws (Scenario 5) can have a significant impact, despite their relatively small numbers. With 50% replacement of taxi rides by E2W trips in 2035 and a continuing trend, the total road emissions will be reduced by an additional 1.4% in 2050.

From the emissions projections we can see that a gradual substitution of combustion motorcycles for E2Ws will have a major impact on the emissions of the 2-wheeler fleet, reducing the emissions from trucks, cars and 2-wheelers by about 4.1% by 2050, whereas the more drastic measure of an outright ban on combustion 2-wheelers in 2035 only makes a minor improvement on this scenario. The substitutions of E2Ws for cars can have a profound effect on transport emissions, reducing the truck-car-motorcycle emissions by an additional 26.3% or so by 2050. Thus, while it is unlikely to expect that all car trips can be substituted with E2Ws, major effort should be made in reducing the number of cars on the road in favor of electric 2-wheelers. A modest substitution of electric 3-wheeler delivery vehicles for trucks can have a big impact: in our scenario Truck-car-motorcycle emissions were reduced by over 5% by 2050. Finally, eliminating taxi rides in favor of E2W trips as per scenario 5 could further reduce emissions in 2050 by 1.4%. The combined impact of these measures could result in a reduction of emissions from trucks, cars and motorcycles of over 37% by 2050. As these vehicles represent about 36% of the total national emissions, these combined measures could result in a 13% reduction in overall national emissions by 2050.

CONCLUSIONS

While precise evaluation of the effect of any given action or policy is very difficult, we have endeavored to evaluate the E2/3W promotion recommendations in terms of their likely impact/cost ratio. The “cost” of each action was broken into three categories: Low, Medium and High, as was the potential impact. A “low” cost measure is something that requires mostly time and brain power, but little or no infrastructure development, for example changing the rules to allow E2W of the scooter class on low-speed roads is considered a low-cost measure. Building many kilometers of new 2-wheeler only lanes is considered to be a “high” cost action, and installation of basic weatherproof E2W charging points at existing parking structures at transportation hubs would be an intermediate cost measure. Intermediate impact/cost measures are actions that either require a moderate investment of resources, and/or have a limited impact on E2/3W proliferation. For example, requiring helmets for all riders on E-scooters is not expensive, and it is an important safety measure, however it will not have a direct impact on the number of E-scooters on the road.

Assessing the impact of a given measure or policy change is even more difficult. Some measures, such as improving the training of potential E2W mechanics to deal with electric vehicle specific issues will have a relatively indirect effect on the number of E2Ws sold, and then only on a fairly long-time scale. Raising the price of fuel or providing subsidies for E2Ws will likely have an immediate and very direct effect on increasing the sales of new E2Ws. Finally, some measures, such as requiring SIRIM compliance testing may actually decrease the number of E2Ws sold as they must now comply with the existing standards, however the vehicles thus eliminated are likely to be poor-quality products which are bound to disappoint their owners and give the whole E2W scene a bad name. In each case we have attempted to use whatever data is available in order to provide some guide to the potential of each proposed measure.

The following are the recommended actions separated into the categories of Policy and Government Incentives, Standards and Technical Regulations, Infrastructure Development, Finance and Investment, and Miscellaneous. Within each category the individual actions are sorted in order of impact/cost.

1. POLICY AND GOVERNMENT INCENTIVES

The following policy measures have been proposed. Many of them are rated as high impact/cost as they do not require extensive investment in new technologies or infrastructure.

HIGH IMPACT/COST

- Allowing E-scooter on <50kph roads
- Allowing E-bikes on low-speed roads (same as for bicycles)
- Including E2W charging in all new development plans
- Comprehensive mandate for E2/3Ws for the long term
- End Of Life Plan to phase out old ICE 2W and Cars

MEDIUM IMPACT/COST

- Reclassifying E-Scooters from Toys to Vehicles
- Allow limited non-road use of E-bicycles and E-scooters, registers as "Sporting Goods"
- KPDNHEP to implement “block chain” tracking like “UCustoms”
- Exempt E-bicycles and E-scooters from annual road taxes

- Allow Pre-existing E2Ws via a “Legacy E-Scooter XXXXXX” Registration
- E-scooters require min age of 16 years + licensed
- E-scooters require helmets for all drivers and passengers
- Helmets for E-bicycles are at the rider’s discretion
- Implement Police EV Accident tracking, making traffic safety data more readily available
- Get Local Authority Buy in/Tracking of E2/3W issues
- Develop EOL Plan for E2/3W including provisions for second life battery usage
- Push ASEAN countries to form a homogeneous E2/3W market

LOWER IMPACT/COST
- Develop E-bike License plate/Registration
- Develop E-scooter license plate/Registration
- Facilitate EV Conversion via establishment of Training, Testing and streamlined Approval processes

2. STANDARDS AND TECHNICAL REGULATIONS

While the generation of new technical standards requires some modest funds, they may not have a direct or immediate impact on the proliferation of E2/3Ws, however they will be important going forwards.

HIGH IMPACT/COST
- Allow inclusion of “throttle” E-bikes in MS2514
- Development of battery standards for inter-operability between different vehicles
- Development of battery swapping and charging station standards (work in progress as of 2024)
- Simplify E2/3W Re-Certification for minor upgrades

MEDIUM IMPACT/COST
- Apply and enforce current standards and VTA regulations
- Mandatory range measurement for EVs on a relatively aggressive drive cycle
- Enforcement of the 300 charge/discharge cycle minimum battery life limit
- EV Battery 2nd Life Plan: AATF Extended Producer Responsibility (EPR) guidelines

3. INFRASTRUCTURE DEVELOPMENT

The items in this category require significant amounts of investment in order to realize benefits in the proliferation of electric 2- and 3-wheelers. In many cases infrastructure must be developed which will take some time, however, to achieve the target emissions reductions this work will be necessary.

MEDIUM IMPACT/COST
- Provide E2W Parking at Transport Hub, Schools, Shopping, Government Offices
- Provide E2W Charging/Swap at Transport Hubs, Schools, Offices and Petrol stations
- Prepare E2W Service Centers: Training up Personnel, Placement at “hubs”
- Expand 2W paths especially to access transport hubs
- Provide Smart Poles with roadside E2W Charging
- Develop Smart charging Tariffs/Meters (lower fare for EV charging and/or at night)

LOWER IMPACT/COST

- Provide E2W Access to Transport Hubs, Schools, Shopping, Government Offices, etc.
- Convert "close in" Car parking to E2W parking
- Expand SIRIM test facilities to accommodate required testing
- Increase E2Ws procurement in government fleets: campuses, airports, POS, TNB

4. FINANCE AND INVESTMENT

A variety of financial incentives and investments can be made which will help disseminate electric 2- and 3-wheelers. While there may be some cost involved in these, they will tend to have a very direct impact on the number of E2/3Ws making their way to the roads.

HIGH IMPACT/COST

- Allow Financing of E2W purchases
- Develop Battery rental, Batteries as a service
- Develop Special Financing for Delivery riders
- Develop Special provisions for E3Ws as Delivery vehicles to take over from trucks
- Fee bating on purchase price of E2/3W via comprehensive "Vehicle Efficiency Tax"

MEDIUM IMPACT/COST

- Feebate E-scooters insurance from larger vehicles (if deemed necessary)
- Allow "EV-Solar Initiative" + PV Net Energy Metering (NEM) quotas for E2/3W Charging

LOWER IMPACT/COST

- Fund EV Charging/Batteries/Motors Tech Development via NTIS "Sandbox"
- Provide Special Financing to increase the number of E2/3W service shops

5. MISCELLANEOUS

The items in this category do not involve major policy changes, technical or infrastructure developments, or significant financing, and many of them have an indirect effect on E2/3W proliferation. For example, while a public awareness campaign certainly requires a moderate level of expenditure, it will only have an effect on the market over a relatively longer period of time. Although it is quite important, it winds up being ranked in the lower impact/cost bin.

MEDIUM IMPACT/COST

- Include E2/3Ws in Low Carbon City Challenge etc.

LOWER IMPACT/COST

- Public awareness promotion of E-bikes, E-scooters and E-motorcycles
- Expansion of EV training for existing motorcycle Shops
- Promote Malaysian EV Products/Talent globally
- Top Down "Majlis Ekonomi Digital dan Dasar 4IR" to unify approach

Achieving the region's emissions reduction goals will be a difficult task and many of the ASEAN countries are not making serious progress towards their stated goals. According to the IEA "Southeast Asia is still a long way off the pathway consistent with its clean energy ambitions”[51]. We believe that by prioritizing the above-mentioned actions a smooth transition to clean light duty electric vehicles is possible without extreme measures. This could potentially reduce the CO_2 emissions of trucks, cars and motorcycles by around 37% by 2050. This represents a total national emissions reduction of over 13%. The more active measures, increasing the price of fuel, increasing the cost of car purchasing and ownership while decreasing that of E2/3Ws, will have a more direct effect, but the degree of shift from combustion vehicles to electrics will depend on an accumulation of factors, including things such as vehicle range, the availability of charging and parking.

In order for the country to achieve its emissions reduction goals significant changes, and sacrifices, will have to be made. In our models we have assumed a continuous ***increase*** in actual transportation (as measured by total passenger kilometers traveled) pursuant to the existing trends. One of the easiest ways to decrease transportation emissions is simply to reduce the need for transportation: live close to where you work, use local schools, combine trips together to reduce the total number of trips, etc. This, however, will involve making some sacrifices. Another easy way to reduce emissions is to use the most efficient transportation option available, and that means light duty electric vehicles, and public transport. If we are serious about reaching our emissions goals, then it is imperative that we very actively pursue the substitution of cars, and especially SUVs and pickup trucks used as passenger cars, with small electric vehicles, replace trucks in delivery roles with electric 3-wheelers wherever possible, and push consumers to use electric 2-wheelers rather than combustion motorcycles.

It is our hope that by prioritizing the above-mentioned actions we can help perform the transition to cleaner transportation as painlessly and efficiently as possible.

[51] “Southeast Asia Energy Outlook 2022”, INTERNATIONAL ENERGY AGENCY Available from: www.iea.org

ABBREVIATIONS

4IR	Industrial Revolution 4.0
AATF	Authorized Automotive Treatment Facilities
AC	Alternating Current
AP	Approval Permit
ASEAN	Association of Southeast Asian Nations
B2B	Business-to-Business
BAU	Business as Usual
BMS	Battery Management System
BMU	German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety
CBU	Complete Built Up
cc	Cubic Centimeter (engine displacement)
CCTV	Closed Circuit Television
CEPA	Communication, Educational and Public Awareness
CKD	Complete Knocked Down
CO_2	Carbon Dioxide
CPO	Charge Point Operators
E2/3W	Electrical 2 / 3-Wheeler
ECER	European Conference on Educational Research
EM	Electro-Magnetic
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
EOL	End of life
ESG	Environmental, Social, and Governance
ETS	Electric Train Service
EV	Electric Vehicle
EVAM	Electric Vehicle Manufacturers Association of Malaysia
g	9.81 m/s^2
GDP	Gross Domestic Product
h	Hours
HZ	Hertz (cycles per second)
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
IEA	International Energy Agency
IGEM	International Greentech & Eco Products Exhibition and Conference Malaysia
ISO	International Organization for Standardization
JKR	Ministry of Work (Jabatan Kerja Raya)
JPJ	Road Transport Department (Jabatan Pengangkutan Jalan)
JPK	Skills Development Department (Jabatan Pembangunan Kemahiran)
km	Kilometer
KPDNEP	Kementerian Perdagangan Dalam Negeri & Hal Ehwal Pengguna
LAB	Lead-Acid Battery
LDEV	Light Duty Electric Vehicle (2-, 3- and smaller 4-wheelers)
LIB	Lithium-Ion Battery

ABBREVIATIONS (CONTINUED..)

MAI	Malaysian Automotive Institute (also called MARII)
MGTC	Malaysia Greentech Corp
MIDA	Malaysian Investment Development Authority
MIROS	Malaysian Institute of Road Safety Research
MITI	Ministry of Investment, Trade and Industry
MMDA	Metropolitan Manila Development Authority
MOSTI	Ministry of Science, Technology and Innovation
MOT	Ministry of Transport
MS	Malaysian Standard
NEF	New Energy Finance, a research division of Bloomberg Finance L. P.
NEM	Net Energy Metering
NOSS	National Occupational Skills Standard
NTIS	National Technology and Innovation Sandbox
OEM	Original Equipment Manufacturer
PBT	Local Authorities (Pihak Berkuasa Tempatan
PCB	Printed Circuit Board
PMA	Personal Mobility Aids
PMD	Personal Mobility Devices
PPP	Purchasing Power Parity
PUV	Public Utility Vehicles
PV	Photo Voltaic (Solar electric)
RESS	Rechargeable Energy Storage System (ie. a battery)
RM	Ringgit Malaysia
RMS	Root Mean Square
SDG	Sustainable Development Goals
SE	South East
SIRIM	Standard and Industrial Research Institute of Malaysia
SLDN	National Dual Training System (Sistem Latihan Dual Nasional)
SOC	State Of Charge
SOH	State Of Health
SST	Sales and Service Tax
SUV	Sport Utility Vehicles
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Program
UNR	United Nations Regulation
USD	United State Dollar
VAC	Alternating Current Voltage
VDC	Direct Current Voltage
VIN	Vehicle Identification Number
VTA	Vehicle Type Approval
WMI	World Manufacturer Identifier
WMTC	World Motorcycle Test Cycle

APPENDIX A Malaysian Vehicle L-Categories

10. KATEGORI KENDERAAN YANG PERLU MEMBUAT PERMOHONAN VTA

Category L – Motor vehicles with less than four wheels

Category	Definition	Term	Drawing
L1	*A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm3 and whatever the means of propulsion a maximum design speed not exceeding 50 km/h.*	*Moped*	
L2	*A three-wheeled vehicle of any wheel arrangement with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm3 and whatever the means of propulsion a maximum design speed not exceeding 50 km/h.*	*Moped*	
L3	*A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm3 or whatever the means of propulsion a maximum design speed exceeding 50 km/h.*	*Motorcycle solo*	
L4	*A vehicle with three wheels asymmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of a thermic engine exceeding 50cm3 or whatever the means of propulsion a maximum design speed exceeding 50km/h(motorcycles with sidecars).*	*Motorcycle with side car*	
L5	*A vehicle with three wheels symmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of a thermic engine exceeding 50cm3 or whatever the means of propulsion a maximum design speed exceeding 50 km/h.*	*Motorcycle (tri-cycle)*	
L6	*A vehicle with four wheels whose unladen mass is not more than 350 kg, not including the mass of the batteries in case of electric vehicles, whose maximum design speed is not more than 45 km/h, and whose engine cylinder capacity does not exceed 50 cm3 for spark (positive) ignition engines, or whose maximum net power output does not exceed 4 kW in the case of other internal combustion engines, or whose maximum continuous rated power does not exceed 4 kW in the case of electric engines.* ***Class I*** *- Seats* *- Horizontally confined by a body* *- Roof and roll-over protection* *- Steered by steering wheel* *- Foot Throttle* ***Class II*** *- Saddles but no seats* *- No roof* *- Steered by handle bar* *- Hand throttle control*	*Light Quadricycle*	 

DATO' IR. HJ. MOHAMAD
KEJURUTERAAN AUTOMOTIF
P(KA)

46

APPENDIX B Battery Cycle Test Procedure

MS 2688:2018

Table 1. Test sequence cycle life

Step	Procedure	Ambient temperature
1	Thermal equilibration	RT
2	SCH	RT
3	SC	RT
4	Discharge at the test current rate until the battery voltage reaches discharge voltage limit defined by the supplier.	RT
5	Charge at the max charged rate as defined by the manufacturer to fully charged state[a].	RT
6	Repeat steps 4 to 5 until: a) the discharge capacity drops down to 80 %; or b) the number of cycles exceeds 300 (in the absence of a manufacturer defined battery life); or c) the number of cycles exceeds the manufacturer defined battery life cycles; or d) The total discharge time (in hours) times the test speed (80% of the defined maximum test speed) exceeds the manufacturers defined battery life range.	RT
7	Thermal equilibration	RT
8	SCH	RT
9	SC	RT
[a] Charging will be done using the products standard charger in the maximum current setting mode		
RT - Ambient temperature, 25 °C ± 5 °C SCH - Standard charge SC - Standard cycle		

APPENDIX C Malaysian VTA Inspection

LAMPIRAN 24

PANDUAN PERATURAN UN YANG DIKUATKUASAKAN MENGIKUT KATEGORI KENDERAAN

E52

TYPE APPROVAL OF MOTORCYCLE

L 1-7 Category

Implementation of UN Regulations based on Vehicle Category

* Generally the mentioned UN Regulations are applicable

Total of 40 UN Regulations

Environment

Noise (3-Wheeled Vehicle)	R9	1
Diesel Smoke	R24	2
Exhaust Emission	R40	3
Noise	R41	4
Exhaust Emission	R47	5
Noise (Moped)	R63	6

General Safety

EMC Compatibility	R10	7
Speedometer	R39	8
Safety Glass	R43	9
Protect Unauthorized Use	R62	10

Passive Safety

Safety-belts	R16	11
Head Restraints	R25	12

Active Safety

Retro Reflecting Device	R3	13
Direction Indicators	R6	14
Stop & End-outline Lamps	R7	15
Front Fog Lamps	R19	16
Audible Warning Devices	R28	17
Filament Lamps	R37	18
Rear Fog Lamps	R38	19
Headlamp Cleaners	R45	20
Rear-view Mirror	R46	21
Lights	R50	22
Installation of Lights	R53	23
Headlamps (Moped)	R56	24
Headlamps (M'cycle)	R57	25
Driver Operated Control	R60	26
Special Warning Lights	R65	27
Halogen Headlamps	R72	28
Installation of Lights	R74	29
Tyres	R75	30
Headlamps (Moped)	R76	31

Braking	R78	32
Rear-view Mirrors	R81	33
Halogen Headlamps (HS2)	R82	34
Day Time Running Lamps	R87	35
Replacement Brake Lining	R90	36
Gas-Discharge Headlamps	R98	37

Headlamps Asymmetrical	R112	38
Headlamps Symmetrical	R113	39
LED Light Sources	R128	40

116

APPENDIX D Compilation of various field data collected

Parking lot survey of motorcycles separated by engine type:

Parking Lot 2W Survey	4T Carb	4T INJ	2T	E2W
Aeon Alma	94	86	3	0
Lotus Alma	38	17	0	1
Mydin PB	67	57	3	3
Wet Market BS	76	21	5	3
Total	275	181	11	7

Parking lot survey of motorcycles separated by manufacturer:

ICE 2W Manufacturer	NO.
BENELLI	1
KTM	2
WMOTO	3
MODENAS 2T	3
SM	4
YAMAHA 2T	4
SUZUKI 2T	4
DEMAK	10
SUZUKI 4T	11
MODENAS 4T	28
SYM	39
YAMAHA 4T	158
HONDA	190
Total	457

Road traffic survey of all vehicles separated by number of passengers:

Road Survey	Pax per Cars							Pax per Motorcycle							Pax per Van							Lorry		
	1	2	3	4	>4	Cars	Pax	1	2	MC	Pax	Del.	Msrg.	Total	1	2	Total	Pass.	Factory	Service	Total	LD	HD	Total
Parit Buntar - Bagan serai	492	160	23	8	2	685	923	293	21	314	335	6	3	9	2	2	4	6	15	13	28	55	40	95
Bukit Tambun - Spg 4	592	94	11	4	2	703	739	237	35	272	307	73	3	76	4	3	7	10	7	30	37	86	40	126
Bagan Serai - Semanggol	447	45	11	3	0	506	582	262	44	306	350	2	0	2	3	1	4	5	0	12	12	40	10	50
Totals	1531	299	45	15	4	1894	2244	792	100	892	992	81	6	87	9	6	15	21	22	55	77	181	90	271

NOTES:

Del. = Delivery (Grab, Food Panda…)

Msgr. = Messenger (parcel delivery: Gdex, Fedex…)

Vans are private MPV vans, not “buses”

Factory = Factory worker busses (passengers not counted)
Service = Corporate Field Service Vans
LD/HD = Light Duty/Heavy Duty Truck

Petrol Station Mileage Survey (ICE 2W) "Qualified" Annual Mileage (km/year) by Year of Purchase																			
2005	2006	2007	2008				2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	1146	1604	1096				1880	1581		2044	2464	4390	3134	3868	5386	7768	19593		
	2048	3124	1595				2708	1704		2323	3030	5334	4148	3938	5528	8244	20076		
	3036	3143	1932				2743	2095		2618	3044	13371	4381	4775	6233	9079	30371		
	3139	3591	2494				2791	2487		2776	3266		4482	6047	6946	12976			
	3197	3727	3397				2833	2563		3104	3497		5142	6480	8215	15238			
	3306	4695	3556				3530	3561		3300	3673		5317	6753	8652	23045			
	4741	6700	4395				3705	4349		3575	3939		5906	7115	8662				
	4842		5966				5049	4921		4078	4121		6264	7132	9020				
			6104				5227	4994		4625	4364		6531	8447	9021				
			6162				5707	5779		4972	4533		6630	11061	9089				
			6629				5777	7129		5014	4672		6849		9959				
			6998				6221	7215		5213	4749		7153		10390				
			7177				6627	7274		5397	5178		8090		11458				
							7276	8209		5424	5651		8247		11549				
							7722	9065		5893	6055		8977		15221				
							7863			6210	6606		9093		16545				
							8045			6511	6857		9130		17317				
							8299			6678	7015		9311		19110				
							9078			6909	7105		9329		23210				
										7290	7444		9388						
										7781	7490		9794						
										8213	7519		9852						
										8339	7598		10044						
										8384	8686		10242						
										8547	9220		10863						
										9729	9464		12191						
										10020	9565		13706						
										10022	9677		13994						
										10378	10360		14163						
										10449	10471		15042						
										10832	12045		16003						
										13114			17325						
										13158									

Annual Mileages are Total Odometer reading divided by vehicle age. Obviously erroneous mileages have been eliminated.

APPENDIX E Electric Vehicle “Fuel Efficiency” Calculation

E2W ENERGY EFFICIENCY CALCULATION

Air Density	1.2	km/m3
Grav Acel	9.81	m/ss

CHARGE TO ROAD EFFICIENCY					
Stage:	Charger	Battery	Motor	Transmission	TOTAL
Efficiency High	0.95	0.95	0.95	0.9	77%
Efficiency Low	0.8	0.8	0.9	0.85	49%

VEHICLE POWER DEMAND				
	E-Scooter	E-Moto		
Total Mass	140	275	kg	(Includes rider)
Frontal Area	0.6	0.7	m2	
Crr	0.02	0.02		(Rolling Resistance)
Cd	0.7	0.6		(Aerodynamic Resistance)
Average Speed	35	55	kph	
Average Speed	9.7	15.3	m/s	
Drag Force	51.3	112.8	N	
Power	499	1723	W	(Required at wheels)
Vehicle Energy	0.499	1.723	kWh	
Mains Energy	1.02	2.23	kWh	(Vehicle E / Efficiency)
Energy Efficiency	**34.4**	**24.6**	km/kWh	

For the smaller E-Scooter we have assumed lower efficiency Charge-Road numbers typical of a lead-acid system. The E-Motorcycle is using the higher efficiency numbers characteristic of lithium battery systems.
Drag force is Mass x Gravity x Crr plus ½ x Air Density x Cd x Frontal Area x Velocity^2
Power at the wheels is Velocity times the Drag Force.

APPENDIX F Manufacturers Survey Form

UN environment programme

ELECTRIC 2 and 3 WHEELER MANUFACTURERS SURVEY

FOCUS APPLIED TECHNOLOGIES

Company: ________________ Date: ________________

Confidential: Yes No Tech: ________________

What are your vehicle specs (Speed, Power, Range, Voltage)?

What battery type, and Why:

MAIN COMPONENTS

	Battery	BMS	Motors	Controller	Frame
Local / import					
Import from					
Problems with Importation					
Cost (High/Med/Low)					

Did you have any problem with customs or any authorities to import these parts?

Did you have any issues with your suppliers? (stock shortage / late component arrival)

Are there any problems with the quality of the component bought?

How do you test the range, top speed, acceleration, battery degradation?

Are the products MS2413, 2514, 2688 Compliant? (Y / N)

Are there any issues with VTA / licensing / standards compliance?

How did you decide on the price for all of your scooters? (High end / Low end)

What are your insights on the electric 2 wheelers market?

How many vehicles have been shipped so far? [ ] How many vehicles sold per year? [ ]

What is your total production capacity? (per month/year) [ ]

Did you have any issue with workers / local resources / machines during the manufacturing process?

Major complaints / Issues from the customer?

List the 2 or 3 most important things that would make production and sales easier.

APPENDIX G Emissions Factors

In the absence of more reliable data the following emissions factors were consulted:

Fuel Consumption and Emission Factors for Different Vehicles in Asia

Vehicle distribution			Fuel Consumption L/100KM	CO_2 (kg/L)	PM (g/ Km)	NOx g/Km	KMPL	CO_2 g/ VKM
MC-two	P	Two Stroke	1.8	2.416	0.057	0.050		24.170
		Four Stroke	1.8	2.416	0.015	0.540		24.820
		NO data		2.416	0.03	0.34		24.56
MC-three	P	Two Stroke	3.5	2.416	0.045	0.200		62.410
		Four Stroke	3.5	2.416	0.015	0.530		73.800
		NO data		2.416	0.03	0.4		69.24

Taken from “Manual for Calculating Greenhouse Gas Benefits of Global Environment Facility Transportation Projects”

REFERENCES

BCG (2022) "ELECTRIFYING INDONESIA'S TWO-WHEELER INDUSTRY", Boston Consulting Group, Nov 2022

Bigazzi (2020) Bigazzi, Alexander and Wong, Kevin, "Electric bicycle mode substitution for driving, public transit, conventional cycling, and walking", Transportation Research Part D Transport and Environment 85:102412, August 2020

Gitano (2016) Gitano-Briggs, Horizon and Leong, Hau Kian "Malaysia Stocktaking Report on Sustainable Transport and Climate Change", Deutsche Gesellschaft für Internationale Zusammenarbeit, 2016

Gitano (2022) Gitano-Briggs, Horizon and Biona, Jose Bienvenido, "Policy Guidelines for Electric 2- & 3-wheelers for Southeast Asia", United Nations Environment Programme 2022

Ha (2021) Ha, Tim Ha and Manongdo, Ping "ELECTRIC VEHICLES IN THE PHILIPPINES: business opportunities, market barriers, and policy signals", Foreign Commonwealth and Development Office, British Embassy Manila, 2021

Hamzah (2021) Hamza, Azhar, "Exploring Moped Use in Malaysia", Malaysian Institute of Road Safety Research (MIROS) 2021

IESR (2023) "Indonesia Electric Vehicle Outlook 2023", Jakarta Institute for Essential Services Reform (IESR)

Sura (2022) Sura, Michal, "The most energy-efficient mode of zero-emission urban transport", Ministry of transport, Lion, Slovakia, March 2022

Lee (2010) Lee Jih Houh et. al, "Analysis of Motorcycle Fuel Consumption in Malaysia", SAE 2010

Le (2022) Le, Huong and Yang, Zifei "Market analysis of two- and three-wheeler vehicles in key ASEAN member states", ICCT 2022

Le (2022-2) Le, Huong, Posada, Francisco and Yang Zifei, "Electric two-wheeler market growth in Vietnam: An overview", ICCT 2022

Nguyen (2022) Nguyen, Minh Hanh, "Thailand Issues New Incentive Package for Electric Vehicle Industry", ASEAN Briefing 10-March 2022