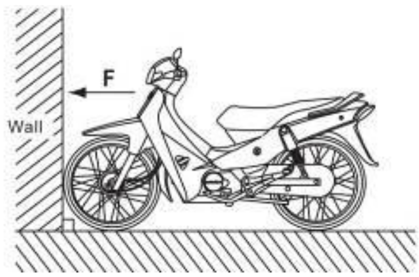
Policy Guidelines for Electric 2- & 3-wheelers for Southeast Asia



October 2020

UN environment programme

INTERNATIONAL CLIMATE INITIATIVE (IKI)

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

ABBREVIATIONS

AC	Alternating Current
ASEAN	Association of South East Asian Nations
BMU	German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety
BMS	Battery Management System
cc	Cubic Centimeter (engine displacement)
EV	Electric Vehicle
EVAM	Electric Vehicle Manufacturers Association of Malaysia
EVAP	Electric Vehicle Manufacturers Association of Philippians
EVAS	Electric Vehicle Manufacturers Association of Singapore
EVAT	Electric Vehicle Manufacturers Association of Thailand
G	9.81 m/s^2
H	Hours
HZ	Hertz (cycles per second)
ISO	International Organization for Standardization
NEF	New Energy Finance, a research division of Bloomberg Finance L. P.
MIROS	Malaysian Institute of Road Safety Research
RESS	Rechargeable Energy Storage System
RMS	Root Mean Square
SOC	State Of Charge
SOH	State Of Health
SUV	Sports Utility Vehicle
TBD	To Be Determined
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Program
USD	United States Dollar
VAC	Alternating Current Voltage
VDC	Direct Current Voltage
VTA	Vehicle Type Approval

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The development of these policy guidelines was led by Dr. Horizon Gitano-Briggs with inputs from Dr. Jose Bienvenido Biona, and Clean Air Asia. Valuable insights and technical inputs were also provided by the Electric Vehicle Associations (EVA) of Malaysia (EVAM), the Philippines (EVAP), Singapore (EVAS), Thailand (EVAT), and Vietnam. Bert Fabian of UNEP provided overall direction and guidance in developing the guidelines while Sudhir Gota provided technical review. These guidelines were developed with the support of UNEP’s Environmental Law Division and as part of an ongoing project on “Integrating Electric 2&3 wheelers in Urban Traffic in East Africa and Southeast Asia” of UNEP’s Sustainable Mobility Unit supported by the International Climate Initiative of the German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU).

1 INTRODUCTION AND BACKGROUND

UNEP is supporting low- and middle-income countries to help mainstream electric mobility and renewable energy. In Southeast Asia, UNEP has been supporting the development of cleaner and efficient fuels and vehicle policies through its global programs, the [Partnership for Cleaner Fuels and Vehicles (PCFV)]() and the [Global Fuel Economy Initiative (GFEI)](). These projects and activities have led to the adoption of vehicle emission standards and fuel quality roadmaps and adoption of fuel economy policies including revision of vehicle excise taxes to favor more efficient vehicles (including electric vehicles), fuel tax, and labeling to promote the uptake of cleaner and more efficient light-duty vehicles in many Southeast Asian countries.

However, there are limited initiatives to promote cleaner and more efficient motorized 2- & 3-wheelers included in these projects and activities. Considering the predominance and importance of 2- & 3-wheelers in Southeast Asia, UNEP developed a program to support the integration of electric 2- & 3-wheelers in transport in East Africa and Southeast Asia in 2017, with support from the International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU). UNEP is helping the Philippines, Thailand, and Vietnam in integrating electric 2- and 3-wheelers in transport. These projects support: planning and project baseline setting, including the characterization of fleets, existing policies as well as other issues such as the state of the art of the electric grid and promoting local manufacturing; and policy design and demonstration projects including stakeholder mobilization and support, and awareness-raising. In order to support a broader number of countries in the region and promote harmonization of policies, UNEP supported the development of these policy guidelines for the Association of Southeast Asia Nations (ASEAN).

The ASEAN, while they have a great diversity of culture, have an even greater degree of commonality. As ASEAN is mostly composed of relatively small countries, over the years they have often been dominated by foreign powers. ASEAN includes many islands, lush tropical countryside dotted with small villages, and modern megacities. Close to 650 million people share this mostly hot and humid environment, a large portion of which still live in relatively (by global standards) impoverished conditions (ASEAN, 2020). Many of the countries are struggling to deal with rapid population increase, and even more rapid urbanization.

In terms of transportation, Southeast Asian countries share a predominance of motorized 2-wheelers (motorcycles and mopeds) and in some countries, motorized 3-wheelers. The great majority of these vehicles are designed and built outside of the ASEAN region. The region represents 22.4% of the sales of motorcycles worldwide, with total sales of 13.75 million units in 2019, 5.3% more than in 2018.[1] Data does not yet include Myanmar, Cambodia, and Laos, where the share of motorcycles in transport is also similar to their neighbours. Figure 1 shows the estimated number of motorized 2-wheelers, increasing to about 370 million units in 2040.

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[1] ASEAN. In 2019 motorcycles sales grew 5%, booming in Singapore & Malaysia https://www.motorcyclesdata.com/2020/02/08/asean-motorcycles-industry/

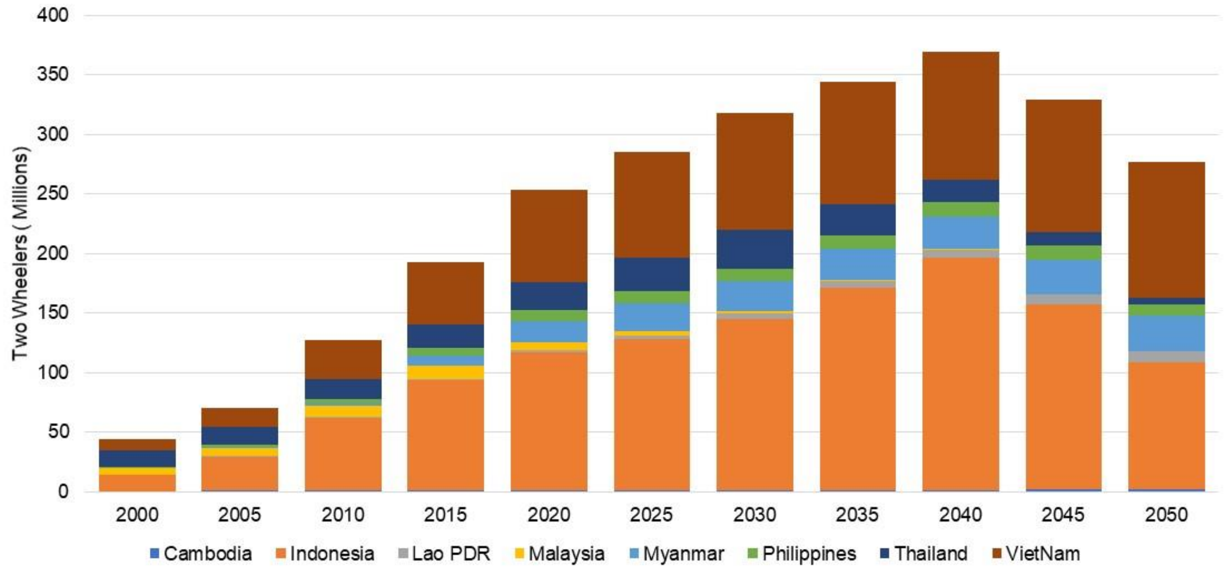

Figure 1. Growth of motorcycles and scooters in the ASEAN
Source: Data from ADB Transport Databank Model; compiled by Gota, S. (unpublished)

Motorized 2- and 3-wheelers play a variety of roles in urban transport. The figure below shows a trip typology for motorized 2- and 3-wheelers. All these types of trips are present in Southeast Asia, and there are now various models of electric bicycles, mopeds/scooters[2], and three-wheelers that are cost-competitive or less expensive than traditional combustion-powered motorcycles and mopeds.

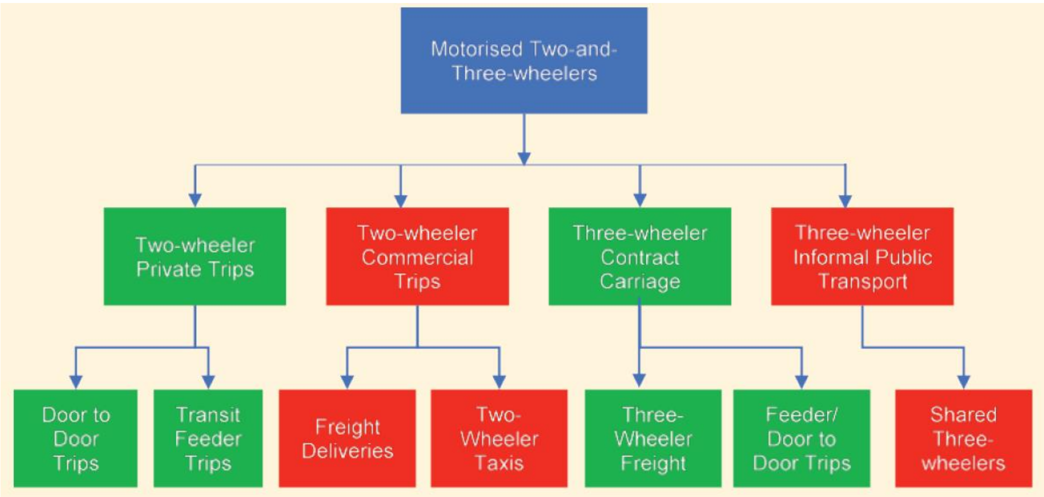

Figure 2. Motorised Two-and-Three-Wheeler Trip Typology
Source: GIZ. 2019. Two-and-Three-Wheelers: A Policy Guide to Sustainable Mobility Solutions for Motorcycles; Module 4c Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities.

In Vietnam, there are already 1.35 million registered electric 2-wheelers as of June 2020.[3] While in Malaysia and Thailand, there are 2,000 and 2,300 registered electric 2-wheelers in 2020 respectively and 3,000 in Indonesia in 2018;[4] and in the Philippines there are 4,318 registered

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[2] The terms “Scooter” and “Moped” are used interchangeably for small 2-wheelers in the 25-50 kph top speed range
[3] Vietnam National Traffic Safety Committee
[4] https://www.solidiance.com/insights/driving/infographics/is-indonesia-ready-for-electric-vehicles

electric 3-wheelers as of June 2020.[5] In each of these countries the vast majority of electric 2- and 3-wheelers remain unregistered due, in part, to the lack of governmental policy regarding these new vehicle categories. The International Energy Agency's Electric Vehicle Outlook for 2020 scenario models for 2030 shows high share of electric 2- and 3-wheelers, about 90% in China, almost 50% in India, and close to 40% for the rest of the world in their stated policies scenario (business-as-usual).[6] While in Bloomberg NEF's Electric Vehicle Outlook for 2020, 30% of the global 2- & 3-wheeler sales and 20% of the existing fleet are already electric.[7]

As many public transport systems have been closed or restricted during the COVID-19 pandemic, more people have relied on cycling and motorcycles/mopeds. As such, sales of conventional bicycles[8] have increased significantly along with sales of electric bicycles.[9] [10] This further raises the need to provide adequate policies and better facilities to support the integration of bicycles and electric bicycles in many cities.

The purpose of this document is to provide an overview of the state of electric 2- & 3-wheeler policies and standards in ASEAN and provide recommendations for harmonization and development of national policies and standards in order to ensure safety for the owners and operators of such vehicles as well as other road users, a reasonable minimum level of quality, and compatibility with existing infrastructure. Implementing these policies and standards at the regional level is intended to facilitate the adoption of clean, efficient, and affordable electric vehicles while mitigating potential hazards caused by low quality, dangerous or excessively inefficient products.

More specifically, these policy guidelines were developed to address the following:

1. The number of electric 2-3 wheelers is growing rapidly and policies and standards for these vehicles are not fully develop in most ASEAN countries
2. Harmonization of transportation regulations on a regional basis has already begun for light-duty vehicles (eg. combustion powered vehicles and fuel economy policies)
3. Apart from mainland China and India, ASEAN is a significant consumer of electric 2-3 wheelers
4. Although ASEAN makes up the 2nd largest market for these electric 2- and 3-wheelers almost 100% of these vehicles are imported
5. To provide an opportunity to harmonize standards facilitating local manufacturers' access to the greater ASEAN market
6. Within ASEAN any certified vehicle test centre or laboratory could perform conformity testing, eliminating the need to repeat the same testing in several different countries, thereby reducing costs
7. Many of the ASEAN countries have only rudimentary standards and testing organizations, and developing the standards in isolation would be a significant hardship

[5] Philippines Land Transport Office
[6] https://www.iea.org/reports/global-ev-outlook-2020
[7] https://about.bnef.com/electric-vehicle-outlook/
[8] https://www.voanews.com/economy-business/pandemic-leads-bicycle-boom-shortage-around-world
[9] https://www.economist.com/business/2020/08/01/the-pandemic-is-giving-e-bikes-a-boost
[10] https://www.theverge.com/2020/5/14/21258412/city-bike-lanes-open-streets-ebike-sales-bicyclist-pedestrian

These policy guidelines cover three main areas:

- Policies for supporting the integration of electric 2- & 3-wheelers in transport
- Technical standards on the vehicle and batteries
- Policies for regulating road usage

Rather than separately facing the challenges and opportunities provided by this new technology, we are proposing that the ASEAN countries come together and establish a workable set of common policies and standards for electric 2- and 3-wheelers. The guidelines also include technical recommendations for low-speed electric 4-wheelers and electric micromobility such as electric kick-stand mopeds, as there is an increasing use of these modes of transport in many Southeast Asian cities.

Electric Tuktuk in Bangkok, Thailand (2019)
Photo from Electric Vehicle Association of Thailand

Electric scooter store in Hanoi, Vietnam (2019)
Photo by Bert Fabian

2 CONCEPTS IN STANDARDS AND POLICY DEVELOPMENT

The small size and electrical power system of 2- and 3-wheelers makes them exceptionally efficient and clean (depending on the electrician power grid energy source), providing inexpensive mobility for people at the lower economic levels, and improving urban air quality. In formulating standards and policies to control these vehicles it is important to keep in mind that these vehicles fill an important niche for people at the bottom end of the economic ladder, and strive to strike a reasonable balance between quality, safety and cost.

There are several fundamental concepts it is important to keep in mind when developing vehicle standards. The primary purpose of standards and vehicle-focused transportation policy is to ensure safety: safety for the vehicle operators and passengers, and safety for other road users. Secondarily, standards are used to provide a reasonable minimum level of quality by eliminating from the market those products which are of such low quality that consumers are bound to find them disappointing. Another use of standards conformity testing it to ensure that products live up to their manufacturer's claims and provide consumers a fair basis for comparison between similar products. Additionally, standards are useful in providing policy guidance for vehicle licensing, registration, taxation, insurance and usage. Finally, in developing standards it is important to not

impede technological progress, therefore as much as possible standards should be performance based, and "technology blind".

Standards should reflect the appropriate local conditions: many of these vehicles are designed and built overseas with very different environmental and traffic conditions. For example, many areas in ASEAN are often inundated by floods, so it is important to confirm that this will not destroy products used in the ASEAN market. Also, in so far as is possible, standards and legislation should be data-driven: a given specification needs to be tested to determine if it is appropriate or not. If it cannot be tested, then it is better not to specify it.

Lastly, although small electric vehicles are exceptionally efficient, they should not be encouraged at the expense of non-motorized transport, or public transportation systems. Instead, policy should strive to integrate use of these vehicles in harmony with existing and future mass transit systems.

Fleet of electric 2- and 3-wheelers for the UNEP Demonstration Project with Philippine Postal Corporation in Pasig, Philippines (2020)
Photo from Clean Air Asia


Surveying Electric 2-Wheeler usage in Malaysia (2019)
Photo from MIROS

3 POLICIES TO PROMOTE INTEGRATION OF ELECTRIC 2- & 3-WHEELERS

This section provides policy recommendations in order to increase the share of electric 2- and 3-wheelers in the market, taking into consideration their integration in urban transport particularly with public transport systems. While the guidelines support the harmonization of policies and standards across ASEAN pursuant to the ASEAN Economic Community, it also recognizes the member countries' prerogative to prioritize policies and standards in accordance with their state of development and economic priorities.

3.1 Fuel economy standards or fuel consumption limits

One of the most effective policies to promote electric 2- and 3-wheelers is mandating fuel economy standards or fuel consumption limits these types of vehicles. Even electric vehicles can have their energy consumption expressed in "liters of gasoline equivalent" units for direct comparison to petrol powered vehicles. China requires fuel consumption standards for 2- and 3-wheelers based on engine size starting from less than 50cc (2L/100km) to more than 1250cc (8L/100km) for 2-wheelers and slightly higher fuel consumption standards for 3-wheelers.[11] Mandating stricter and progressive fuel consumption or fuel economy standards for motorcycles would encourage the use of electric 2- and 3-wheelers. Several countries have adopted fuel economy standards for light-duty vehicles or are in the process of developing them.[12]

3.2 Vehicle Tax Rationalization

The fundamental idea of vehicle tax rationalization is to transfer the costs, including environmental and infrastructure costs, of vehicle ownership and operation to the less efficient vehicles. Road vehicles are subject to several taxes including importation duties, sales/excise tax, as well as annual road usage or licensing/registration fees, and these can be utilized by governments in order to influence the market towards more efficient vehicles.

In order to encourage the adoption of efficient vehicles, such as the 2- and 3-wheeled electric vehicles and low-speed electric 4-wheeled vehicles referred to in this document, it is recommended to rationalize vehicle taxes and fees, reducing them on lighter and more efficient vehicles, and increasing them on larger, less-efficient ones. This is already a common practice as light-duty vehicles with bigger and more powerful engines are usually given higher excise taxes in Southeast Asian countries and should be extended to electric vehicles as well.[13]

In Thailand, the excise tax on electric motorcycles were set to 1% compared and excise tax for conventional motorcycles are based on CO_2 emissions which progressively increases as emissions of CO_2g/km increases.[14] Essentially, conventional motorcycles with bigger engines are taxed higher.

[11] https://www.transportpolicy.net/standard/china-motorcycles-fuel-consumption/
[12] https://asean.org/storage/2019/03/ASEAN-Fuel-Economy-Roadmap-FINAL.pdf
[13] https://webdev.excise.go.th/aec-law/en/compare-en-vehicle.php
[14] https://www.bangkokpost.com/business/1674440/excise-revved-for-new-levy-on-motorcycles

Vehicle licensing fees and annual road tax fees in Malaysia are similarly progressive with small motorcycles (<150cc) paying annual road tax of only 0.5 US, whereas motorcycles in the 150-200 cc range pay about 7 USD.

3.3 Insurance Rationalization

Similar to rationalization of vehicle taxes and fees, insurance rates should also be adjusted to favor lighter, lower speed vehicles, which will cause less damage to other vehicles and people on the roads, and as well as emit less air pollution. For example, it is well known that larger "Sports Utility Vehicles" (SUVs) are more than twice as likely to kill pedestrians as passenger cars (Lawrence et. al 2018). Additionally in an extensive study (Ross and Wenzel 2001) it was statistically demonstrated that passenger car occupants are 6 times as likely to die in a collision with an SUV than the occupant of the SUV, thus the heavier vehicle should rationally carry much higher insurance premiums than lighter vehicles. In general, larger, faster and heavier vehicles should be subject to much higher insurance premiums, while more efficient, smaller and slower vehicles should have their insurance premiums reduced using surplus funds from the larger vehicles. Electric 2- and 3-wheeled vehicle insurance should be lower compared to their combustion engine counterparts because of the lower externalities associated with electric vehicles.

In some cases, such as electric 2-wheelers with 25-50kph speed, it may even make sense to have universal basic insurance covered by the government using the extra funds generated from the higher premiums of the faster, heavier vehicles such as combustion engine two- and four-wheelers.

3.4 Manufacturing and Consumer Purchase Support

The larger economies in Southeast Asia particularly Indonesia, Malaysia, Philippines, Thailand, and Vietnam, have traditionally provided fiscal and non-fiscal policies to support local manufacturing and assembly of motor vehicles resulting in strong growth in recent years.[15] Many countries have vehicle manufacturing roadmaps that provide incentives, subsidies, and guidelines for companies, mostly foreign, to establish or strengthen local manufacturing and assemblies. In order to encourage the increase of electric vehicles, including electric 2- and 3-wheelers, similar or more favorable fiscal and non-fiscal support for local manufacturing should be established.

Thailand has become the leader in manufacturing motor vehicles and exports completely-built-up units to the region and world. In March 2020, Thailand announced a target to produce 250,000 electric cars, 3,000 electric buses and 53,000 electric motorcycles by 2025. The Ministry of Industry is also planning a three-year car and motorcycle trade-in scheme for buyers of electric cars and motorcycles where the state will subsidize US$475 per motorcycle from a planned budget of US$23.7 million.[16] Malaysia also updated their National Automotive Policy in February 2020 and included electric vehicles as Next Generation Vehicles (NxGV) that includes automation, however, it is not explicit what incentives and support electric 2-wheelers will receive.[17] Indonesia's Auto Industry Roadmap (Indonesia Automotive 4.0) also explicitly refers to production of electric two-wheelers and setting a phase-out plan for conventional motorcycles from 2025. The Indonesia

[15] http://investasean.asean.org/index.php/page/view/automotive
[16] https://english.nna.jp/articles/8452
[17] https://www.miti.gov.my/miti/resources/NAP%202020/NAP2020_Booklet.pdf

Automotive 4.0 roadmap also includes production targets of electric motorcycles – 10% out of 8 million units in 2020, 20% out 10million in 2025, 25% out of 12.5 million in 2030, and 30% out of 15 million in 2035.[18]

Other Southeast Asian countries are also well prepared to support local manufacturing of electric 2- & 3-wheelers. There should be a concerted effort from relevant government ministries to support research and development, local manufacturing and assemblies of these modes, as the region is poised to become a world leader in electric 2- & 3-wheeled vehicles.

Consumer subsidies for electric vehicles, where national and/or government agencies provide monetary subsidy for electric car purchase similar to China and some European countries, are not common in Southeast Asia. Most governments are not in a position to implement this scheme because of a lack of budget. In China, the impact of this scheme was not as effective as providing support for charging infrastructure. Li et. al (2020) found that "compared with consumer subsidies, investment in charging infrastructure is about four times as cost-effective in promoting EV sales." However, this is true only for electric cars in China. For electric 2-wheelers, the experience will likely be entirely different, as charging requirements for these vehicles are not as demanding as for cars.

Consumer subsidy schemes for buying electric bicycles are now widely adopted in many developed countries[19] resulting in skyrocketing sales, especially during the COVID-19 pandemic as many people switch to cycling as their primary mode of transport. ASEAN countries should also consider consumer subsidy schemes for electric-assisted bicycles, particularly with lower power vehicles with top speeds below 25kph. Targeted consumer subsidy schemes can be considered for electric mopeds and three-wheelers used for e-commerce and passenger transport.

It is noted that manufacturing support for electric bicycles are lacking or not explicitly stated in country and industry roadmaps. This is another sector that countries in the region should consider as the use of electric bicycles can support and complement non-motorized transport policies.

3.5 Urban and Public Transportation Integration

Motorcycles and 3-wheeled taxis have a significant share in traffic in many Southeast Asian cities. Many people, particularly those in low-income groups, rely on motorcycles and 3-wheelers as their main mode of transport or for last-mile connectivity. Motorcycle and 3-wheeled taxis are also the main source of livelihood for many people in Southeast Asia, both in cities and in rural areas. These modes of public transport should be properly integrated into the urban transport system, where efficiency, connectivity and safety issues are considered. There should be an assessment of the optimum number of units to be deployed in different localities to make sure operations are efficient and sustainable for drivers and clients alike. Terminals should also be strategically located and integrated with the public transport (bus and rail) system.

To encourage electric 2-wheeler users to also use public transport, parking and charging should be provided at transportation hubs such as train or bus stops. A single car parking space can be turned into 5 or more electric 2-wheeler or electric 2-wheeler taxi parking spaces. Electric 2- & 3-wheeler

[18] https://www.gaikindo.or.id/wp-content/uploads/2019/07/01.-Dirjen-Ilmate_-Sesi-Siang-GOVERNMENT-POLICY-ON-FUTURE-AUTOMOTIVE-TECHNOLOGY-GIIAS-Conference-240719.pdf
[19] https://ebikeshq.com/electric-bike-subsidies-grants-around-world/

charging facilities are not as expensive as those for cars. Supporting charging infrastructure investments in strategic areas and/or terminals of 3-wheeler or motorcycle taxis will support electrification of these vehicles and benefit the drivers, who predominantly come from the low-income sector. In commercial and government establishments, parking and charging facilities should be provided free of charge.

The demand for e-commerce has quadrupled because of the COVID-19 pandemic. Another area to encourage and support is the electrification of 2- & 3-wheeler delivery vehicles. There are many initiatives in the region like those from DHL, UNEP, etc. to promote the use of electric 2- and 3-wheelers.[20] [21]

3.6 Integration into 2- and 3-wheeler Only Infrastructure

In some countries, notably Malaysia and Indonesia, there is already extensive "Motorcycle Only" infrastructure. This infrastructure allows motorcycles to bypass dangerous intersections, use short-cuts across rivers and freeways, and sequesters them from road going automobiles. This greatly enhances the safety of these vulnerable vehicles, while also providing a big incentive for their use. Electric 2-wheelers should be allowed and encouraged to use these facilities. However, it is noted that, providing exclusive lanes for slow electric 2-wheelers and non-motorized 2-wheelers should always take precedent.

3.7 Information, Labeling, and Public Awareness

Finally, efforts should be made to encourage the use of clean and efficient vehicles via public awareness campaigns. Vehicle labeling at the time of sales, indicating the annual or lifetime cost of energy consumed by the vehicle, is a good way to allow consumers greater insight into the long-term cost savings of electric vehicles, especially when applied to combustion vehicles as well. Thailand and Vietnam already have labeling schemes for motorcycles.

"Share the Road" public awareness campaigns can also have an effect in supporting greater acceptance, and hopefully adoption of light electric 2- & 3-wheelers.

[20] https://discover.dhl.com/business/business-ethics/electric-cars
[21] https://www.unenvironment.org/explore-topics/transport/what-we-do/electric-mobility

4 PROPOSED TECHNICAL REGULATIONS AND STANDARDS

These policy recommendations apply to all 2, 3 and 4-wheeled low-speed electric vehicles with gross vehicles weights not in excess of 400kg. For a summary of the proposed regulations and standards including a partial list of current regulations by country, see Appendix 1 and 2.

Vehicles are to be classified by top speed into the following categories:

Category	**Top Speed (kph)**
Pedestrian	Less than 10
Slow	10 - 25
Low Speed	25-50
Intermediate	50-100
High Speed	Greater than 100

Table 1. Vehicle Speed Classes

In general, the specifics of the standards, road usage regulations and other policies are differentiated by vehicle speed category. The justification for using speed as a primary designator of vehicle type is that the kinetic energy and thus potential danger of a vehicle is directly related to its speed squared. Additionally, vehicles are customarily separated by speed categories (or proxies there of such as engine displacement) for road use purposes.

For example, “bicycle-class” electric 2-wheelers of speeds less than 25kph are generally allowed only on designated bicycle paths, or at the shoulder of “lower speed” roads and are often forbidden on high speed roads and highways. These bicycle-class EVs, also called electric bicycles, are often separated into pedal-assisted or throttle-assisted, where the electric motor is activated by pedaling or by a throttle, and the motor is rated at 250Watts or less. The EU and other developed regions have put in place comprehensive policies for e-bicycle usage. Essentially, for e-bicycles that have an electric motor of not more than 250Watts and speeds of up to 25kph, the restrictions are more or less the same as a regular bicycle.[22] [23]

“Pedestrian” class vehicles (<10 kph top speed) are often allowed to mix with pedestrian traffic on sidewalks. While these very low speed “pedestrian” vehicles are not the primary focus of these guidelines, it is useful to distinguish them as a separate category if only to separate them from the more road worthy vehicles of the other categories.

[22] https://www.loc.gov/law/foreign-news/article/netherlands-new-rules-pending-for-e-bikers/
[23] https://currentebikes.com/ebike-classes-california/

Small electric car, Renault Twizy (left), and low-speed 4-wheeled "scooter" (right)

These policy guidelines apply to the smaller vehicles only as the larger electric cars are covered by existing automotive policies. While these guidelines are primarily targeting 2- and 3-wheeled vehicles, some countries have opted to apply them to low-speed electric 4-wheel vehicles as well. These are distinct from “common electric cars” in that they are much lighter and often simply 4-wheeled versions of existing 3-wheeled “motorcycles”. In recent years, however, the distinctions between “electric cars” and smaller, low-speed electric 4-wheelers has become blurred with the introduction of “micro EV” cars (e.g. Renault Twizy) which are 2-seater car format vehicles intended for urban commuting.

For the purposes of the policy guidelines presented here, the 4-wheelers mentioned are “sub-micro” 4-wheeled electric vehicles, not intended to be directly comparable to cars, and significantly smaller. Thus, although we will continue to refer to motorcycle and 3-wheeled vehicles in this document, some countries may also cover some low-speed electric four-wheeled vehicles with these same guidelines. The following maximum weights are allowed by speed class:

Maximum Weight (kg)

Class	2-Wheelers	3-Wheelers	4-Wheelers
Pedestrian	40	100	N/A
Slow	40	100	200
Low Speed	60	200	350
Med. Speed	200	300	400
High Speed	400	400	400

Table 2. Maximum Vehicle Weights by Speed Class and number of Wheels

4.1 Power-to-Engine Capacity Conversion

For reference, the common electric motor power to combustion engine displacement equivalency for these categories of vehicles is: 20.1 cc = 1 kW. This may be used when accessing combustion engine equivalent regulations (MS2413 2015).

Motor power is often used as a proxy for, or in combination with, vehicle top speed as a vehicle classifier. While there is a wide range of existing regulations globally, below are the most common speed – power correlations for these light duty vehicles. It can be noticed that there is an approximate relationship between power and maximum speed: Top speed varies as the square root of the motor power at higher speeds due to the aerodynamic drag on a vehicle, which varies as the square of the vehicle speed. Additionally, larger vehicles, including those with more wheels, require more power to attain the same speeds as smaller vehicles.

	Maximum Motor Power (W)		
Top Speed (kph)	**2-Wheelers**	**3-Wheelers**	**4-Wheelers**
10	N/A	N/A	N/A
25	250	300	350
50	1,000-1,500	1,500	4,000
100	5,000	5,000	15,000
>100	Unlimited	Unlimited	Unlimited

Table 3. Vehicle Speed-Power Cross-Reference

It should be noted that electric motors can often be operated at significantly higher powers than the motors rated power for short (30 to 60 seconds) of time. In some products a motor nominally rated at 250W for example can produce over 500W for up to one minute. This is generally used for "burst" acceleration or overtaking and is limited by the vehicle's controller. Thus, it is common to classify the vehicle based on the "maximum continuous" motor power.

EUROPEAN VEHICLE CLASS CROSS REFERENCE

The European "L" vehicle categories are based on older regulations which separated "light" vehicles based on a top speed of 45 to 50 kph. With the proliferation of small electric mopeds and other light duty vehicles this has been expanded in to the various "LXe" categories. While ASEAN is not bound to follow the European categories, there is a good deal of correlation between the proposed categories and the European "L" classes. A summary of the European "L" vehicle classifications is presented here for reference only.

It does bear mentioning, however, that there have been some counter-productive results of over emphasis on strict adherence to the various categories. For example, there are two different categories for 3-wheelers including L4 (an asymmetric 3-wheeler, eg. motorcycle + side car) and L5 (symmetric 3-wheeler) where the difference may be unimportant for all practical purposes. Additionally, there was an instance in Malaysia where a special 4-wheeled category was approved for disabled people where the vehicle was a motorcycle with two rear-mounted "outrigger" wheels. An enterprising company developed a dedicated 3-wheeled motorcycle (2 rear wheels) which was a major improvement over the modified 4-wheeled motorcycle design. Unfortunately, the Malaysian government did not allow this to receive Vehicle Type Approval, as it was an "L5 vehicle".

UNECE “L Categories”

Class	2-Wheelers	3-Wheelers	4-Wheelers
Pedestrian	L1e-A	L2e	L6
Slow	L1e-A, L1e-B	L2e	L6
Low Speed	L1	L2	L6 Maximums: 45kph, 4kW, 350kg
Med. Speed	L3, L3e-A2	L4, L5	L7 Maximums: 400kg 550kg for good carrier
High Speed	L3, L3e-A3	L4, L5	L7 Maximums: 400kg 550kg for good carrier

Table 4. Proposed ASEAN classes compared to European “L” Vehicle Classes

4.2 Standard Vehicle Test Conditions

Unless otherwise specified, all vehicle testing is to be performed under the following conditions:

Wind:	Less than 3kph in any directions
Road Surface:	Smooth and flat with less than 0.5% gradient
Temperature:	Between 25C and 35C
Rider Weight:	75 +/- 5kg (use ballast weight if necessary)
Rider Posture:	Upright riding position (ie. not tucking in)
Speed Measurement:	Device should be calibrated and accurate to within 0.5kph
Rain/Fog:	Testing is not permitted on a wet surface, during rain or heavy fog
Tire Pressure:	Within 5% of stated maximum pressure, or 2bar (if not stated)
Battery SOC:	As close to full charge as possible, nominally 90-100%

5 DEFINITION OF COMMON TERMS

The following terms will be referred to in this document (MS2413 2015, MS2514 2015, MS2688 2017).

Electric 2- and 3-Wheeled Vehicles and Low-Speed Electric 4-Wheelers

For the purpose of this guideline electric 2- and 3-wheeler vehicles and low-speed electric 4-wheelers are defined as any L_1, L_2 and L_6 category vehicle with a gross weight below 400kg *(NOTE: maximum weight varies by vehicle class)* which derives its motive power primarily from electric energy stored in a traction battery. This can include hybrid vehicles, except for “mild hybrids” where the electric propulsion unit is only temporary or auxiliary to the main combustion engine. For example, an electric motorcycle with a petrol powered “range extender” consisting of a small combustion engine connected to a generator for charging the batteries is considered a hybrid

vehicle to which these standards apply. Modern motorcycles with AC Generator “idle cutoff” (e.g. Honda PCX Scooter) may be considered “mild hybrid” machines as over 90% of the propulsive power comes from the combustion engine, thus these standards do not apply to this type vehicle.

Controller
An electrical power control module supplying throttle-controlled power to the motor from the traction battery.

Battery Charger
The battery charger is the device converting mains AC line voltage to electrical power to charge the traction battery. This may be separate from the vehicle (referred to as an External Battery Charger) or fixed permanently within the body of the vehicle (Internal Battery Charger).

Battery Management System
The Battery Management System (BMS) is circuitry associated with the battery, often contained inside the battery housing, which helps control and monitor the battery during charging and/or discharging to protect the battery and vehicle.

High Voltage rechargeable electrical energy storage system (traction battery)
A high voltage traction battery is defined as any traction battery having nominal voltage higher than 60 Vdc or 30 VAC rms.

Hybrid Vehicle
A vehicle where the primary propulsion energy can be provided by electrical traction batteries and/or an internal combustion engine during normal vehicle operation.

Motor
Electrical motor(s) which convert the stored electrical power to tractive effort (motion) of the vehicle.

Traction battery
Electrical power storage system, i.e. batteries or similar device. These can be of the “open” or “closed” type as follows:

- Closed type traction battery - Any battery not venting any gases to the atmosphere.
- Open type traction battery - A liquid electrolyte type battery requiring refilling with liquid and potentially generating gas released to the atmosphere.

Rechargeable Electrical Energy Storage System (RESS)
A rechargeable energy storage system provides electric energy for electric propulsion. The RESS may include a traction battery together with additional subsystem(s) necessary for physical support, thermal management, electronic control and enclosures. In this standard the RESS will be referred to simply as a traction battery.

Removable traction battery
A removable traction battery is defined as any traction battery where the end user can remove the battery (either for storage or charging) on a daily basis without requiring special tools. In some cases, a key is required to unlock the removable battery from the frame. This is a common feature on bicycle type vehicles.

State Of Charge
The State Of Charge (SOC) is a measure of how much energy remains in the battery, being 100% at full charge, and dropping to 0% on a depleted battery. Note: Some manufacturers may limit the upper end or lower end of the SOC in order to prolong battery life (eg. Only allow charging to 90% full and discharging down to 10% full). In this case the vehicles SOC is taken to be the fractional charge between the lower and upper charge limits, thus yielding an accessible SOC from 0 to 100% regardless of the batteries' actual capacity.

State Of Health
The State Of Health (SOH) of a battery is the maximum charge capacity available as a fraction of the original charge capacity. For example, as traction batteries age, the amount of energy they can deliver per charge is reduced. When a vehicle's SOH drops to 80%, the battery can only supply 80% of the energy (eg. range) it could when it was new.

6 VEHICLE PERFORMANCE

This section covers common vehicle performance measurements.

6.1 Top Speed

As vehicles are segregated into various classes based on their maximum design speed, it is important to have an accurate measure of the vehicles top speed. Additionally, other measurements (such as range and battery life) are related to the vehicles top speed.

Vehicle top speed is to be measured on a smooth flat track under the standard test conditions, ensuring that the battery is charged to the maximum possible state of charge. Additionally, the vehicle should be in its maximum performance mode (if selectable).

Vehicle is to be driven over the test track 3 times in opposite directions, averaging the six measured maximum speed readings. This averaged speed, rounded to the nearest 0.1km/h, is to be taken as the Vehicles Top Speed for all subsequent measurements.

NOTE: The speed measurement system can be of any type, providing that it can accurately measure speed to within 0.5kph over the range of 10-100 kph.

6.2 20% Hill Climb Capability

Lacking gears, many electric 2- and 3-wheelers and low-speed electric 4-wheelers have relatively poor hill climb capabilities. As it is relatively common to experience 20% gradients in many countries (for example on hills, but also on flyovers, elevated roadway entrances, parking garages and etc.) this has been chosen as a convenient test point.

This test applies to all EVs. Slow vehicles and Pedestrian vehicles (<25kph) should be excluded if they are "pedal assist" type vehicles or included if they are Electric Only propulsion vehicles.

Test shall be performed on a well paved asphalt or concrete surface free of water or debris. The test surface shall have a slip-proof surface with a test area of 10 m in length with consistent 20% gradient. Prior to performing this test, the vehicle should be fully charged, and then operated until the SOC is reduced to 50% +/-10%.

6.3 Test method

Vehicle shall be tested with a payload mass of 75 kg for every rider/passenger as declared by the manufacturer. For example, if it allows for 2 occupants, then the total payload mass should be 150kg above that of the vehicle.

- Use the lowest gear and highest performance setting (if selectable) to conduct the test.
- Vehicle shall be placed facing up the test slope and held in position by the braking system at the beginning of the 10 m section.
- The throttle should be opened as the brakes are simultaneously released.
- Any reverse motion of the vehicle shall be recorded as the 'roll-back' distance.
- The vehicle shall then accelerate forward passing the 10 m test section.
- Time to traverse the 10 m section shall be recorded.

The vehicle is considered to have failed the test if any of the following conditions occur:

a) the vehicle rolls back more than 0.15 m before accelerating forward
b) the vehicle fails to accelerate forward
c) the vehicle moves so slowly that the rider is required to place his feet on the ground to stabilize the vehicle within the 10 m test section
d) the total time from application of throttle to passing the 10 m mark exceeds 10 seconds

6.4 Braking distances

Braking distance is an important safety aspect of any moving vehicle. In larger vehicles this is tested according to standard automotive practices. For smaller vehicles the following procedure is suggested (MS2688 2017).

The following procedures apply to slow, low-speed class vehicles. For Medium and High-Speed vehicles brake testing is done via the ECER78 (Interregs 2020).

Prior to any braking tests the brakes should be "burnished" by performing repeated hard braking in the following manner:

- Accelerate the vehicle to maximum speed.
- Release the throttle and apply all brakes firmly so as to decelerate as quickly as possible without wheel slip.
- Decelerate to a complete stop.
- Repeat the above deceleration cycle 20 times.

6.4.1 Dry Braking Test Procedure

The vehicles wheels and brakes should be completely dry for the dry braking test. The break surface temperature should be cooled to below 100C before performing the brake test. The test surface should be dry, clean concrete or asphalt similar to a well paved national road surface.

From a consistent velocity of 20 km/h the throttle should be released, and the brakes should be firmly applied simultaneously until the vehicle comes to a full stop without causing wheel slip. The distance from the start of braking to the final stopping point is to be recorded as the dry stopping distance.

This procedure should be repeated 5 times.

If the vehicle experiences excessive lateral path deviation (eg. side skidding) of more than 0.5 m or the wheel significantly slips (skids), then the individual braking test is to be considered invalid and repeated.

If any of five dry stopping distances exceeds **3.5 m** it is considered failed.

6.4.2 Wet Braking Test Procedure

The brakes should be “burnished” as stated above. Prior to wet brake testing the brake temperature should be below 100C. The test surface should be dry, clean concrete or asphalt similar to a well paved national road surface. The intention of this test is to confirm that the brakes do not fail catastrophically when wet. Thus, the road surface may become somewhat wet during the testing (from water splash from the vehicle), however it need not be inundated.

The vehicles wheels, brakes and hubs should be wet via spraying with water at the beginning of each wet braking test.

Water should be sprayed from two separate hoses, one from the left, and one from the right side of the vehicle onto the wheels, rims and hub for a period of 5 min prior to the test, being sure to inundate the brake mechanism. The intention of this water spray is to simulate heavy rain and flood fording on the braking gear wheels and tires only. It is therefore not necessary to completely flood the rest of the vehicle (seat, motor, instrument panel, etc.) for this test.

The flow rate of the hoses should be at least 30 L/min.

Water spray should be continued through out the duration of the test up to the point of brake application.

From a consistent velocity of 20 km/h the throttle should be closed, and the brakes should be fully applied simultaneously until the vehicle comes to a full stop. The distance from the start of braking to the final stopping point is to be recorded as the wet stopping distance.

This procedure should be repeated 5 times, making sure to re-wet the wheels of the vehicle between repetitions as performed above.

If the vehicle experiences excessive lateral path deviation (eg. side skidding) of more than ±0.5m the individual braking test is to be considered invalid and repeated.

If any of the five wet vehicle stopping distance exceeds **5.25 m** it is considered failed.

6.5 *Initial Maximum Achievable Range*

Vehicle range is a very important consumer quality aspect. Verifying the actual range is important, and this measurement is also used to establish the batteries capacity degradation in subsequent tests.

The vehicle should be tested for Initial Range after assessing the maximum speed and being fully recharged. The vehicle should be driven at a constant speed of 80% of the vehicles maximum speed (as measured previously) until the SOC reaches 0%, the vehicle stops, or a display indication shows that the vehicle should be stopped and recharged. This defines the end of the test. The range in kilometers from the beginning of the test to the end of the test is measured and recorded as the vehicles “Initial Range”.

The minimum range requirements for the various classes are as follows:

Category	**Minimum Range (km)**
Pedestrian	10
Slow	25
Low Speed	45
Intermediate	60
High Speed	80

Table 5. Minimum Range by Speed Class

Failure to achieve the minimum stated range results in failure of the test.

6.6 *Number of Battery Cycles (capable of 80% of specified range)*

Battery life is one of the major customer quality aspects and has been shown to be one of the biggest sources of customer complaints (MIROS 2019). With conventional vehicles the range of the vehicle (how far it can be driven on a full tank of fuel) is essentially constant over the life of the

vehicle. With EVs, however, the battery degrades, reducing the range of the vehicle (per charge) over time. While the actual degradation will vary widely based on individual user behaviors, and the environment, a standard test has been developed to determine the standard battery degradation. Generally, a battery is considered to be at the end of its useful life for an EV when its capacity drops to 80% of the initial capacity. Additionally, a minimum number of 300 charge-discharge cycles has been selected as a lower limit to the battery life. This allows well designed systems using a wide range of battery chemistries (including lead-acid). Poorly designed, or over stressed systems, however, are likely to fail this limit.

This test takes place on the traction battery, BMS and Battery Charger provided with the vehicle. During testing the battery should be maintained in an environmental temperature of 30C +/- 5C.

First the average current draw from the battery is measured during road operation at 80% of the previously defined maximum speed. This is referred to as the ***Test Current***.

The fully charged battery is discharged at the **Test Current** until any one of the following occurs:

1) The battery can no longer supply at least 98% of the test current
2) The BMS shuts down battery output
3) The on-board SOC indication system indicates that the battery is low and must be charged

This is considered the end of this cycle’s battery discharge.

NOTE: Generally, this test will require a system to actively control the discharge current due to the fact that as the battery discharges, its terminal voltage will drop, thus reducing the actual current draw from a constant load.

The time from start of discharge to end of discharge is measured as the individual cycle's test duration. This measurement should be recorded for conversion to kilometers of range.

Once discharged the battery is allowed to dwell (rest unloaded) for 30 minutes, and then re-charged with the vehicle's supplied charger at the maximum charging current available until it indicates that it is full. Again, the battery is allowed to dwell for 30 minutes. The above discharge cycle is then repeated.

The battery charge-discharge cycles are repeated until the average of the most recent 3 test cycle durations fall below 80% of the first cycle’s duration. The batteries life cycle is then defined as 2^{nd} from last cycle number (ie. one less than the final cycle).

The vehicle fails the Battery Life cycle test if the measured Battery Life Cycle is less than 300 cycles, or less than the vehicle manufacturer's stated life cycle (but more than 300). If the battery cycles exceed 300 but do not meet the manufacturers stated life cycles, the manufacturer must reduce their stated life cycle to below the measured figure.

If a manufacturer defines the batteries life span in kilometers (rather than cycles), the measured Battery Life Cycle can be converted to kilometers by multiplying the total discharge time (in hours) times 80% of the vehicles maximum speed (ie. the test speed). If the vehicle fails to achieve the manufacturer’s stated total range, but exceeds the 300-cycle limit, then the manufacturer must reduce their stated total range to below the measured figure.

7 MECHANICAL SAFETY

EVs may be used in a number of modes, including an “idle” mode where accessories (such as lights) are operable, but the vehicle is not capable of motion. The specified key-switch operation is intended to prevent accidental actuation (motion) of the vehicle.

A key system is required to start and operate the vehicle. The key system shall allow for three modes of operation as shown in Table 6. The use of another switch to change the mode from ON to RUN is also allowed.

Mode	Operation
OFF	Vehicle is disabled, and the motors may not be actuated.
ON	Vehicle has power to accessories and display, but the motors are not active.
RUN	Motors are armed, and when the throttle is actuated the motors will operate unless overridden by other safety features (i.e. side stand deployment or overload condition).

Table 6. Modes of operation for key system

To enter the RUN mode, the vehicle shall first be placed in the ON mode by means of the key/switch. A separate action of the key/switch is required to enter the RUN mode. This is to prevent accidental entry directly into the RUN mode from the OFF mode.

The vehicle may only be taken out of RUN mode by means of the key/switch which can either return it to the ON mode or the OFF mode. The key/switch shall then be deliberately actuated in order to return to the RUN.

Whenever in the drive mode, the vehicle should have clear signal to indicate that the vehicle is ready to move.

For any vehicle having a side stand, when the side stand is engaged, the drive mode shall be automatically disabled as long as the side stand is deployed.

For any vehicle with front wheel drive with side stand or center stand, the drive mode shall be automatically disabled as long as either stand is deployed.

8 ENVIRONMENTAL ROBUSTNESS

8.1 Tropical Rain Test

Southeast Asia experiences periods of heavy rain. Thus, the Tropical Rain test has been designed to ensure that the vehicle will remain fully functional after exposure to heavy rain.

The requirements for tropical rain resistance test shall be as follows:

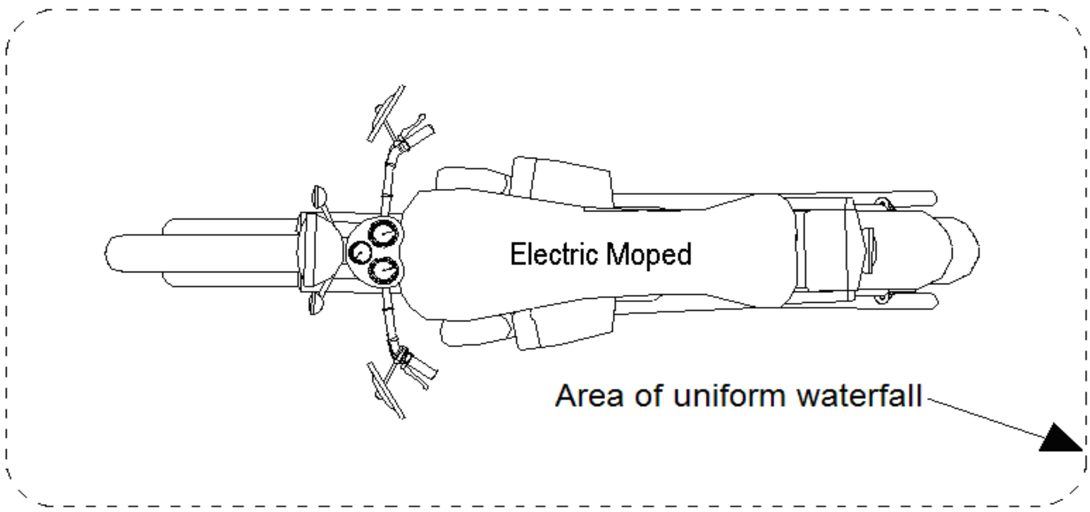
a) Place test vehicle in upright position, inside the test chamber
b) Water shall be sprayed uniformly over the vehicle at a flow rate of at least 25 cm/h as measured by standard rainfall measurement method
c) Water temperature shall be between 20ºC to 35 ºC
d) Test shall be carried out for a total of 8 hours

The test procedure shall be as follows:

a) Before the water spray test is conducted, the vehicle shall be operated unloaded with chassis suspended and all powered wheels in air, and free running at a wheel speed of 80 % of max speed continuously for ½ hour.
b) The vehicle is then powered off, and the water spray system is turned on. After 7 hours of water spray the vehicle is again powered on and operated for 1 hour, unloaded, at a wheel speed of 80 % of max speed. Water spray is continued during this final hour.
c) Upon conclusion of 8 hours of water spray, the water is to be shut off
d) Remove the vehicle from the water spray chamber
e) The insulation should now be tested. The test area can be wiped with a cloth to remove surface water.

During and upon completion of 8-hour testing:

All meters, switches, motor, controller, lights shall function as per normal
The vehicle operator shall not receive electrical shocks from operation of the vehicle
Insulation Resistance measurement should be greater than 250 ohms



Water soak test chamber

8.2 Flood Fording

Similar to the above, flooding is a common problem in Southeast Asian countries. The Flood Fording test has been designed to ensure that EV products can pass through a minimum level of flooding without malfunctioning.

Vehicle is to be driven by a driver of 75 kg ± 5 kg weight at a speed of 7.5km/h to 12.5km/h speed through a minimum of 20 cm deep water for a distance of at least 50m. During and upon completion of the flood fording test:

a) all electrical items shall function as per normal
b) all functional items i.e. meter, switches, motor, controller, lights shall function as per normal
c) the vehicle shall pass the insulation test of >250ohms
d) the vehicle operator shall not receive electrical shocks from operation of the vehicle
e) the vehicle shall then be ridden at 80 % of max speed for an additional 30 min
f) the vehicle is considered failed if it cannot function normally during any of the above testing.

8.3 Mechanical Shock and Vibrations

8.3.1 Vibration test

Mechanical vibration tests are intended to ensure a roadworthy mechanical design of the frame and mounting of components on the vehicle. This test does, however, require a large, high-power vibration table.

During vibration testing of the vehicle the whole vehicle is mounted to the vibrational actuator at the wheel axle locations. Additional supports may be used to prevent the vehicle from falling over if required (e.g. a lateral support at the seat post). The vehicle shall be mounted on an appropriate shake table and subjected to an 8Hz to 100Hz "swept sine" vibration test of 3 G in the axis specified in the table below.

Time	Direction
4 h	"Z" direction (vertical)
2 h	"Y" direction (lateral)
2 h	"X" direction (front-back)

Table 7. Vibration Test Orientation and Duration

8.3.2 Drop Test

The vehicle drop test is a simplified mechanical test intended to ensure that the major frame components tires, and rims can withstand expected mechanical shocks.

The vehicle shall be loaded with the nominal load distributed around the frame of the vehicle in a realistic manner. For example, "bicycle class" vehicles should have the standard rider weight of 75 kg mounted on the seat handle bars and foot pegs. The vehicle is then to be raised to a height

50cm from the ground (giving an impact velocity of approximately 3.13 m/s independent of vehicle weight) and then dropped to free fall vertically straight down on to a concrete floor, such that it lands on its wheels, and is prevented from falling on its side. This test shall be performed a total of 6 times.

Failure criteria for vibration test and drop test

After the vibration test and drop test, the vehicle shall be tested for full functionality including all systems and visually inspected for evidence of cracks or deformation. The mechanical test is considered failed if any of the following occurs:

- obvious deformation or damage to the rims, frame or battery pack
- failure to perform normal functions in post test usage
- wheelbase deformation in excess of 4.0 mm.

8.3.3 Knock-Over Test

The knock-over test is intended to ensure that the battery and major components are securely fastened in the vehicles frame, and do not shift or leak during vehicle roll over.

The vehicle should be fully charged before the knock-over testing. From an initially upright position the vehicle should be tilted to the left side until it rolls over onto its side. It should be allowed to roll onto its side without restraint. The vehicle is then righted, and the test repeated on the right side. This test is performed twice per side.

Finally, the vehicle is completely inverted (placed upside down). In this case the vehicle should be steadied to prevent accidental rollover to either side.

The traction battery and its components should be installed in the vehicle so that they do not become free, break or leak during vehicle knock-over or inversion.

Test Failure Criterion

- If the battery becomes lose, leaks or vents gas the test is considered failed.
- If the vehicle can no longer perform normally after the test (excluding things such as turn indicators which may have been damaged in the rollover test) it is considered failed
- Some minor superficial damage may occur (scratching, broken plastic body panels and etc.), however this is not considered a test failure as long as the electrical safety, braking systems and propulsion systems are still functional.

9 ELECTRICAL SAFETY

Voltage Classification
For the purpose of these tests, vehicles are separated in to the following voltage classes:
Low Voltage: Nominal System Voltage of <60VDC or <30VAC
High Voltage: Nominal System Voltage of >60VDC or >30VAC

9.1 Insulation Resistance

Insulation tests are performed to ensure the vehicle has sufficient electrical insulation in order to prevent shocks, or other electrical hazards. Dry primary insulation should have a resistance of greater than 1M ohm. When performing insulation tests on a vehicle subject to water spray (in the rain or flood fording tests), the insulation should have a resistance of greater than 250 ohms.

9.2 Hi-pot test

The High Potential test should take place under the following conditions:

a) temperature shall be at 25 ºC ± 5 ºC;
b) humidity shall be within 85 % to 100 %; and
c) pressure shall be within 86 kPa to 106 kPa.

Any electrical components that are likely to be damaged due to high pot test shall be removed before the test is carried out. Traction battery shall be removed prior to testing.

- For Low Voltage vehicles, perform the Hi-pot test at 500V.
- High Voltage vehicles perform the hi-pot test at 1500V for primary insulation, 4000V for secondary insulation.
- Test the vehicle using 50 Hz to 60 Hz at the proscribed voltage AC voltage for 1 min.
- The high pot test leakage current shall be below 100 mA. If it is greater than 100mA, the vehicle fails the Hi-pot test.

9.3 Electrical Safety: Overload Protection

The vehicle must have "overload cutoff protection" to avoid running dangerously high currents to the motor when stalled. To test this, the drive motor(s) of the vehicle must be stalled, by either restraining the vehicle (ie. preventing motion of the vehicle by blocking the wheels) or by locking the drive wheels to prevent them from spinning.

With the vehicle powered on, open the throttle fully, and confirm that the vehicle initially sends current to the motors. This can be evidenced by humming noise and slight motion of the drive wheels. The throttle is to be held open for 30 seconds. The vehicle must cut off current to the motors in less than 5 seconds. After the test, when the wheels are allowed to move, the vehicle should return to normal operation.

If the current to the motors continues for more then 5 seconds when wheels are stalled, the vehicle fails the test.
If the vehicle no longer performs normally after the test, then it fails the test.

9.4 Electrical Safety: Shorting

This is a part of the UNR136 focused on the traction battery (Cho, 2016). Inclusion of this test is TBD.

9.5 Electrical Safety: overcharging

This is a part of the UNR136 focused on the traction battery. Inclusion of this test is TBD.

9.6 Electrical Safety: over discharging

This is a part of the UNR136 focused on the traction battery. Inclusion of this test is TBD.

9.7 Electrical Safety: maximum mains charge current

With the standard charger operating at the highest charging current (if selectable) on a depleted battery the current draw from the mains must be below 10A. This is to prevent overloading of the electrical mains wiring in residences and other casual charging points.

9.8 Charger Ingress Protection

For vehicles with external chargers:
The charger must have an Ingress Protection rating of IP45 or higher or must be labeled “For Indoor Use Only” to prevent electrical shock hazard in case of rain/water splash.

For vehicles with Internal chargers (permanently fixed inside the body of the vehicle) the charger must have an IP rating of IP45 or higher.

10 STANDARD VEHICLE ACCESSORIES

10.1 Lights (Headlight, Tail-Light, Turn indicators)

The required lighting depends on the speed class of the vehicle as follows:

SLOW	As per ISO 6742-2 (ISO 6742 2015). Rear reflectors shall be red in color
LOW SPEED	As per ISO 6742-2 (ISO 6742 2015). Rear reflectors shall be red in color
MEDIUM SPEED	ISO 10604 (ISO 10604 1993)
HIGH SPEED	ISO 10604

10.2 Audio Device (HORN)

All vehicles are required to have an audible warning device such as a bell or horn enough for warning others when the vehicle is approaching.

10.3 Noise Device

"Slow" Vehicles (<25 kph top speed) are not required to have any noise making devices. Low, Medium and High-Speed vehicles are required to have a noise making device operating at low speeds. The device should emit a modulated tone (not a constant frequency) of at least 70dB when operating at speeds below 40kph. This is to provide an audible queue to others that there is a moving vehicle in their vicinity.

10.4 LABELING: EV

Electric Vehicles should be clearly labeled as an EV for emergency responders. The size of the label should be appropriate for the vehicle type, with bicycle type vehicles requiring a 25mm sized symbol, and larger vehicles requiring a label up to 100mm.

Malaysian Light Duty EV Standard Label

10.5 LABELING: HIGH VOLTAGE

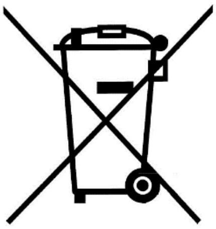
For vehicles with high voltage traction batteries, they must have an appropriate high voltage label displayed prominently on the protective cover for access to the traction battery or associated electronics.

High voltage warning

Background is yellow with black frame and signage as per ISO 3864 (ISO 3864 2011).

10.6 LABELING: BATTERY RECYCLING

If the materials in the traction battery are classified as scheduled waste (for example if they contain Cadmium, Lead or other heavy metals), then it shall be labeled as such with the statement "This battery must be returned to the manufacturer or importer for recycling or disposal" and the battery shall be clearly labeled with the "Separate Collection Symbol" as shown below.



Separate collection symbol

10.7 Vehicle Identification Number

All vehicles with a top speed of greater than 25kph (e.g. Intermediate and High-Speed Electric 2- and 3-wheelers) require a unique Motor Vehicle Identification Number in compliance with international standard ISO 3779 for vehicle tracking and registration purposes (ISO3779 2009).

11 ELECTROMAGNETIC COMPATIBILITY

To ensure that the light-duty electric 2- and 3-wheelers do not cause undue interference with existing electronic and telecommunication devices their electro-magnetic emissions must be below the stated limits. Additionally, electromagnetic radiation from external devices must not cause the vehicle to perform unexpectedly. While these are very common industrial tests, the equipment and facilities are fairly large and expensive. A good explanation is available in Rodriguez (see references).

11.1 Electromagnetic Emissions

Electromagnetic emission from the electric motorcycle shall comply with broadband and narrow band limits as shown in Tables 8 and 9. In the 30 MHz to 1 GHz frequency range, the vehicle shall comply with both:

a) broadband limit when the vehicle is in “motor running” and “charging” mode; and
b) narrow band limit when the vehicle is in “key-on, motor off” mode.

Frequency range (MHz)	**Broadband** dB (µV)	**Narrow band** dB (µV)	**Test method**
30 to 75	32	22	CISPR 12
75 to 400	32 to 43	22 to 33	CISPR 12
400 to 1 000	43	33	CISPR 12
NOTE. The limits increase linearly with logarithm of the frequency in the range of 75 MHz to 400 MHz.			

Table 8. Limits for radiated disturbance at a measuring distance of 10 m ± 0.2 m

Frequency range (MHz)	**Broadband** dB (µV)	**Narrow band** dB (µV)	**Test method**
30 to 75	42	32	CISPR 12
75 to 400	42 to 53	32 to 43	CISPR 12
400 to 1 000	53	43	CISPR 12
NOTE. The limits increase linearly with logarithm of the frequency in the range of 75 MHz to 400 MHz.			

Table 9. Limits for radiated disturbance at a measuring distance of 3 m ± 0.05 m

11.2 Low voltage AC or DC supply mains port emission measurement

During charging from the AC or DC mains supply the vehicle and charger shall be subject to the following emissions limits:

No	Environmental phenomenon	Test spec	Basic standard
1.	Emission of harmonics generated on AC power lines	Class A	MS IEC 61000-3-2
2.	Emission of voltage changes, voltage fluctuations and flicker on AC power lines	Class A	MS IEC 61000-3-3
3.	Emission of radio frequency conducted disturbances on AC or DC power lines	Class B	MS CISPR 22
4.	Emission of radio frequency conducted disturbances on network and telecommunication access from vehicles	Class B	MS CISPR 22

Table 10. Emission test - For traction battery charging mode coupled to the power grid

11.3 Vehicle immunity test

Vehicle shall be unladen condition except for necessary test equipment. All equipment which can be switched on permanently by the driver should be in normal operation.

Environmental phenomenon	**Typical test specification** (for the latest specification refer to basic standard in this table)	Basic standard
Radiated electromagnetic immunity test Vehicle mode during test: a) engine-running mode (50 km/h with no load); and b) key-on, engine off with brake-on.	30 V/m 80 MHz to 800 MHz AM 80 % 1 kHz	ISO 11451-2
	30 V/m 800 MHz to 2 000 MHz PM; t on 577 µs, period 4 600 µs	ISO 11451-2

Table 11. Immunity test on "motor-running" mode

Environmental phenomenon	Typical test specification	Basic standard
Immunity of vehicles to electrical fast transient / burst disturbances along AC or DC power lines	± 2 kV 5 kHz 1 min duration	MS IEC 61000-4-4
Immunity of vehicles to surge conducted along AC or DC power lines	1.2/50 µs (8/20 µs) AC = ± 2 kV, ±1 kV DC = ± 0.5 kV	MS IEC 61000-4-5
Immunity of vehicles to RF conducted immunity test along AC or DC power lines	3 V_{rms} 150 kHz to 80 MHz 1 kHz 80 % AM	MS IEC 61000-4-6
Immunity of vehicles to electrostatic discharge test	±4 kV contact discharge ±8 kV air discharge	MS IEC 61000-4-2
Radiated electromagnetic immunity test. Vehicle at charging mode during test	30 V/m 80 % AM 1 kHz 80 MHz to 2 000 MHz	ISO 11451-2
	30 V/m 800 MHz to 2 000 MHz PM; t on 577 µs, period 4 600 µs	ISO 11451-2

Table 12. Immunity test - For traction battery charging mode coupled to the power grid

Test Pass/Fail Criteria
A vehicle is deemed to fulfill the requisite immunity conditions if, during the tests carried out in the manner required by this clause, none failure criteria listed in Tables 13, 14 and 15 occurs.

Test condition	Failure criteria
Vehicle speed is 80 % of max speed. If the vehicle is equipped with a cruise control system, it shall be operational.	Speed variation greater than ± 10 % of the nominal speed. In case of automatic gearbox: change of gear ratio inducing a speed variation greater than ± 10 % of the nominal speed.
Dimmed beams ON (manual mode)	Lighting OFF
Direction indicator on driver's side ON	Frequency change (lower than 0.75 Hz or greater than 2.25 Hz). Duty cycle change (lower than 25 % or greater than 75 %).
Alarm unset	Unexpected activation of alarm
Horn OFF	Unexpected activation of horn

Table 13. Failure criteria for 80 % of max speed cycle vehicle test conditions

Test conditions	Failure criteria
To be defined in brake cycle test plan. This shall include operation of the brake pedal (unless there are technical reasons not to do so) but not necessarily an anti-lock brake system action.	Stop lights inactivated during cycle brake warning light ON with loss of function. Unexpected activation

Table 14. Failure criteria for key-on, motor off with brake-on vehicle test conditions

Test conditions	Failure criteria
The traction battery shall be in charging mode.	Vehicle sets in motion, or wheels begin to spin without throttle application

Table 15. Failure criteria for traction battery in charging mode vehicle test conditions

12 INTEROPERABILITY OF BATTERIES

12.1 Battery charger

One of the great advantages of these small electric vehicles is that they can be charged from standard AC Mains power outlets, whereas most electric cars and larger vehicles require special charging stations. Additionally, many of the smallest electric 2- and 3-wheelers have removable batteries which can safely be charged in the owner’s place of residence. All battery chargers for connection to standard outlets should be compatible with 56-60Hz, 220-240VAC, with a current draw of no more than 10A. For higher current chargers the preferred connector type (TBD) is to be selected by the ASEAN Electric Vehicle Manufacturers Association. For vehicles with non-removable batteries the chargers should have the appropriate water ingress (IP) protection rating for outdoor use.

12.2 Removable Batteries and Battery Swapping

In urban settings where charging facilities are not available at vehicle parking places, removable batteries have the advantage of allowing owners to charge the batteries in their own apartments. This, however, limits the maximum size and weight to around 5 to 10 kilos. With removable battery designs comes the possibility of battery swapping. Swappable batteries have the advantage of eliminating the battery recharge time as a serious constraint as exhausted batteries can be quickly changed for fully charged batteries, either with user owned batteries, or from commercial battery recharging stations.

Regulating swappable battery design will be crucial to ensure interoperability of the batteries among the various vehicles within the ASEAN region. Failure to regulate this early on may result in multiple incompatible systems, or systems patented by foreign bodies, disallowing local production of batteries, charging stations or even vehicles capable of using existing swappable batteries.

In the future, internationally compatible battery swapping formats will be required for vehicles with swappable batteries.

13 VEHICLE USE POLICY RECOMMENDATIONS

The following are recommended policies for the various vehicle speed classes.

13.1 Road Usage

Generally, “pedestrian” and “slow” vehicles will be restricted to off-road use only. This includes bicycle paths but may also include sidewalks. Vehicles capable of speeds in excess of 50kph may be allowed on all roads, or, in some countries, all roads except expressways.

Class	Road Usage
Pedestrian (<10kph)	Off Road Only (Bike Paths, Sidewalks, which allow lower speeds)
Slow (10-25kph)	Low Speed Roads (Urban, Residential)
Low Speed (25-50kph)	Low Speed Roads (Urban, Residential)
Medium Speed (50-100kph)	All (Some countries prohibit Expressways)
High Speed (>100kph)	All roads

13.2 Vehicle Registration

It is recommended that all *road going* vehicles (ie. those capable of speeds in excess of 25kph which may be operated on roads) have registered license plate numbers. For the “Low-Speed” category it is further recommended that these have a unique license plate allowing police to easily identify them as low-speed vehicles.

Class	Vehicle Registration Requirement
Pedestrian	Not necessary; Decided by Local Authority (City)
Slow	Not necessary; Decided by Local Authority (City)
Low Speed	Yes: Requires “Low Speed” plate number
Medium Speed	Yes: Requires standard plate number
High Speed	Yes: Requires standard plate number

13.3 Operator (driver) Age Requirement

Although enforcement of age limits on vehicle operators is very difficult in the absence of licensing, below are the recommended minimum driver ages, based on typical global standards.

Class	Minimum Driver Age
Pedestrian	No limit – 14 years
Slow	14 – 16 years[24]
Low Speed	16 years (or minimum national drivers licence age limit)
Medium Speed	As per drivers’ licence
High Speed	As per drivers’ licence

13.4 Operator (driver) Licensing

It is recommended that operators (drivers) of all road going vehicles be licensed to ensure safe operation.

Class	Operators Driver Licence Requirement
Pedestrian	Not Required
Slow	Not Required
Low Speed	Recommended
Medium Speed	Yes: Standard Drivers Licence
High Speed	Yes: Standard Drivers Licence

13.5 Safety Equipment

It is recommended that operators be required to use the appropriate safety equipment on all road going vehicles. Generally, the slow vehicle class is left up to local authorities to decide, while

[24] https://easyebiking.com/what-age-ride-electric-bike/

vehicles traveling in excess of 25kph require riders to wear appropriate safety helmets.

Class	Safety Equipment Required
Pedestrian	Decided by Local Authority (City)
Slow	Yes: Helmet
Low Speed	Yes: Helmet
Medium Speed	Yes: Helmet
High Speed	Yes: Helmet, closed shoes

13.6 Vehicle Insurance

For countries requiring motor vehicle insurance it is recommended that the medium and high-speed electric 2 and 3-wheelers and be subjected to similar requirements. For engine displacement-based insurance rates a conversion of 20cc to 1kW engine power should be used. Furthermore, due to the low cost and high efficiency of the low-speed electric 2 and 3-wheelers (<50kph top speed) it is recommended that this class of vehicle only require a one-time fee for a government provided basic insurance policy. This is to encourage their use, while providing a basic level of protection to the users.

Class	Insurance Requirement
Pedestrian	Not required; Decided by Local Authority (City)
Slow	Not required; Decided by Local Authority (City)
Low Speed	Recommended: 1-time fee, government policy
Medium Speed	Yes: standard similar to motorcycle insurance
High Speed	Yes: standard similar to motorcycle insurance

13.7 Annual Road Tax

For countries requiring annual road tax, again it is recommended that the <25kph vehicles, being largely off-road, be exempt from road tax, while the slow-speed (25-50kph) vehicles be subject to a relatively low one time fee to cover administration costs associated with their registration.

Class	Annual Road Tax
Pedestrian	Nor Required
Slow	Not Required
Low Speed	One-time fee at registration (eg. 5 USD)
Medium Speed	As per standard motorcycle tax
High Speed	As per standard motorcycle tax

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APPENDIX 1

Proposed Electric 2- and 3-Wheelers Vehicle Standards in the ASEAN

PROPOSED ASEAN STANDARD				
2 Wheeler Terminology:	**Bicycle**	**Moped**	**Motorcycle**	**Superbike**
3-4 Wheeler Terminology:	**Low-Speed**	**Low Speed**	**Intermediate**	**Highway**
Vehicle Performance				
Top Speed (kph)	25	25-50	50-100	>100
Minimum Range (km)	25	45	60	80
Hill Climb Capability (%)	0	20	20	20
Number of Battery Life Cycles (cycles)	300	300	300	300
Breaking distances (wet and dry)	20 kph: 3.5/5.25m	Per standard Motorcycle		
Environmental Robustness				
Tropical Rain Test (25cm/hour)	7 hour (non-op) + 1 hour operation			
Flood Fording	20cmx50m			
Mechanical Shock and Vibrations	Stairs, bump track, 3g 10-1000Hz			
Drop Test	0.5m 6x			
Knock-Over Test	2 x each side + Inversion (1x)			
Battery Specific	Some parts of UNR 136 adopted			
Electrical Safety				
Insulation Resistance (Wet and Dry)	250/1M	250/1M	250/1M	250/1M
Internal Voltage Safety (Shorting, Overload Protection, BMS cutoff)	Automatic via BMS			
Charger Ingress Protection	IP45			
Standard Vehicle Accessories				
Lights (Headlight, Tail-Light, Turn indicators)	Per standard Bicycle	Per standard Motorcycle	Per standard Motorcycle	Per standard Motorcycle
Audio Device	NA	70dB	70dB	70dB
Vehicle Labeling	1"	2"	3"	3"
Vehicle Identification Number	Serial #	ISO 3779	ISO 3779	ISO 3779
Electromagnetic Compatibility				
Electromagnetic Interference	-	Cisper 12	Cisper 12	Cisper 12
Electromagnetic Susceptibility	-	Cisper 12	Cisper 12	Cisper 12
Legislation Recommendations				
Road Usage	Low Speed	Low Speed	All	All
Licensing of riders	N	Y	Y	Y
Vehicle Registration & plate numbers	N	Y	Y	Y
Safety Equipment (Safety Helmets)	Y	Y	Y	Y
Insurance guidelines	N	1-Time	Motor	Motor
OTHER SPECS				
Battery Recycling	Labeling			

APPENDIX 2

Adopted Standards in Thailand and Malaysia

	Thailand				Malaysia		
	Motorcycle	**3W**	**Quad Cycle**	**Car**	**Bicycle**	**Moped**	**Motorcycle**
Vehicle Performance	>250W, 45kph	>4kW, 45kph	<4kW, 45kph	>15kW, 90kph	**<25 kph**	**25-50**	**>50 kph**
Top Speed	**Protocol Only**		ISO 8715: Considered		**25**	25-50	50+
Minimum Range					25	40	50*
Hill Climb Capability (% gradiant)					0	20	20
Number of Battery Life Cycles	**Bat Test Protocol only**				**0**	300	300*
Breaking distances (wet and dry)					5m/10mm	ECER78	ECER78
Energy Conservation	**Under Consideration**						
Environmental Robustness							
Tropical Rain Test (25cm/hour)					7h+1 Op	7h+1 Op	7h+1 Op
Flood Fording					10cmx140m	10cm/200m	10cmx200m
Mechanical Shock and Vibrations					NA	3g	3g
Drop Test					0.5m 5x	0.5m 5x	NA
Knock-Over Test					Reauired		
Battery Spesific	**UN R136**				**UNR136**	**UNR136**	**UNR136***
Electrical Safety							
Insulation Resistance (Wet and Dry)	ISO6469 Considered				250/1M	250/7M	250/7M
Internal Voltage Safety (Shorting, Overload Protection, BMS cutoff)					**UNR136**	**UNR136**	**UNR136***
Charger Ingress Protection	**On/Off Board Charging Protocol**				**IP45**	**IP45**	**IP45**
Charger Connection	**ISO 17409 External Electrical Connection**						
Standard Vehicle Accessories							
Lights (Headlight, Tail Light, Turn indicators)					ISO 6742	ISO 10604	ISO 10604
Audio Device					NA	NA	NA
Vehicle Labeling	Voluntary				1"	2"	3"
Vehicle Identification Number					ISO 3779	ISO 3779	ISO 3779
Electromagnetic Compatibility							
Electromagnetic Interference	CISPER12: Considered				Cisper 12	Cisper 12	Cisper 12
Electromagnetic Susceptibility					Cisper 12	Cisper 12	Cisper 12
Legislation Recommendations							
Road Usage	No Highway	No Highway	All	All	Off Road	Low Speed	All
Licensing of riders					N	TBD	Y
Vehicle Registration and plate numbers					LA	TBD	Y
Safety Equipment (Safety Helmets)					LA	Y	Y
Insurance guidelines					N	TBD	Motor
OTHER SPECS							
Battery Recycling					Label	Label	Label

APPENDIX 3

Additional Resources

E-Bike Laws and Regulations
https://en.wikipedia.org/wiki/Electric_bicycle_laws

Low-Speed “Transporters”
https://en.wikipedia.org/wiki/Personal_transporter

European “L” Vehicle Categories
https://en.wikipedia.org/wiki/Vehicle_category

Electric Motorcycles
https://en.wikipedia.org/wiki/Electric_motorcycles_and_scooters

Mobility Scooters (Pedestrian speed 4-wheelers)
https://en.wikipedia.org/wiki/Mobility_scooter

European EV “Mini” cars
https://en.wikipedia.org/wiki/Quadricycle_(EU_vehicle_classification)

Summary of “E-Bike” rules
https://easyebiking.com/what-age-ride-electric-bike/