Supporting Policy and Technical Standards Development for Electric Vehicles in Lao PDR

AUGUST 2022

Global Green Growth Institute
Jeongdong Building 19F
21-15 Jeongdong-gil
Jung-gu, Seoul 04518
Republic of Korea

Supporting Policy and Technical Standards Development for Electric Vehicles in Lao PDR

AUGUST 2022

PREFACE

The Ministry of Public Works and Transport has been actively promoting an efficient use of motor vehicles in line with applicable laws and regulations. Especially, in an era of rapid innovative transport engineering development, programs and action plans are being developed to stop the import, manufacturing/assembly of fossil fuel vehicles. The Ministry of Public Works and Transport, as the national authority in ground vehicles technical standards and registration in Lao PDR, has been focusing on the importance of transport sector development in line with green and sustainable development, and environmentally friendly practices, as well as to comply theGovernment's Resolution on EV promotion in Lao PDR. Therefore, MPWT has collaborated with the Global Green Growth Institute (GGGI) to conduct research and identify policy measures for the deployment of electric vehicles, in alignment with the National Social-Economic Development Plan 2021 – 2025, applicable laws and with international and regional treaties that Lao PDR has ratified. This report will be one of key tools for Lao PDR to identify its supporting policies to promote electric vehicles efficiency and effectively, and for the benefit for Lao PDR.

Lastly, on behalf of the Government, I would like to express my sincere gratitude to the Global Green Growth Institute (GGGI) for providing the technical support to MPWT to develop supporting policies and mechanisms to facilitate electric vehicles' transition in Lao PDR in compliance with domestic and international practices. This will also contribute to achieve the target of Lao PDR on environmentally friendly vehicles for transportation, in line with the Government and Party's vision and leadership.

Minister
Ministry of Public Works and Transport
H.E. Mr. Viengsavanh Siphandone

FOREWORD

Electrifying the transport sector as a key priority in high-level strategic plans, including the National Green Growth Strategy, the 9th National Socio- Economic Development Plan (2021-2025) and the 2020 update of Lao PDR's Nationally Determined Contribution (NDC) to the Paris Agreement. In the Lao context, an e-mobility transition will contribute to reducing demand for fossil fuels, thereby addressing macro-economic issues such as energy security and balance of payments, as the country suffers from a trade deficit and fuel demand represents 32.7% of total imports. Moreover, Lao PDR has large untapped domestic renewable energy sources and a seasonal oversupply of hydropower that can be utilized to power sustainable transportation.

Cleaner transport modes will generate environmental co-benefits such as the reduction of noise, emissions of greenhouse gas and local pollutants, thus positively impacting public health. The creation of new equitable business opportunities will be boosted, by promoting consumer demand and incentivizing private investments across the value chain. Furthermore, improving affordable public mobility services will generate economic opportunities for vulnerable populations such as women, young people, people with disabilities and migrants.

These anticipated benefits are fully coherent with the structural reforms brought forward globally as part of COVID-19 response plans. For every country, it is now imperative to reduce exposure to exogenous shocks, drive the establishment of domestic value chains, take advantage of domestic natural resources and create new inclusive business opportunities. The pandemic has negatively impacted Lao PDR socially and economically, resulting in a sharp increase in unemployment rate and leaving the country at high risk of debt distress.

Since 2018, GGGI has been advising the Ministry of Public Works and Transport on how to overcome the various barriers hindering the shift to electric transportation. Such barriers include a low level of understanding of the benefits of electric vehicles (EVs), a limited regulatory framework, insufficient technical expertise, a lack of financing and innovative business models, and limited EV supply and charging network infrastructure.

This GGGI Technical Report on "Supporting Policy and Technical Standards Development for Electric Vehicles in Lao PDR" aims to provide recommendations and help set up a robust regulatory framework for EVs, as well as anticipate and address the potential negative impacts on fiscal revenues due to reduced taxes on fossil fuels. It also proposes technical standards for different types of vehicles, following a detailed review of regional practices. Since only 45% of government employees and less than 20% of private sector employees are aware of EVs, a program for generating awareness and creating market demand is outlined. Additionally, components of a training curriculum for creating skilled technicians for EVs are provided to promote new job opportunities in the car industry and create a better post-sales service ecosystem in Lao PDR.

I would like to sincerely thank the Government of Lao PDR for giving GGGI the opportunity to accompany the Ministry of Public Works and Transport in the design of policies and incentives that will accelerate a shift to e-mobility and support green economic recovery. Much remains to be done though, starting by mainstreaming these recommendations into actual policies and regulations. GGGI is fully committed to continue supporting the Government, so that Lao PDR can sustainably utilize its geographic advantages to power the future of the transport

sector, and beyond. We look forward to expanding our cooperation with the Government, development partners and stakeholders under our new 2021-2025 Lao PDR Country Planning Framework, in order to support policy, financing and knowledge sharing for sustainable mobility, and contribute to achieving the target of 30% EV penetration for two-wheelers and passenger cars by 2030, as set out in Lao PDR's NDC.

Dr. Frank Rijsberman
Director-General
Global Green Growth Institute

ACKNOWLEDGEMENTS

The "Supporting Policy and Technical Standards Development for Electric Vehicles in Lao PDR" study was conducted by the Global Green Growth Institute (GGGI), aided by Emergent Ventures India and pManifold Business Solutions.

The team received significant guidance from the Ministry of Public Works and Transport (MPWT) and would like to extend its sincere gratitude for the support. The team is grateful for the valuable inputs received from Dr. Bounta Onnavong (Director General), Mr. Stefan Ekelund (Urban Transport Advisor) and Mr. Khamathideth Manikham (Deputy Director).

The study framework was formulated by Mr. James Seong-Cheol Kang with support from Mr. Christophe Assicot and Dr. Jaeseung Lee from GGGI.

The study was executed by a consortium led by Emergent Ventures India. The team was headed by Mr. Vinod Kala, and comprised of Mr. Deepak Bawari, Ms. Snigdha Kala and Mr. Anirudh Narla. Technical support came from Mr. Rahul Bagdia and Mr. Ankit Agrawal – both from the consortium partner, pManifold Business Solutions. Mr. Syvang Xayvang and Mr. Phaknakhone Rattana provided valuable field support to the consultant.

To enhance the recommendations in the study and obtain a detailed understanding of the parameters that affect the development of a sustainable electric mobility ecosystem in Lao PDR, the team conducted extensive stakeholder consultations. We express our sincere gratitude to Mr. Worapoj Ruenrerngwong (CEO, EV Lao), Mr. Thongchan Santhasith (Deputy Director, EV Lao), Mr. Bounleuth Luangpaseuth (CEO, Luangpaseuth Cooperation), Dr. Keomorakoth Sidlakone (Deputy Director, Department of Import and Export, Ministry of Industry and Commerce), Ms. Viengkhone Chindavone (Head of Legislation Division, Department of Tax and Custom, Ministry of Finance), Mr. Keovanphone Vonethyvongsy (Director General, Vientiane Capital State Bus Enterprise), Mandate Staff (Division of Public Works and Transport, Vientiane Capital), Ms. Duangtavanh (Deputy Head of Planning Division, Department of Road, MPWT), Mr. Xong Ver (Technical Staff, Technical Division, Department of Road, MPWT), Mr. Bounhome Phanouvong (Director of National Standards Certification and Quality Inspection Center, Department of Standardization and Metrology, Ministry of Science and Technology), Mr. Phouthasak Baochanh (Deputy Director of Standard Division, Department of Standardization and Metrology, Ministry of Science and Technology), Mr. Saneu Chounlamany (President, Lao Automotive Association), Mr. Sombath Southivong (Senior Infrastructure Specialist, World Bank), Mr. Chanin Manopiniwes (Senior Infrastructure Economist, World Bank), Mr. Viboon Jirapatanakul (Managing Director, Krungsri Leasing), Mr. Pawach Kulteerajesada (Head of Product Marketing and Public Relations, Krungsri Leasing), Mr. Inpone Soundala (Accounting and Human ResourcesManager, Suzuki), Mr. Khammanh (Institute of Renewable Energy Promotion), Mandate Staff (Vehicle Inspection Center, MPWT), Mr. Chalongchai Chayutrapong (Director/CEO, UMG Lao (Vientiane testing facility), Mr. Boualay (Lao Toyota Thongkhankham), Ms. Xu and Ms. Nok (Electric Motorcycle – Sabai), Ms. Sone (Sales Assistant, Saisavanh Motor), Mr. Sisongkham (Hino Representative, Laothani Sole Co.), Ms. Muit and Mr. Soukhapangna (Honda New Chip Xieng), Mr. Van (Isuzu Lao Services), and Maruhan Japan Bank Lao.

The team also thanks Ms. Stella Seung-Yeon Lee and Mr. Michael Lee of GGGI, and all others who have been involved in this assignment directly or indirectly.

ABSTRACT

Since 2018, the Global Green Growth Institute (GGGI) has been supporting the Lao People's Democratic Republic (Lao PDR) in its Electric Vehicle (EV) deployment plans. This document has been developed under the guidance of GGGI and involved a consortium led by Emergent Ventures India to provide guidance to the Ministry of Public Works and Transport (MPWT) and help formulate a regulatory framework for EVs in Lao PDR. The framework document includes EV policies and technical standards, along with incentive mechanisms, to ensure successful deployment of EVs in the country.

EVs offer a great opportunity for Lao PDR to initiate transformations in the transport sector and address several challenges faced by the country. EVs will result in reduced fossil fuel demand and can thus, help control the country's rising trade deficit, which was US$163.95 million in the second quarter of 2019 (Trading Economics 2019a). EVs will also help decarbonize the country's economy. The cumulative value of fossil fuel imports that can be avoided during 2020-2030 due to EVs is estimated to be US$2.3 billion, and the cumulative greenhouse gas reduction is estimated to be 422,000 tons of carbon dioxide emissions. In fact, reductions can be as high as 5.39 million tons of carbon dioxide emissions if the electricity to charge EVs is sourced from hydroelectricity plants.

The impending domestic power generation surplus in the country (expected in the coming years) can be profitably utilized locally if EVs are deployed on a large scale. Further, EVs can support the country's renewable energy programs if renewable energy sites are paired with EV charging. The introduction of EVs in the country will result in additional demand for electricity (estimated at 2,000GWh in 2030), thus the electricity sector utilities will witness a rise in revenue. This gain is estimated to be US$518 million during 2020-2030.

This is also an opportunity for the country to introduce sector-wide growth accelerators to improve transport sector efficiency and standardization and introduce regional vehicle sector harmonization.

Despite the benefits associated with EVs and the advantages of EVs over internal combustion engine vehicles (ICEVs), the transition towards EVs is hindered by the initial high cost of EV procurement compared to ICEVs. Thus, EV deployment will require government support to make such a transition easier for vehicle owners. The ICEV-EV crossover point as per the current price trend is 2023, hence such government support will only be required during the first few years (until 2023).

In the ICEV-EV transition, the government will lose revenue due to reduced tax collection from vehicle and fossil fuel sales. Compared to the baseline (when zero EVs are introduced), the cumulative financial burden on the government for the 2020-2030 period will be about US$415 million[1].

Policy measures to support EV deployment and reduce revenue losses

The following measures are suggested for EVs to remain competitive while revenue loss to the government is minimized:

- **Reduce excise revenue losses by phasing out the current low-rate regime.** It is suggested that the excise tax rates for EVs be made equal to ICEVs in three years (post-2022) for all vehicle types, except for minibuses (transport use), for which the rate can be capped at 25%.
- **Charge road fees for all vehicle types to replenish the Road Fund.** Across EV types (except electric bicycles), a use-based road fee is proposed:

[1] This estimate assumes EVs to be 30% of the vehicle mix in Lao PDR in 2030.

Vehicle segment	Road fee (LAK/km)
Electric two-wheeler	9
Electric car	54
Electric minibus/van	54
Electric bus	173

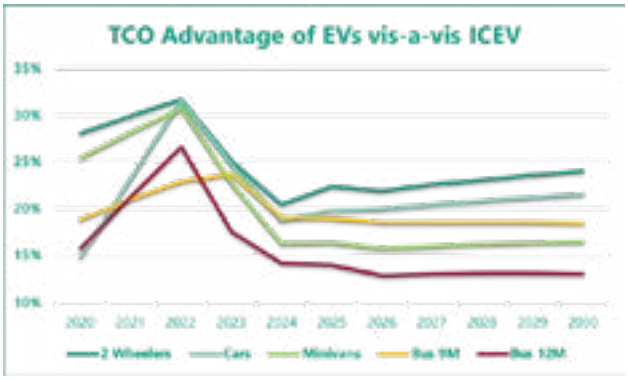
- **Levy charges on fossil fuel sales.** Such feebate (or public benefit surcharge) collected from ICEV owners at the time of fuel sales can be introduced at 6% in 2020. As EV deployment expands (with more EVs on roads), this surcharge can be gradually increased, reaching a maximum of 10% by 2022.
- **Provide interest subvention to EV buyers to maintain total cost of ownership (TCO) advantage across vehicle types.** It is suggested that during the initial years of the program (until 2023), 50% of the interest levied on loans granted to EV buyers can be borne by the government.
- **Provide direct capital subsidy of up to 30% to 12-meter electric buses until 2022.** This is because despite support, the TCO of 12-meter electric buses will not be competitive compared to ICEVs (the big batteries escalate the price of such vehicles).

Other policy measures that will help in the deployment of EVs in the country are summarized in the table below:

	Policy area	Recommendation for Lao PDR
EV-specific policies		
1	Mandates (general)	• Government procurement to support EVs – Government-owned fleets (bus services) and ministries can lead EV deployment
2	Taxes (concessions)	• Annual road tax exemption for electric bicycles
3	Registration of vehicles/licensing/permits	• Mandatory registration for all type of vehicles • Registration based on motor capacity (kW) • Special registration plate to differentiate EVs from ICEVs
4	Preferential access rights	• Right to enter in defined city areas
Charging infrastructure-specific policies		
5	Special charging tariff	• Proposed tariff of LAK500/kWh to be maintained during initial years, and can be increased after 2025
Used/waste battery management		
6	Battery disposal	• Identify public sector enterprise for used battery buy-back and sale for secondary use

TCO advantage of EVs

In the proposed policy scenario, EV users have an attractive cost advantage over ICEVs (see figure below), which will fuel EV demand in the country. During the period when EV capital expenditure is high compared to ICEVs, government support ensures that the TCO_{EV} is less than TCO_{ICEV}. After 2023, when all EV support measures are withdrawn, the falling prices will help EVs retain their competitiveness (when TCO_{ICEV} - TCO_{EV} is more than 20% across all vehicle segments).



EV-specific standards suggested for Lao PDR

Large-scale uptake of EVs will be possible when regional EV standard is harmonized, confidence in EV safety is achieved and consumer confusion is minimized. There are multiple technical and process standards that are needed, not only for EVs but also for the batteries and charging infrastructure, and for communication between vehicle and grid, and vehicle and consumer.

An analysis of EV-specific technical standards, charging infrastructure configuration, and protection and safety standards was carried out and standards for the Association of Southeast Asian Nations (ASEAN) were studied to derive recommendations for Lao PDR. The recommended standards are highlighted in the tables below.

Particular	Recommended technical standard
Batteries	• Lithium-ion batteries
Charging standards	• EV supply equipment (EVSE) system: IEC 61851 • Plugs and sockets: IEC 62196 • Communication between EV and EVSE: ISO 15118
Communication protocol (between chargers and utility)	• Standard open-source protocol like OCPP and its extensions

The EV chargers and charging stations should comply with protection and safety standards like IEC 62335, IEC 62752, IEC 62955 and the local code of practice for electrical installation. The charging station configuration recommended for the country is as follows:

Vehicle segment	Vehicle safety, functional safety and battery testing requirement	Range and energy consumption	Vehicle roadworthy inspection
Electric bicycle	<2kWh	<0.25kW DC	Customized (ensuring safety standards)
Electric moped or motorcycle	<4kWh	<3.7kW AC	AC Type 2 or customized
Electric car	<50kWh	3.7 / 7.2 / 22kW AC 30-50kW DC	AC Type 2 or CCS Combo 2
Electric bus	<300kWh	43.5kW AC 50-200kW DC	AC Type 2 or CCS Combo 2
Note: Vehicles with CHAdeMO and GB/T connectors to have either AC Type 2 or CCS Combo 2 vehicle connectors			

The protection and safety standards recommended for the country is as follows:

Vehicle segment	Vehicle safety, functional safety and battery testing requirement	Range and energy consumption	Vehicle roadworthy inspection
Electric bicycle (speed of <25km/ hour)	UL 2272 standards	UNECE R101 standard can be adopted	The roadworthiness inspection for EVs to be similar to ICEVs except for noise and emission tests. Additional visual inspection and operation checks to be performed: Electrical wiring, connection quality and status, battery leakage, and functioning of indicators and warning device.
Electric motorcycle or moped	(L category), UNECE R136 standards		
Car and bus (M and N categories)	UNECE R100		

Awareness raising to create demand for EVs

The success of EV deployment is dependent on widespread consumer acceptance, and the first step to commercialization is building awareness.

Despite the superiority of EVs over ICEVs on several dimensions such as TCO, low emissions and ease of driving, scaling up EVs will require significant investments in awareness generation and in ensuring that the initial experience of consumers is positive in all dimensions, including quality, cost, service and financing.

Key barriers to EV adoption include consumer beliefs about the high cost of EVs, limited infrastructure support and range anxiety (due to lack of charging infrastructure). With evolving EV technology, such issues have already been addressed.

For successful EV deployment a "Program for Generating Awareness and Creating a Market Pull" is suggested. The program should include:

- Wide dissemination of government policy and incentives for owning EVs;
- Highlight and validate the advantages and benefits of EVs;
- Create a demand for EVs, including awareness about EV products, and the charging and financing options that exist; and
- Ecosystem development through awareness generation and training for various stakeholders.

EV technician training

In order to build and retain consumer confidence in EVs, robust technical support across the EV supply chain will be essential. The EV technician training program will be an important aspect of EV deployment in Lao PDR. The country has an acute shortage of skilled human resources, and industry-supported technical training programs are missing as the country is completely dependent on imports to meet its vehicle demand. Thus, a skills development program that is led and supported by the Government of Lao PDR (to be spearheaded by the Ministry of Labor and Social Welfare) with implementation support from private players, is recommended.

TABLE OF CONTENTS

TABLES

FIGURES

ABBREVIATIONS

AC	alternating current
ACFTA	ASEAN China Free Trade Area
Ah	ampere hour
ASEAN	Association of Southeast Asian Nations
ATIGA	ASEAN Trade in Goods Agreement
BNEF	Bloomberg New Energy Finance
cc	cubic centimeter
CCS	combined charging system
cm	centimeter
CMS	central management system
DC	direct current
DPWT	Division of Public Works and Transport
EDL	Électricité du Laos
EV	electric vehicle
EVSE	electric vehicle supply equipment
GB	Guobiao
GGGI	Global Green Growth Institute
ICE	internal combustion engine
ICEV	internal combustion engine vehicle
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
km	kilometer
kW	kilowatt
kWh	kilowatt hour
l	liter
LAK	Lao Kip
Lao PDR	Lao People's Democratic Republic
m	meter
MPWT	Ministry of Public Works and Transport
OCPP	Open Charge Point Protocol
OEM	original equipment manufacturer
OPEC	Organization of the Petroleum Exporting Countries
PACE	Program for Generating Awareness and Creating a Market Pull
PMD	personal mobility device
RDC	residual direct current
RESS	rechargeable energy storage system
SAE	Society of Automotive Engineers
SPE-PRCD	switched protective earth – portable residual current device

SUV	sports utility vehicle
TCO	total cost of ownership
TR	technical reference
UL	Underwriters Laboratories
UNECE	United Nations Economic Commission for Europe
VAT	value-added tax

1. Current Usage and Experience of EVs in Lao PDR

1.1 Introduction

Electric Vehicles (EVs) are not new to Lao People's Democratic Republic (Lao PDR). EV programs of varying formats have been implemented in different cities of the country (often as pilot initiatives) for both public and private use, with mixed success. Some of the recent EV interventions include the following:

- The Vientiane Capital State Bus Enterprise operated electric minibuses and carts with mixed results. The EV program started in 2009 with support from the Chinese government, but within six years, the EVs stopped operating due to technical glitches (PricewaterhouseCoopers 2018).
- Savannakhet has an EV program through collaboration with a private firm to operate electric minibuses in the city.
- Luang Prabang has an EV program that has introduced electric buses and taxis in the city since 2015. The buses are operated by Lao Green Company.
- A Vientiane Sustainable Urban Transport Project is planned that aims to develop a demonstration model based on EVs as possible replacements for existing highly-polluting vehicles.
- On the testing and establishment of a charging infrastructure, Électricité du Laos (EDL) and the EV Lao Company Limited have been installing and testing charging stations at select locations. Twenty-two such charging stations have already been installed in January 2020 –of these six are home chargers and 16 are public chargers.[2]

In addition to these examples, there are privately-operated electric two- and three-wheelers in the country that are imported from China and Taiwan.[3] More than 20 EVs have been registered in the country as of January 2020.

[2] Information from EV Lao Company Limited
[3] Based on the survey of dealers carried out by the consultant.

1.2 Perception of EVs

In February 2019, the Global Green Growth Institute (GGGI) carried out a two-wheeler focused consumer and dealership survey in Lao PDR (GGGI 2019). A total of 177 consumers and six dealers were approached for information on their awareness and perception around electric mobility in the country.

Of the sample, 70% of the respondents were aware of electric motorcycles, and such awareness level was highest among students compared to other consumer types, including office workers. The total cost of ownership (TCO) was an important consideration, and almost three-quarter of the respondents were keen to switch to EVs if the operation and fuel costs for such vehicles were 50% of the internal combustion engine (ICE) motorcycles. In this scenario, the high capital expenditure of EVs will not deter respondents from buying EVs.

The major concerns of the respondents were lack of charging infrastructure (range anxiety) and lack of user experience (due to the low penetration of EVs). Other barriers highlighted by the survey include lack of sales services and spare parts availability, and vehicle quality.

The respondents indicated that educating consumers on the benefits of EVs can help raise their demand in Lao PDR, and implementing smart youth-focused outreach programs (including on mobile-based platforms) can speed up EV uptake.

These insights have been taken into consideration in developing the proposed Program for Generating Awareness and Creating a Market Pull as part of EV deployment in Lao PDR (see Section 4.1).

1.3 Government Priorities

The consultant engaged with different stakeholders in Lao PDR to assess the current status and government priorities concerning EV deployment.

The country is progressing towards introducing the United Nations Economic Commission for Europe Regulation Number 100 (UNECE R100 or UNR 100). It addresses EV safety requirements and is in line with ensuring vehicle sector standards harmonization between Association of Southeast Asian Nations (ASEAN) countries. The current focus of standardization is on two-wheelers and passenger vehicles. Any new standards that are to be considered by the country will have to fully comply with UNECE R100.

The government has already introduced select fiscal measures to promote EVs. The EVs in the country will be subjected to subsidized excise taxes and the electricity tariff for EV charging is kept low compared to tariffs for home and commercial electricity usage.

The government is in favor of promoting EVs for the following reasons:

EVs will result in reduced fossil fuel demand, thus, issues related to balance of payment can be addressed.

EVs will create domestic demand for electricity. The country is adding electricity generation capacity, thus the demand for electricity has to be maintained. Currently, the only market where the country can sell electricity is Thailand and on every unit of electricity sold to Thailand, EDL loses one US cent. The government is trying to increase domestic electricity demand and EVs can address this issue.

The main concerns regarding EVs highlighted by government stakeholders include the following:

EVs can negatively impact upon government revenue. The revenue from excise tax collection will reduce as EV sales grow.

EVs can negatively impact the Road Fund that is currently collected with levy charged on gasoline and diesel sale in the country. In the EV scenario (when new policies to support EV deployment are introduced), revenue for this fund will shrink.

There are no tailored EV financing products available in Lao PDR and leasing agencies have no EV financing experience. The perceived risk associated with EV financing is high.

1.4 Introduction of EVs among Distribution Channels

1.4.1 Two-Wheeler Distribution Channel

Honda is the biggest market player in the two-wheeler segment. The sole distributor of Honda in Lao PDR is New Chip Xieng, based in Vientiane. Honda has a wide presence and reach in Lao PDR, with 88 dealerships in 18 provinces of Lao PDR, and a service center for its customers at all of the dealer locations. Annually, 75,000-76,000 Honda two-wheelers (mostly 100-125cc) are imported as semi-knocked down units from Vietnam, and another 16,000-17,000 are imported as completely built units from Thailand. The spare parts for the vehicles are imported from Thailand. Two-wheelers from Vietnam are imported into the country from the port in Nam Phao and those from Thailand enter from Thanaleng (this is a common port center for most vehicle imports from Thailand).

The only active electric two-wheeler dealer in Lao PDR is E-Sabai. All E-Sabai two-wheelers are imported in completely knocked down or semi-knocked down form from China through the Boten Border Crossing into the Luang Namtha Province in Lao PDR. These are then assembled in Vientiane and are made available for sale at the two dealer showrooms of E-Sabai in Vientiane (E-Sabai also has two service centers in Vientiane). About six electric two-wheeler variants are made available by E-Sabai and the total annual import reported by the dealer for all such vehicles in 2019 was about 3,000 units.

1.4.2 Passenger Car Supply Chain

Lao PDR allows imports of all types of cars, some with ⩽1,000cc and few even ⩾5,000cc. Engine capacity wise, the most popular car segment is between 1,601cc and 2,000cc, based on a survey of various dealers (Honda, Suzuki and Toyota) carried out by the consultant in Vientiane. These numbers represent only the sedan and sports utility vehicle (SUV) models and do not cover pickup trucks that are imported in bigger numbers than sedans and SUVs. All the car dealers import spare parts along with the cars in completely built forms.

Among passenger car dealers, Toyota is the leader in the country with almost eight dealerships. It is present in all major cities – Vientiane, Pakse, Champasak, Luang Prabang and Savannakhet, along with vehicle servicing and spare parts at all these locations. Toyota imports its four-wheelers from Malaysia, Japan and Thailand.

Suzuki is a relatively smaller player, with around 300 imports per annum, and has its presence limited to Vientiane. It operates one service center for its customers. The majority of Suzuki's imports in Lao PDR are from India, followed by Japan, Thailand and Indonesia.

Honda is another small player in the car segment in Lao PDR, and has its presence in Vientiane. It imports around 550 completely built cars per annum from Thailand. It has two dealerships with service centers in Vientiane.

1.4.3 Minibus and Van Supply Chain

Isuzu and Toyota are dominant players in the minibus and van (15 seats or less) segment, with few other small dealers like Ford. The vehicles and spare parts are imported mainly from Japan and Thailand both by Isuzu and Toyota. The import numbers are dependent on orders from customers. Isuzu has its service center in Naxaythong district.

1.4.4 Technical Capacity Building

Most of these car dealers are not involved in the training of the mechanics for their vehicle services in Lao PDR. Based on the information provided by the President of the Lao Transport Association, Lao PDR needs more than 500 automotive technicians each year to meet automotive industry growth, but can supply only about 200 automotive technicians annually, most of whom are graduates from the Lao-German Technical School (The Nation 2017).

Honda is engaged in training mechanics for repairing and maintenance of its products (including cars). It runs a training center in Vientiane. However, no other mechanic capacity building programs have been identified.

1.5 Summary

The country has some experience with EVs. Electric two-wheeler ownership is fast expanding and electric cars are being introduced. Still, some concerns are holding back the quick switch to EVs. The government is very clear in its support for the deployment of EVs through the adoption of the New Motor Vehicle Law and the UNECE R100 standard.

However, EV deployment can only succeed when consumer confidence in EVs is maintained, and this is only possible by establishing and communicating the benefits associated with EVs. The communication will have to be supported with a countrywide presence of robust EV financing, supply chains and servicing mechanism. But the financial institutions have apprehensions, the vehicle supply chain is weak with limited dealership, and the country's technical capacity is low since most automotive companies do not have capacity building programs for technicians.

2. Policy and Regulation

2.1 Current Policies and Regulations Governing ICEVs and EVs

This section reviews the broad measures that are in place to regulate vehicles in Lao PDR. Since there is no specific EV policy in the country, the applicability of the existing transport sector regulatory environment to EVs is assessed.

Currently, Lao PDR's institutional guidelines for governing EVs are not adequate and EVs are loosely regulated (specifically, the electric bicycles with low speed as there is no regulation on registration and operation of such vehicles in the country). At the same time, the government offers tax reliefs to EVs that are imported as part of city transport plans.

Table 1: Regulatory analysis of EVs in Lao PDR

No.	Policy/regulation	General provisions applicable to EVs
1	Law on Insurance (ALMEC 2014)	Compulsory general insurance conditions for road transit transport vehicles and motor vehicles that run on any type of engine. But since electric bicycles are exempted from registration, they are outside the ambit of the Law on Insurance.
2	Law on Standards (Amended in 2014)	The Lao National Standards for Services determine the operation systems that relate to many areas of work, including transportation. However, there is no directive on EV standards.
3	Law on Land Transport (MPWT 2012b)	• Defines "vehicle" as "all types of transport vehicles running by machine", thus by default, all regulatory provisions applicable to ICEVs are also applicable to EVs. • Defines the different aspects of regulation based on engine capacity of the ICEVs (in cc) but does not categorize EVs based on their "power". • Defines the insurance rules for vehicles, and governance parameters for technical qualification of vehicles (personal and commercial).

No.	Policy/regulation	General provisions applicable to EVs
4	Law on Land Traffic (MPWT 2012a)	• Defines driving license requirements and driver qualification criteria. • Defines the technical standards for vehicles. As per the law, the producer'stechnical standards are to be abided with for all vehicles, irrespective of whether the vehicle is imported, assembled or produced in Lao PDR. • The government is in the process of phasing out the two-stroke three-wheelers.
5	Agreement on the National Environment Standard (Water Resources and Environment Adminstration 2009)	**Battery specific:** • The guideline on permitted concentration for battery producing units in industrial discharge is defined in Article 5. • Waste battery management or extended producer responsibility guidance does not exist in the country. **Vehicle specific:** • The standard defines permissible levels of air emissions and noise pollution from vehicles.
6	Regulation on the Technical Standard for Vehicles and Accessories of Vehicles (MPWT 2002)	• Defines the eligibility criteria for new and used vehicles that can be imported. • Defines the conditions and technical standards of accessories of imported vehicles for assembly and use in the country. • Defines the inspection of conditions and technical standards for imported vehicles and accessories of vehicles.
7	Vehicle importation policy	• The ASEAN Free Trade Area policy guides imports and exports between member countries. • Lao PDR does not allow the import of used vehicles, only state enterprises can import used vehicles (including buses). • There is no specific regulation on EVs and they can be imported into the country, although clarity on taxation is required.
8	**Tax environment**	• For ICEVs (both two- and four-wheelers) the tax rate increases in proportion to engine capacity. • The excise tax rates are low with plans for further reduction to 3% in 2020 for vehicles using clean energy.
	Excise taxes	
	Customs duty	Lao PDR is part of the ASEAN Free Trade Area and is a party to five regional free trade agreements through ASEAN. Thus, no customs duty is charged on imports from ASEAN member countries and from Australia, China, India, Japan and the Republic of Korea (Dunseith 2017).
	Value-added tax (VAT)	A uniform VAT rate across vehicle segments of 10% is applicable.
9	Law on Investment Promotion (Amended in 2016) (Ministry of Planning and Investment 2016)	• Investment incentives are provided for businesses that apply modern, innovative and environmentally-friendly technologies, and make efficient use of natural resources and energy. • Incentives are provided for investments in poor zones (defined by applying socio-economic criteria) and special economic zones.

No.	Policy/regulation	General provisions applicable to EVs
10	Draft Strategy on the Promotion of Green Energy for Transportation Development	The draft document is prepared by the Institute of Renewable Energy Promotion.
11	Prime Minister's Office Order No. 829/PMO.DE 13 June 2016	There is a temporary ban on recycling and import of used batteries.
12	Draft Pollution Control Strategy 2030 and 2021-2025 Action Plan	Provides guidance on hazardous material use, management and its safe disposal (provisions applicable to vehicle batteries).

2.1.1 Vehicle Taxation

The various taxes and fees levied on different vehicle segments have been compiled from different sources and are presented in Tables 2 to 5. It is to be noted that all these prices, taxes and fees are for new unused models and not for used or resold vehicles.

Excise taxes on different vehicle segments

The excise tax varies according to the vehicle's engine capacity as shown in Table 2 (VDB Loi 2016). VAT is 10% for all vehicles (PricewaterhouseCoopers 2018).

Table 2: Excise taxes on different vehicle segments

Vehicle segment	Tax rate for ICEVs	Tax rate for EVs
Two-wheeler <50cc	10%	3%
Two-wheeler (according to engine capacity)	10%-70%	3%
Car (according to engine capacity)	30%-90%	3%
Bus and truck (3.5-15 tons)	8%	3%
Bus and truck (15-50 tons)	5%	3%

Customs duty on imported vehicles

The customs duty on imported vehicles varies across countries and is governed by bilateral and multilateral treaties that Lao PDR is a party to. Based on the ASEAN-China Free Trade Agreement (ACFTA) and the ASEAN Trade in Goods Agreement (ATIGA), the excise tax rate is zero on items imported from China and the ASEAN region. Lao PDR also has bilateral trade arrangements with India, Australia and New Zealand.

Table 3: Customs duty for imports from the ASEAN region and China

Country of import	Tax rate for ICEVs	Tax rate for EVs
China: Import governed by ACFTA	0	0
ASEAN: Import governed by ATIGA	0	0
India, Australia, New Zealand	0	0

Table 4: Customs duty for imports from countries without trade agreements with Lao PDR

Vehicle segment	Tax rate for ICEVs	Tax rate for EVs
Two-wheeler	30% for <50cc 40% for >50cc	3%
Four-wheeler	20%	3%

Other transport sector taxes and fees

The information on one-time vehicle registration cost and annual taxes like road tax (paid annually), technical inspection and licensing fee (both to be renewed every five years) was provided by the Ministry of Public Works and Transport (MPWT) and vehicle dealers. For ICEVs, the taxes and fees are defined as per the vehicle capacity, but the rates and values are yet to be defined for EVs. See Appendix 2 for details on tax rates and fees.

Table 5: Other transport sector taxes and fees

Tax/fee type	Tax rate for ICEVs	Tax rate for EVs
Vehicle registration costs	Defined based on engine capacity and vehicle type	Not defined
Annual road tax		
Technical inspection fee		
Licensing fee		

2.1.2 Vehicle Registration

The imported vehicles are initially registered in the name of the importers by the Customs Department, after the application form (IM4) has been filled by the importer and the registration charges have been paid to the Customs Department. This one-time vehicle registration cost is passed on to customers along with vehicle registration.

2.1.3 Vehicle Inspection

The Division of Public Works and Transport (DPWT, a subsidiary of MPWT at the provincial or municipality level) carries out technical inspections of vehicles every five years. The primary objective of these roadworthiness inspections (also referred to as periodic technical inspections) is to ensure that vehicles are reliable and safe to be driven on roads without putting anyone at risk.

Inspections take place at the DPWT provincial offices with general tests to check the condition of the vehicle prior to renewal of vehicle registration for another five years. It includes the testing of lights, steering, suspensions, horn, seatbelts, emissions, bodywork, doors, mirrors, brakes, wheels, wipers and fuel system.

In Lao PDR, the testing facility is equipped to only conduct roadworthiness tests on cars and SUVs. For bigger vehicles (buses and trucks) no such facility exists. The two-wheeler inspection is done by manually operating the vehicle.

2.1.4 Vehicle Insurance

Public or government-owned insurance agencies are not present in Lao PDR. The vehicle riders have few private insurance options from companies like Lao-Viet Insurance, Allianz General Lao, Toko Assurance and Vientiane Insurance. The insurance premiums per annum for the full coverage of a new car are around US$500-1,000, US$150-200 for a new two-wheeler and US$800-1,300 for a new bus.

Based on the vehicle owner survey carried out by the consultant, 80-90% of the vehicles that are more than two years old do not opt for full coverage or are denied full coverage by the insurance agencies. Such vehicle owners have to opt for low-quality insurance, often with a low premium amount (e.g., third-party coverage mostly in the range of US$200-400 per annum for cars, US$50-100 for two-wheelers and US$500-800 for buses).

2.1.5 Fuel Pricing Structure

Based on information provided by the Ministry of Energy and Mines, 23 oil companies are operating in the country. The Lao State Fuel Company, a state-owned company, is a significant market player that competes with other oil sector operators and ensures secure fuel supplies in the country.

The Ministry of Industry and Commerce and Ministry of Finance control retail oil prices. Every month a state-wise retail price directive is issued, which is used as the baseline for setting the retail price for fossil fuels in the country.

Petroleum fuel is a major source of taxes for the Lao government. The taxation of fuel in Lao PDR is a mix of ad valorem taxes (based on the percentage of the selling price) and specific taxes (a fixed amount on unit volume sold at fuel dispensers). For marketing and taxation purposes, fuel is divided into three broad categories – super gasoline (with high octane number), regular gasoline and diesel.

The ad valorem components are the import and excise taxes.

Import tax is calculated using the following formula:

*Import tax=Import price for fuel type in LAK*Import tax rate*

The import tax rates in August 2019 were 20% for super gasoline, 15% for regular gasoline and 5% for diesel fuel.

Excise tax is calculated using the following formula:

*Excise tax=(Import price of fuel in LAK+Import tax)*Excise rate*

The excise tax rates applied to fuel sales in August 2019 were 39% for super gasoline, 34% for regular gasoline and 24% for diesel fuel.

In addition, a fixed 10% VAT (at import) is applied on any goods and service items sold in Lao PDR. The VAT value is calculated using the following formula:

*VAT=(Import price of fuel in LAK+Import tax+Excise tax)*VAT rate*

The specific taxes for fuel include charges for the Road Fund, various management costs and pump service. For the Road Fund, a fee of LAK520/liter of fuel (diesel and gasoline) is charged on fuel-dispenser sales (see details in Section 2.1.6). Various management costs, including for risk provisioning and reserve are also added to the fuel sold at fuel dispensers, as well as a pump service charge. For the latter, a flat rate per liter across all fuel types is set on a regular basis (e.g., for August 2019, the rate was set at LAK250/liter)

Details on the different taxes and fees levied on fossil fuels are provided in Table 6.

Table 6: Taxes and fees levied on fossil fuel

Fuel	Super gasoline	Regular gasoline	Diesel
Import duty (%)	20	15	5
Excise tax (%)	39	34	24
VAT (%)	10	10	10
Road Fund (LAK/liter)	520	520	520
Other management costs (LAK/liter)	898	598	798
Pump service (LAK/liter)	250	250	250

2.1.6 Road Fund

The Government of Lao PDR established the Road Fund in 2002 to ensure predictable and sustainable allocation of funds for road maintenance in the country. As per the mandate of the Road Fund, it supports routine, periodic and emergency maintenance, as well as rehabilitation and upgrading of existing roads (Asian Development Bank 2019).

The Road Fund is generated from fuel levy, which has increased over the years to ensure the sustainability of the fund. In 2009, the fuel levy was LAK40/liter, which increased to LAK420/liter in 2013 and LAK520/liter in 2019. The rise in fuel levy and the drastic increase in transport fuel sales resulted in accelerated growth in revenue for the Road Fund. By 2013, the fuel levy was able to meet 97% of the Road Fund revenue (Asian Development Bank 2015).

In light of the projected EV mix in the country and as the number of EVs increases, shrinkage of the Road Fund is likely.

2.1.7 Electricity Tariff Structure

In Lao PDR, electricity distribution is managed by EDL, a state-owned enterprise. The EDL charges consumers using the base tariff, which includes establishment cost of power generation facilities, transmission and distribution costs, and all costs involved in power generation and its delivery to consumers. EDL decides the base price of electricity (Nanthavong 2015).

Table 7: Peak tariff across consumer type charged by EDL

Consumer type	Connection type	Highest tariff rate applicable to the type (LAK/kWh)
Residential	(>500kWh)	999
Non-residential low voltage	Commercial	1,101
	Industrial	779
Non-residential medium voltage	Commercial	734
	Industrial	714
High voltage	-	714

EDL exports electricity to countries in the ASEAN region. According to the World Bank, the utility incurs losses of approximately one US cent per kWh of electricity exported.

EDL is currently offering special tariffs for EV charging. Under the current arrangement between EDL and EV Lao, for electricity consumption, EDL charges LAK500/kWh from home chargers and LAK650/kWh from business chargers. However in future, when actual commercial operations start and the number of EVs increases, EDL might reconsider the tariffs for EV charging.

Table 8: EV charging costs in Lao PDR

Charging type	Electricity charge (LAK/kWh)	Service charge (LAK/kWh)	Total (LAK/kWh)
Home	500	200	700
Business (including public charging)	650	550	1,200

2.1.8 Used and Waste Automotive Battery Management

The consultant conducted a survey in Vientiane to collect information on the waste automotive battery policy and management practices from government entities, vehicle dealers, battery retailers and battery recycling units. The findings are presented below.

Status

The automotive batteries are imported from Thailand and the Republic of Korea. According to the GGGI report on "Promoting Electric Mobility in Lao PDR", lead-acid automotive batteries for vehicles are also sourced from China. Batteries are imported by dealers and sold through retailers who maintain a stock of two to three battery brands.

Table 9: Automotive batteries available with surveyed retailers

No.	Battery type	Country of origin
1	3K/Maintenance free (lead-calcium alloy)	Thailand
2	ATLASBX/Dry maintenance free	Republic of Korea
3	Rocket/Dry	Republic of Korea

Batteries are produced locally by the Lao Power Pro-Manufacturing Sole Co., Ltd. (located at Kangphosy Village, Outhoumphone District in Savannakhet Province). The products from the facility are consumed locally (in small vehicles such as forklifts) and exported.

Policy on used battery management

There is no specific policy for battery management in the country, but the Ministry of Natural Resources and Environment is in the process of developing a Pollution Control Strategy that includes aspects related to hazardous material management.[4]

Used battery recycling

Lao PDR had a battery recycling facility, but in 2016, due to environmental concerns, the government terminated the operations of the facility. As per an order issued by the Prime Minister's Office,[5] the following was notified:

- Suspension of import of used batteries and electronics waste;
- Temporary closure of factories recycling used battery and electronic waste; and
- The Ministry of Industry and Commerce and the Ministry of Natural Resources and Environment will inspect these factories, following which further notification on battery recycling will be issued.

The urban waste management body plays no role in waste battery management, but there is a used-battery market in the country. Users have the option to sell used batteries to the retailers or the recyclers. The survey indicated that the waste batteries fetch about LAK1,500/Ah for the primary sellers irrespective of whether they are sold to a battery retailer or directly to the recyclers. Here it should be noted that not all battery retailers buy back used batteries.

The battery retailers and recyclers who deal in waste batteries charge a margin of about LAK100/Ah to bulk (used) battery buyers. Since none of the battery recycling facilities in the country are operational, all the waste batteries are exported to Vietnam. Also, Vietnam-based motorcycle manufacturers recover waste batteries from the Lao PDR market and ensure their responsible disposal in facilities in Vietnam.

[4]Information from the Pollution Control Department in Vientiane, Lao PDR.
[5]Prime Minister's Office Order No.829/PMO.DE, 13 June 2016.

Export of Used Batteries

According to discussions with the Ministry of Industry and Commerce, export of used batteries is not permitted in the country.

2.1.9 Summary

From the analysis in the section, it is clear that the country will need additional provisioning for EV deployment. The aspects that need attention are as follows:

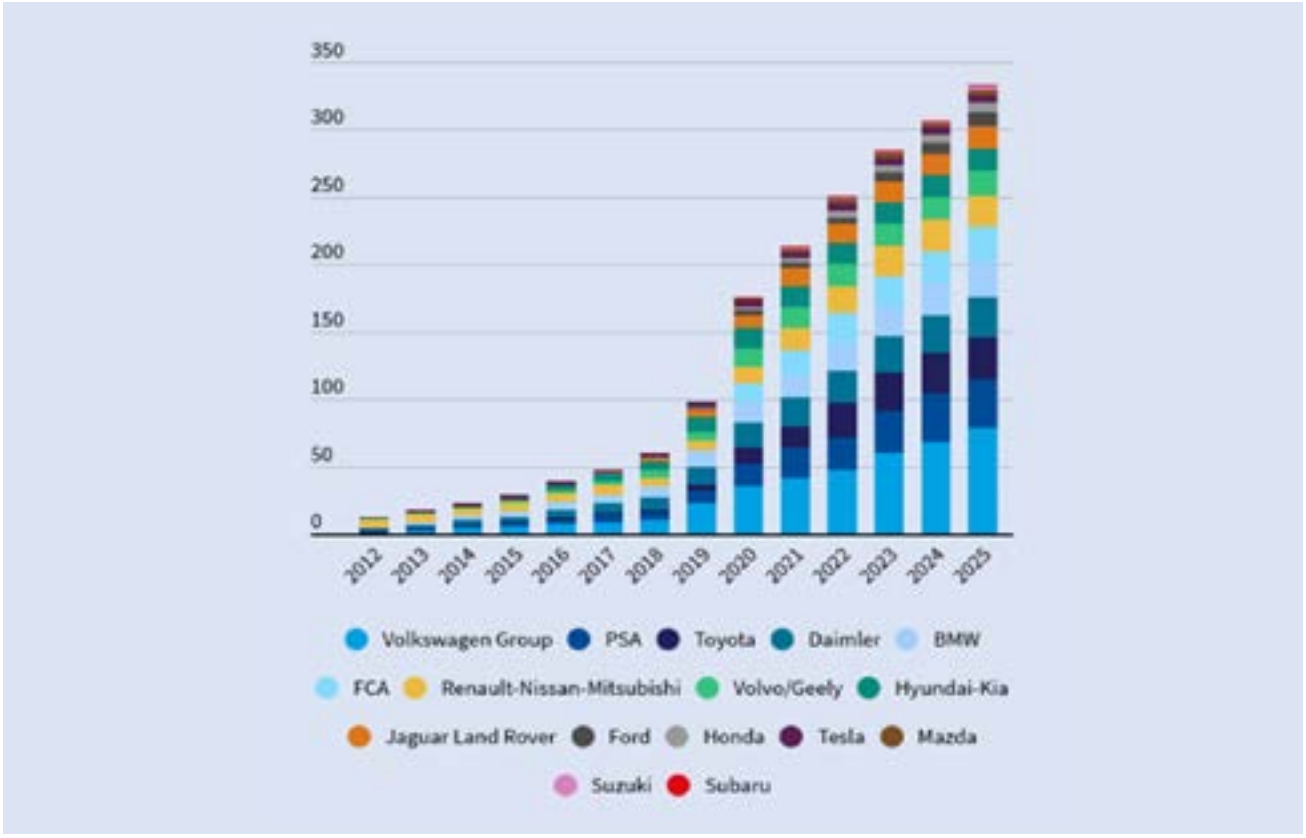
- The regulatory environment in the country needs revision and provisioning for EVs. The country is open to introducing supportive provisions to facilitate EV tax rebates offered on vehicle imports. However, road sector regulations will have to be revisited to ensure regulatory compliance by EVs.
- Currently, the country does not have any technical regulations covering EVs. As a general rule, all EVs imported into Lao PDR must comply with the producer's technical standards, and the country has not introduced any Lao-specific technical standards for vehicles (including EVs). Further, the institutional capacity to ensure the implementation of such standards is weak.
- There are transport sector-linked revenue streams that will be impacted upon when EVs are introduced in the country. Revenues from excise taxes, petroleum sales and the Road Fund will be reduced.
- In addition, EDL revenue will be impacted upon and EV charging tariffs might require revision.

2.2 Global EV Developments

EVs are increasingly becoming popular across the globe. Efforts made by governments and automotive industry associations are the reasons behind the growing stock of EVs. Ambitious EV targets and policy support from governments have resulted in the lowering of EV costs. Additionally, factors such as extended vehicle range and improvement in charging infrastructure have fueled the growth of the EV market globally.

Vehicle users have started realizing the advantages that EVs offer over ICEVs. Figure 1 shows the sudden surge of new EVs available in the European market post-2017. Most EVs have a driving range of more than 300km, and consumers have more choices across brands and price-bands. Further, the new EV pipeline is very impressive. Figure 1 also provides a glimpse of the EV models that car companies plan to launch in Europe alone. According to a report by McKinsey, there will be over 400 new EV models in the pipeline over the next three years, compared to 136 in 2018 (Fehrenbacher 2020).

Figure 1: Total number of EV models available in the European market



Source: (Transport & Environment, 2019)

2.2.1 Technological Advancement

The limited driving range of EVs has been one of the biggest challenges for the expansion of EVs in the global market. To improve the driving range, EV manufacturers have been trying to reduce the weight of the vehicle by using lightweight materials, improve battery capacity and reduce battery weight (as the battery accounts for about 70% of the weight of an EV). These crucial advancements are expected to open new possibilities for the growth of the global EV market in the future.

It is expected that by 2025, batteries will start using cathode chemistries that are less dependent on cobalt, such as NMC 8111, NMC 622 or NMC 532 cathodes in the NMC family or advanced NCA batteries, leading to an increase in energy density and a decrease in battery costs (Wentker, Greenwood and Leker 2019).

Improvements in the charging infrastructure are happening at a very fast pace. Utilities, charging point operators, charging hardware manufacturers and other stakeholders in the power sector are increasing investments in the charging infrastructure. Utilities, as well as major energy companies that traditionally focused on petroleum goods, are investing in the charging infrastructure. This covers private charging at home, publicly accessible chargers at key destinations and workplaces, as well as fast chargers, especially on highways.

One of the reasons for rapid progress in charging technology is increasing interest in EVs for heavy-duty applications (primarily buses). Standards have already been developed for high-power chargers (up to 600KW), and interest in mega-chargers that can charge at one megawatt or more (e.g., for use in heavy trucks, shipping and aviation) is growing. Benefiting from battery technology improvements, the time required to charge at fast-charging stations is predicted to decrease substantially in the next 10 years.

2.2.2 EV Growth Trends

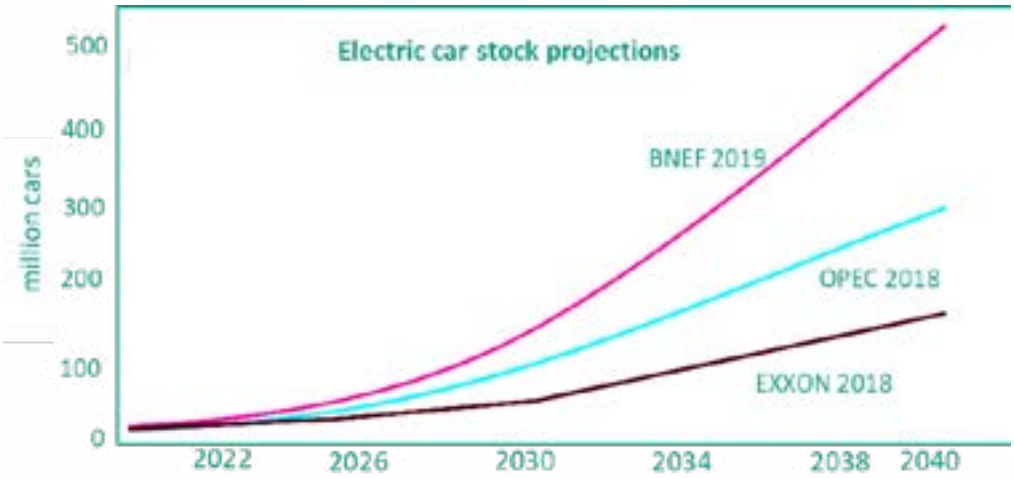
Currently, EVs are more costly compared to ICEVs, and the battery of EVs constitutes the biggest share of the vehicle cost. For a mid-sized electric car in 2019-2020, for example, battery cost is almost one-third of the vehicle cost. But battery prices are falling fast (see Appendix 8), and the crossover point (i.e., when EVs' upfront purchase price is at par with equivalent ICEVs) as per current price trend is 2023. Deloitte estimates that the market will reach a tipping point in 2020 when the cost of ownership of an EV will be at par with its ICEV counterparts.

With the cost of ownership no longer a barrier to purchasing EVs, such vehicles will surely become a viable option for any new vehicle buyer, and the indications are clear – EV sales across the globe are picking up. If only car sales are considered, EV sales were 2% of global car sales in 2018. But by 2030, the global EV market size is projected to grow from an estimated 3 million units to 27 million units at a compound annual growth rate of 21.1%. The Asia-Pacific region, led by China, has the highest sales of EVs (Markets and Markets Research 2019). In Lao PDR, the number of registered EVs has increased from zero in October 2019 to about 20 EVs by January 2020.

The sale of electric two-wheelers is on the rise, especially in the Asia region where there are many brands offering superior electric two-wheeler products. This vehicle segment has been an area of key focus due to the large stock and sales numbers in countries like China and India.

Multiple studies have provided long-term EV projections. In Figure 2, projections by Bloomberg New Energy Finance (BNEF), Organization of the Petroleum Exporting Countries (OPEC) and ExxonMobil are shown. BNEF presents the most optimistic scenario with electric cars reaching a stock of 548 million by 2040 (representing 32% of total passenger cars on the road). At the lower end, ExxonMobil forecasts 162 million electric cars by 2040 (Coren 2019).

Figure 2: Electric car stock projections



Source: (Coren 2019)

2.2.3 Summary

Globally, EV technology has evolved rapidly. Ambitious EV targets and policy support from governments have resulted in the lowering of EV costs, and factors such as extended vehicle range and improvement in the charging infrastructure have fueled the growth of the EV market globally. With the cost of ownership no longer a barrier, EVs will become a viable option for any new car buyer. This will be the case in Lao PDR as well.

The years 2022 and 2023 will be important for setting and adopting national EV policies since it is during this period that EV prices will roughly match the equivalent ICEVs. Hence, EV-specific fiscal support can be rolled back when the crossover point is hit.

2.3 Policies to Support EVs: ASEAN and Global Regulatory Review

Policymakers across the globe and in the ASEAN region are encouraging the adoption of EVs. The EV deployment focus, degree and design measures vary across nations and are influenced by macro-economic considerations, environmental commitments and technical advancements. To derive policy lessons for Lao PDR, a policy analysis of four ASEAN countries – Indonesia, Malaysia, Singapore and Thailand – has been carried out, and policy measures that are currently applied to promote use and penetration of EVs, and are relevant to the Lao PDR context, are identified.

The policy analysis framework for cross-country comparison is described in Table 10.

Table 10: EV sector policy analysis framework

Aspect	Remark
Overarching vision document	A national-level document outlining the macro-level vision, rationale for EV adoption and sector-focused goals and strategies.
EV mandates in the country	• Shifting demand for vehicles to EVs in government departments, state-owned companies and urban local bodies. • Timeline for transition to EVs. • Vehicle segment-specific targets.
Taxes	• Taxes (customs duty, excise, VAT) that apply to EVs, batteries, cells, chargers, controllers and other components. • Road tax reductions or waivers (annual or one-time).
Capital subsidies on sale of EVs	• Based on the type of vehicles or capacity (battery). • Paid as a percentage of price or kWh of capacity with a cap.
Income tax credits	Credits given in income tax based on the purchase cost of the EV.
Registration of vehicles/licensing/ permits	Cost waivers or exemptions from licensing. This is especially important in the case of taxis and transport vehicles. Some cities have capped the ICE taxis whereas the cap on EVs has not been imposed.
Feebates	These are fees that are raised on polluting technologies (e.g., ICEVs) to finance rebates on clean technologies (e.g., EVs): • Special tax on fossil fuels. • Additional parking charges for ICEVs. • Additional road tax or registration tax on ICEVs. • Special tax on commercial vehicle fares (e.g., bus tickets, taxi fares) • Additional VAT on the sale of ICEVs.
ICEV scrapping incentives/buy-back programs	Incentives for existing users to sell the ICEV back to a government-appointed agency that will scrap the ICEV and give credit to buy an EV.
Preferential access rights	EV-only zones and roads, right to enter defined city areas, right to enter in restricted times and preferential parking rights.

Aspect	Remark
Development of charging infrastructure	Capital subsidies, mandates, charging tariff, fixed or demand charges, and land sale/ lease rates for charging infrastructure stations.
Financing	Financing approaches like interest subvention, partial risk guarantee, battery financing models, operating lease models and financial lease for vehicles.
Environmental obligations (battery disposal)	Post-life buy-back programs and extended dealer/producer responsibility.
Support for the EV manufacturing sector	• Special economic zones. • Favorable taxations – waivers for income tax, VAT, customs duty, excise tax. • Special access to government procurement programs. • Capital subsidies. • Low-cost financing.

Secondary research for four ASEAN countries was carried out to assess their policies promoting EVs, based on the framework described in Table 10. An overview of the results is presented in Table 11.

Table 11: Summary of policy support mechanisms in select ASEAN countries

	Policy area	Malaysia	Thailand	Singapore	Indonesia
1	Overarching vision document				
	EVs				
2	Mandates (general)				
	• Government procurement				
	• Transition to EVs (sales)				
	• Transition to EVs (vehicle stock)				
3	Taxes (concessions)				
	• Customs duty				
	• Excise tax				
	• VAT				
	• Annual road tax				
4	Capital subsidies on sale of EVs				
5	Income tax credits				
6	Registration of vehicles/licensing/permits				
7	Feebates				
	• Special tax on fossil fuels				
	• Additional parking charges for ICEVs				
	• Additional road tax or registration tax on ICEVs				
	• Special tax on commercial vehicle fares				
	• Additional VAT on the sale of ICEVs				
8	ICEV scrapping incentives/buy-back programs				
9	Preferential access rights				

	Policy area	Malaysia	Thailand	Singapore	Indonesia
	• Right to enter defined city areas				
	• Right to enter in restricted times				
	• Preferential parking rights				
	Charging infrastructure				
10	Capital subsidies				
	• Public charging stations				
	• Swap stations				
	• Private charging stations				
11	Mandates				
12	Charging tariff				
11	Fixed or demand charges for charging infrastructure stations				
12	Financing EV sector (EVs, charging infrastructure)				
	• Interest cost subvention				
	• Partial risk guarantee				
	• Battery financing				
	• Operating lease				
	• Financial lease				
13	Battery disposal				
	• Post-life buy-back programs				
	• Extended dealer/producer responsibility				
15	Manufacturing				
	• Special economic zones				
	• Income tax waivers				
	• VAT, customs duty, excise tax waivers				
	• Special access to government procurement programs				
	• Capital subsidies				
	• Low-cost financing				

Notes:

Provision exists

Draft provision

Findings from the assessment show that countries in the region are moving with similar goals to green the transport sector and introduce EVs, but with differing strategies. The next sub-sections provide more details on each policy area.

2.3.1 National-Level Overarching Vision Document

None of the ASEAN countries have dedicated EV policies in place. However, they have developed national policies or strategies that include the adoption of EVs. Malaysia's EV promotion is guided by the 2014 National Automotive Policy, and EVs are considered under the Energy Efficient Vehicle Program. In Thailand, a 20-year national strategy for advanced development called Thailand 4.0 has been introduced and EV promotion is integral to the transport sector plan under the strategy document. Singapore is guided by the Sustainable Singapore Blueprint 2015 and Smart Mobility 2030 that envisage an EV-based shared transport system.

2.3.2 Transition to EVs: Mandates and Targets for EVs

All four focus countries have defined generic targets for EV adoption (Table 12).

Table 12: EV targets for select ASEAN countries

	Malaysia	Thailand	Singapore	Indonesia
EV target	100,000 electric cars, 2,000 electric buses, 100,000 electric four-wheelers by 2030 (Malaysian Investment Development Authority 2017)	1.2 million EVs by 2036 (Parpart 2019)	1,125 EVs by 2020 (See 2020)	2.1 million electric motorcycles and 2,200 electric cars by 2025 (Medimorec 2019)

Malaysia plans to be the EV market leader in the region, and has the most aggressive targets among the four countries with aims to have 100,000 electric cars, 2,000 electric buses, and another 100,000 electric four-wheelers on the roads by 2030 (Malaysian Investment Development Authority 2017). Thailand plans to introduce 1.2 million EVs by 2036, and is encouraging the use of EVs by government offices, nationalized industries and public transport systems. Government offices are advised to devote 20% of their budget to buy EVs and the Bangkok Mass Transit Authority has been advised by the government to buy 200 electric buses (Grütter and Kim 2019). Indonesia is targeting for 25% of all vehicles produced to be electric by 2030, (Suhartono and Singgih 2019), or more specifically, 2.1 million electric motorcycles and 2,200 electric cars by 2025 (The Manila Times 2019). Singapore is adopting a unique approach by introducing a car-sharing mechanism (Audenhove, et al. 2018).

2.3.3 Tax Regime to Support the Transition to EVs

Annual road tax

Malaysia has targeted incentives in place for EVs with electric and plug-in hybrid vehicles having to pay just 50% of road taxes (Ashaari 2019). Indonesia is planning to introduce a road tax exemption incentive for EVs (Silviana and Suroyo 2019).

Vehicle excise tax

Thailand has a favorable excise tax regime for EV producers at reduced rates of 2-10%, while for conventional vehicles their excise tax ranges between 10% and 30% (Grütter and Kim 2019).

Other taxes (in special economic zones)

In Indonesia, all entities operating in special economic zones qualify for postponement of import duties, exemption on excise taxes and VAT, and reduced rates or total exemption of sales taxes and local taxes (Roux and Schoeman 2016). Similarly, in Malaysia, entities operating in special economic zones qualify for exemption on customs duty, excise tax, sales and service tax, and income tax for 5-10 years (Roux and Schoeman 2016).

2.3.4 Charging Infrastructure Development

In support of planned EV deployment, the charging infrastructure is critical and the select countries from the ASEAN region have developed targets to increase the number of charging stations (Table 13). Thailand plans to install 7,000 charging stations in the country by 2036, Singapore has plans for 500 charging stations and 2,000 charging points by 2020 to support its car-sharing mechanism, and Malaysia currently has 251 charging stations.

Table 13: EV charging infrastructure targets for select ASEAN countries

	Malaysia	Thailand	Singapore	Indonesia
Target	Currently has 251 charging stations (Malaysia Automotive Robotics and IoT Institute 2019)	7,000 charging stations by 2036 (Parpart 2019)	500 charging stations and 2,000 charging points by 2020 (Lim 2018)	-

2.3.5 Charging Infrastructure Development Support

In Indonesia, companies producing EV batteries are entitled to tax holidays (Nangoy and Christina 2019). Thailand is considering an 8% reduction in excise taxes levied on EV batteries to support local battery production (KPMG 2018).

2.3.6 Capital Subsidies

In Malaysia, all charging stations are government-owned, therefore, their establishment and management are well supported by the government. Thailand, on the other hand, has a mix of public and private charging assets, and is using the Energy Conservation Fund to subsidize about 40% of the charging stations. As of March 2018, the government had provided US$1.5 million from the Energy Conservation Fund to support 125 charging stations (Harman 2018). In addition, the government is providing import duty exemptions for machinery and equipment required for charging stations, and suspending corporate tax until 2021 (Yongpisanphob 2017).

2.3.7 Feebates

In none of the select ASEAN countries, fossil fuels are overtaxed to support EVs. But some countries directly charge polluting vehicles. In Thailand, for example, the excise tax for vehicles is dependent on the carbon dioxide emission standards for vehicles (Lye 2019). Similarly in Singapore, ICEVs have to pay high charges for emissions (Ng 2020). Other elements of feebates like additional parking charges for ICEVs, additional road tax or registration tax, special taxes on commercial vehicles fare, or additional VAT on ICEVs do not exist in the focus countries.

2.3.8 Preferential Access Rights

In Malaysia, a project for building a route and highway for electric buses in the capital city of Kuala Lumpur is underway (Parpart 2019). In addition, the country has roads and lanes marked only for two-wheeler use (Gitano 2018), and is developing EV-only parking and driving lanes (Silviana and Suroyo 2019). Similarly, Indonesia plans to introduce a policy that will result in establishing special parking zones for EVs (Suhartono and Singgih 2019).

2.3.9 Battery Disposal Management

Although countries are promoting EVs for environmental reasons, safe and environmentally friendly disposal of used batteries is not strongly regulated in any of the four ASEAN countries. Due to the economic benefits of battery recycling, some countries have domestic industries engaged in waste battery recycling.

In Thailand, EV battery disposal is regulated by the Hazardous Substance Act 1992 (amended in 2013) (Chareonsong 2014). Some private sector initiatives have emerged such as Toyota's establishment of a used battery management plant in the country that accepts batteries from other vehicle manufacturers, as well as other electronic and electrical devices (CTN News 2019).

Indonesia has become the largest recycler of lead-acid batteries in the ASEAN region. All the materials in these batteries can be recycled, and more than 200 battery smelters have sprouted in the country (Zakiyya, Distya and Ellen 2017).

Malaysia's Solid Waste and Public Cleansing Management Act 2007 has a provision for electronic waste management with a specific article dealing with take-back, deposits and refunds (Tran and Salhofer 2018).

2.3.10 Manufacturing Sector Support

The Government of Thailand has introduced a number of incentives to promote EV production. Manufacturers producing more than one key EV components have an additional year of tax exemption per key component, capped at a maximum of 10 years (Largue 2018). In addition, the Thailand Board of Investment has announced new investment privileges to reduce excise tax from 8% to 2% for qualified auto manufacturers planning to produce hybrid EVs, plug-in hybrid EVs and battery EVs[6], effective until December 31, 2025 (KPMG 2018).

In Malaysia, the National Automotive Policy 2014 provides an investment tax allowance of 100% until 2024 for those investing in the energy-efficient vehicles sector.

2.3.11 Summary

The framework developed in this section is applied to develop an EV-specific policy and regulatory gap analysis for Lao PDR and generate policy lessons for the country, particularly in vehicle sector standards harmonization with the ASEAN region. The analysis and lessons are presented in the next sub-section of the report.

[6]There are three main types of EVs, categorized by the degree that electricity is used as their energy source: (1) hybrid EV; (2) plug-in hybrid EV; and (3) battery EV.

2.4 Analytical Model to Define Policy Measures for EVs

To derive EV deployment policies for Lao PDR, a comprehensive analytical model has been developed and a comparative analysis between baseline ICEV and projected EV penetration has been carried out. From a macro perspective, the economics of the overall impact of EVs on the country has been studied and from the EV user perspective, a TCO comparison between ICEVs and EVs has been carried out across vehicle segments. This analysis is discussed in detail in the subsequent sub-sections and forms the basis for arriving at policy recommendations to support EV deployment in the country.

To develop the model for economic analysis and TCO comparison, vehicle models and specifications that can potentially replace existing ICEVs have been identified. This is essential to arrive at the values critical for developing and running a quantitative analytical model.

Guided by the project scope, five vehicle segments have been considered for analytical reasoning and comparative analysis between ICEVs and EVs (three-wheelers have not been considered in the analysis as the Government of Lao PDR is phasing out such vehicles). Considering the diverse range of ICEVs that Lao PDR imports from various countries, only those models with good market presence in the ASEAN countries and preferably, enjoying popularity among the Lao people (from the imports and sales perspective), have been chosen for the TCO analysis. Among the EVs, only the better performing lithium-ion models from the ASEAN region (based on battery life, range, efficiency, etc.) have been considered.

- The following EVs models across vehicle segments have been considered for analysis:
- **Electric bicycles** – The 0.3kWh City Commuter Electric Bicycle has been evaluated from a TCO perspective. No comparative ICEV type has been considered for this vehicle segment.
- **Two-wheelers** – A 110cc ICEV model is compared with a 2kWh EV two-wheeler.
- **Cars** – A 1,600cc ICEV model is compared with a 30kWh electric car.
- **Minibuses/vans** – A 2,500cc ICEV model is compared with a 36kWh model.
- **9-meter buses** – An 80kWh electric bus model is compared with an equivalent ICE bus with matching specifications.
- **12-meter buses** – A 324kWh electric bus model is compared with an equivalent ICE bus with matching specifications.

The technical specifications and the cost trends for each EV type (selected models) are provided in Appendix 3. All cost estimations include excise tax rates of 3% for EVs.[7] All other taxes are considered to be the same for ICEVs and EVs (as concluded from the stakeholder consultation).

To analyze the economics of EV penetration in the country, it is essential to understand how the vehicle composition in Lao PDR is going to change over the years. The consultant has generated the vehicle mix (for the EV scenario) based on the available projections on registered vehicles for the year 2030 and the country's aspiration to have 30% EV penetration by 2030 (PricewaterhouseCoopers 2018).

[7]As per the Lao PDR's 'Draft Law on Taxation' dated 10th July 2019

Table 14: Projected number of registered vehicles in Lao PDR

Vehicle segment	2030	2050
Two-wheeler	2,426,985	3,895,448
Three-wheeler	10,341	13,217
Car	132,495	227,333
SUV	568,325	942,802
Truck	96,749	159,410
Bus	7,338	11,533
Total	**3,242,233**	**5,249,653**

EV penetration for the country is based on the following:

- The vehicle stock is the sum of the number of old vehicles, replacement and new purchases made by the users.
- The replacement rates for different vehicle segments have been considered for estimating the vehicle market size and its growth (Table 15).

Table 15: Vehicle segments and replacement rate

Vehicle segment	Replacement rate (% per annum)
Two-wheeler	5.0
Car	3.0
Minibus/van	3.0
9m bus	2.0
12m bus	2.0

- Currently, EV deployment in Lao PDR is in a nascent stage. Electric bicycles do exist, but its presence is sporadic. Hence, EV penetration is considered to be zero in 2019, the base year. EV penetration is projected to be 1% in 2020, reaching 2% in 2021 and expanding by 6% in subsequent years. From 2023 onwards, EV penetration is projected to grow annually at a uniform rate to hit the desired 30% level by 2030.
- Electric bicycle is a new vehicle segment. Due to associated convenience, cost and hassle-free operations, electric bicycles are projected to become a preferred vehicle of choice for students, officegoers and others to support regular short commutes. Electric bicycles are not covered under road transport regulations, which reduce the hassles involved in owning a vehicle. To estimate this vehicle segment, the following assumptions are made:
    - The population in the country is projected to grow at a flat rate of 2% per annum and will expand from the current 6.86 million to 8.5 million by 2030.
    - Lao PDR currently has low vehicle penetration (including bicycles). From vehicle ownership of 27% in 2019, it is projected to hit 40% by 2030,[1] thus vehicle penetration should experience a compound annual growth rate of 4%.

Considering the above assumptions, EV sales projection and the proportion of ICEV and EV sales are estimated. In 2020, new EV sales are expected to vary from 12% (two-wheelers) to 21% (9m and 12m buses), excluding electric bicycle sales figure. Considering the high share of electric buses in new sales, this is the vehicle segment where EVs will quickly surpass total new ICEV sales (in 2023). For the two-wheeler segment, EVs will surpass ICEV sales in 2027. See Table 16 for ICEV and EV sales comparison across the years (the green boxes indicate years when EV sales are higher than ICEV sales).

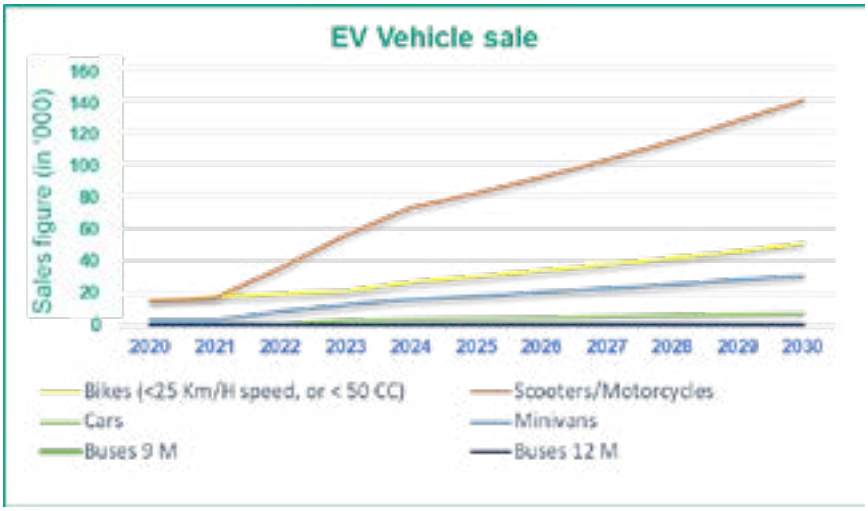
Table 16: Comparison of ICEV and EV sales by year

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Two-wheelers											
Cars											
Minivans											
Buses 9M											
Buses 12M											

Note: The green boxes indicate years when EV sales are higher than ICEV sales.

EV sales are projected to grow every year, reaching 230,000 EVs in 2030, with two-wheelers constituting the largest segment of EV sales at 82% (Figure 3).

Figure 3: EV sales projection in Lao PDR



2.4.1 TCO Model

The capital cost of EVs is higher than ICEVs, while the operational costs of EVs are lower than ICEVs. Hence, a TCO analysis has been carried out to compare the lifetime costs of EVs with that of ICEVs. In the TCO-based approach, despite the initial high capital expenditure of EVs, the high life-time cost of operating the relatively cheaper ICEVs gets factored-in, and a better measure of vehicle ownership cost estimation is made available that can guide new purchase decisions. The analysis focuses on the period 2020-2030, with 2020 being the year when EVs are introduced in the country.

2.4.2 TCO Calculation

As discussed in Section 2.2, EVs currently have high capital expenditure. Although technologically competitive, they do not have an initial cost advantage over ICEVs.

In the TCO analysis, all factors that have cost implications for the vehicle owner/operator are considered. Apart from initial capital investment, there are regular costs such as fuel, maintenance, repairs, debt cost, vehicle depreciation, various fees and taxes, and insurance charges incurred over the twenty-year lifecycle of a vehicle. For EVs, battery charging and its replacement add to the cost. Here it should be noted that EV prices are going down and the year 2023 will be an important milestone for it is expected that by this year, EV prices will stabilize and will not depreciate at current (high) rates. Thus, the TCO analysis across the years also factors in the technological development resulting in a reduction in EV prices.

[8]The ASEAN Statistics Division in its ASEAN key figures 2018 document shows that Brunei has a vehicle penetration of 97.1 vehicles per 100 people, Malaysia 89.7, Thailand 54.8 and Indonesia 49.9 in 2017.

Table 17: Cost factors considered for TCO analysis

Vehicle type	Upfront cost	Fuel cost	Electricity cost	Operations and maintenance	Battery replacement	Financing costs	Various taxes and fees	Insurance costs
ICEV	√	√	×	√	×	√	√	√
EV	√	×	√	√	√	√	√	√

Other factors that are considered in the TCO analysis include:

- The vehicle performance features – mileage, vehicle life, tire life, battery life, etc.
- The baseline taxes applicable to ICEVs and EVs, and EV charging rates.

The TCO_{ICEV} and TCO_{EV} for vehicles purchased in a particular year are compared for analysis.[9] Across different economic settings, a 20% cost differential between TCO_{ICEV} and TCO_{EV} is considered an ideal scenario for EV transition. This cost advantage is a qualitative threshold and it is experienced to act as an enabler when EVs are marred with issues like range anxiety, technology immaturity and lack of reliability. The TCO analysis summary in the form of the percentage point difference between the respective TCOs of ICEVs and EVs is presented in Table 18.

Table 18: TCO differential between ICEVs and EVs (in percentage)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Two-wheeler	22%	24%	26%	28%	30%	32%	32%	33%	33%	34%	34%
Car	6%	16%	26%	35%	37%	38%	38%	38%	39%	39%	39%
Minibus/van	20%	23%	27%	30%	32%	32%	33%	33%	33%	33%	34%
9m bus	16%	18%	21%	23%	24%	24%	24%	25%	23%	25%	25%
12m bus	-8%	-2%	12%	22%	23%	25%	25%	25%	26%	26%	26%

Notes:

- The values presented are the percentage point difference between TCO_{EV} and TCO_{ICEV}.
- Red cells denote TCO_{ICEV} - TCO_{EV} = <20%.

The conclusions that are drawn from the TCO analysis are as follows:

- TCO of EVs is less than TCO of ICEVs across vehicle segments (except for buses in the 12-meter segment where TCO_{ICEV} is less than TCO_{EV} for the years 2020 and 2021).
- From 2023, as EV prices reduce considerably and the market scales up, the TCO_{ICEV} - TCO_{EV} is more than 20% across all vehicle segments.

2.4.3 Impact of EVs on Government Revenue

In the previous section, we have seen that EV share in Lao PDR is projected to become 30% of the vehicle mix in the country by 2030. This has consequences for government income as different revenue streams linked with the transport sector will be impacted. The concessions offered to EVs will result in exchequer losses, and government revenue linked to the sales of vehicles and fuel will be impacted.

At the same time, the introduction of EVs will result in a net reduction in transport sector fuel demand, and therefore a reduction in the country's trade deficit[10]. Rising EVs will have implications on other sectors – the service sector may witness growth, particularly for services related to the transportation of people and goods, and EVs will increase demand for electricity.

This sub-section analyzes the following impact of EV deployment on government revenue streams for the period 2020-2030:

[9] Net present value for the vehicles purchased in the year are compared

[10] During 2004-2019, the average annual imports of the country were US$730 million (Trading Economics 2019c) and the average annual exports were US$553 million (Trading Economics 2019b).

- Impact on government revenue due to changes in the sales mix of vehicles;
- Impact on government revenue due to reduced demand for transport fuel; and
- Impact on the Road Fund.

Impact on government revenue due to changes in the sales mix of vehicles

Vehicles in Lao PDR are subject to three types of taxes – excise tax, import duty and VAT. All these taxes are imposed on the value of imported or sold goods or items (Table 19).

Excise tax – Currently, there is a differential excise tax charged on new vehicle sales. The ICEVs considered as part of this study are charged a low of 5% for buses, and a high of 40% for minibuses. The excise tax can be as high as 90% for certain luxury cars. A concessional excise tax of 5% is charged on clean vehicles (EVs qualify as clean vehicles), and the government has proposed to increase the tax concession from March 2020 and levy a reduced excise tax rate of 3%.

Import duty – Lao PDR has tax treaties with China and ASEAN countries to reduce import-export barriers and no taxes are levied on items imported from such countries. In all likelihood, EVs in the country will be imported from China and ASEAN countries, hence no import duties have been considered for EVs.

VAT – A flat VAT rate of 10% is applied across categories including vehicles and there is no indication by the government to relax the VAT rate for EVs.

Table 19: Taxes applicable to ICEVs and EVs (in percentage)

Tax type	Two-wheeler	Car	Minibus	9m bus	12m bus	EVs (all segments)
Excise tax	10-70%	25-90%	40-90%	5%	5%	3%
Import duty	0%	0%	0%	0%	0%	0%
VAT	10%	10%	10%	10%	10%	10%

After 2020, the change in the vehicle sales mix will have a net negative impact on government revenue as collections linked to excise tax on ICEVs will fall due to projected decrease of new ICEV sales. The excise revenue collected from EVs will not be able to compensate for such losses since the excise tax rate levied on EVs is less than ICEVs. The VAT collected from EV sales will initially be high since EVs have a comparatively higher capital expenditure, but as the price of EVs fall, the amount of VAT collected will also drop.

Besides excise tax, import duty and VAT, vehicles in Lao PDR are subject to multiple fees and taxes payable to the Transport Department (Table 20).

Table 20: Fees and taxes levied on ICEVs by the Transport Department

Fee/Tax	Fee/tax range across vehicle segments (LAK)	Frequency of payment
Annual road tax	15,000-500,000	Annual
Licensing fee	93,000-105,000	Every 5 years
Registration fee	88,000-113,000	One time
Inspection fee	50,000-200,000	Every 5 years

In the analysis, all the fees and taxes for EVs have been pegged with comparative ICEVs. Theoretically, there is no difference between these other fees and taxes in the baseline scenario (when no new policies to support EV deployment are introduced) and the EV scenario. But since in the EV scenario electric bicycles are being considered and they are exempt from these other fees and taxes, the EV scenario results in a very slightly lowered taxes and fees collection rate as compared to the baseline scenario.

Impact on government revenue due to reduced demand for transport fuel

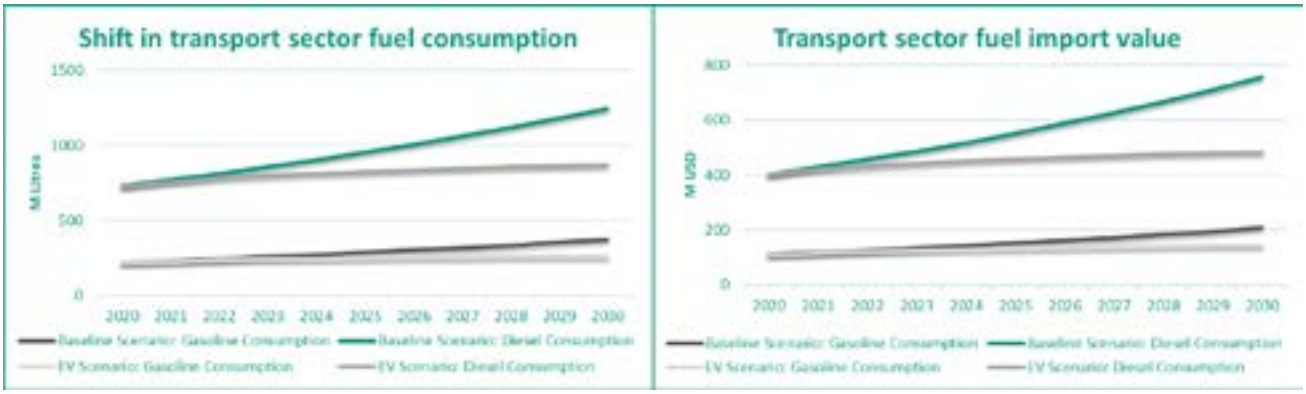
EV deployment will reduce the net demand for fossil fuel in the transport sector, and this will have two implications on the tax revenue of the country:

- Government revenue linked to taxes imposed on the import of fossil fuels will reduce; and
- The Road Fund collected from gasoline and diesel sales at fuel dispensers will drop.

Based on comparisons between the baseline scenario and the EV scenario (Figure 4), annual gasoline requirement will fall by 2 million liters in the first year (2020) in the EV scenario, and the gap between the scenarios widens to 112 million liters in 2030. The demand decline for diesel fuel is relatively high, with the year 2020 witnessing a reduced demand of 7 million liters, which sharply widens to 373 million liters in 2030.

The corresponding decrease in fuel import is shown in Figure 4 (graph on the right). The values are derived from fuel prices trend. The dampened demand for oil will result in a reduction of US$1.16 million worth of fuel imports in 2020, and as EV penetration increases, by 2030, the net fuel import reduction will be equivalent to US$334 million.

Figure 4: Impact of EV deployment on transport sector fuel consumption and import



There are three taxes levied on fuel in Lao PDR (Table 21), and the reduced demand for fossil fuel will thus impact government revenue.

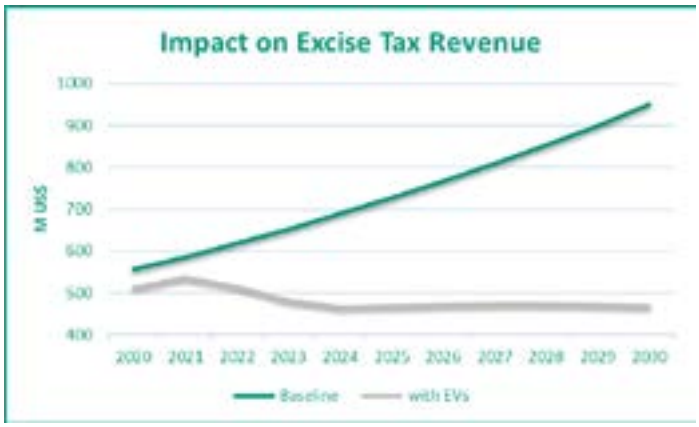
Table 21: Taxes levied on fossil fuel (in percentage)

Taxes levied on transport fuel	Gasoline		Diesel
	Super	*Regular*	
Import duty	20%	15%	5%
Excise tax	39%	34%	24%
VAT	10%	10%	10%

Revenue loss due to reduced excise collection

The impact of EV deployment on excise revenue is reflected in Figure 5. The rising share of EVs in the vehicle mix and falling EV prices will result in revenue loss of an estimated US$483 million by 2030, or about 50% of the baseline scenario.

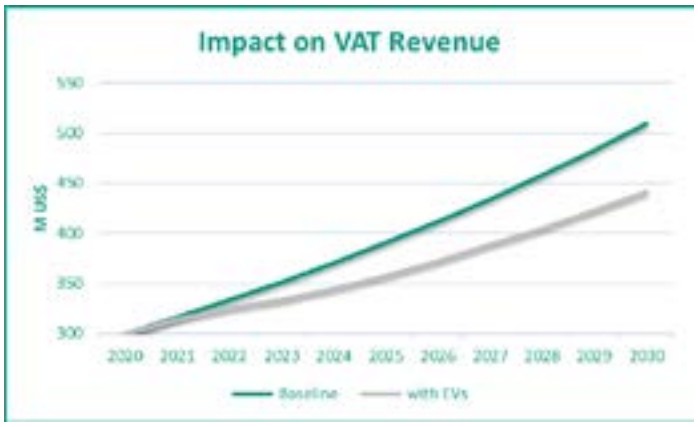
Figure 5: Impact of EV deployment on excise tax revenue from vehicle sales



Revenue loss due to reduced VAT collection

Since the EV unit price is high during the initial years, VAT collection from sales of EVs will also be high initially compared to the baseline scenario. But due to the fall in fossil fuel sales, the net impact on VAT collection will be negative. The VAT collection value is presented along with the VAT losses due to reduced fuel demand in Figure 6.

Figure 6: Impact of EV deployment on VAT collection for vehicle and fuel sales



Impact of EVs on the Road Fund

The Road Fund is charged on fuel sales at fuel dispensers. Considering the projected EV mix in the country, the shrinkage of the Road Fund is expected as the number of EVs increases and fuel sales decrease. The Road Fund deficit is estimated to be US$0.56 million in 2020 and US$29 million by 2030 (Figure 7).

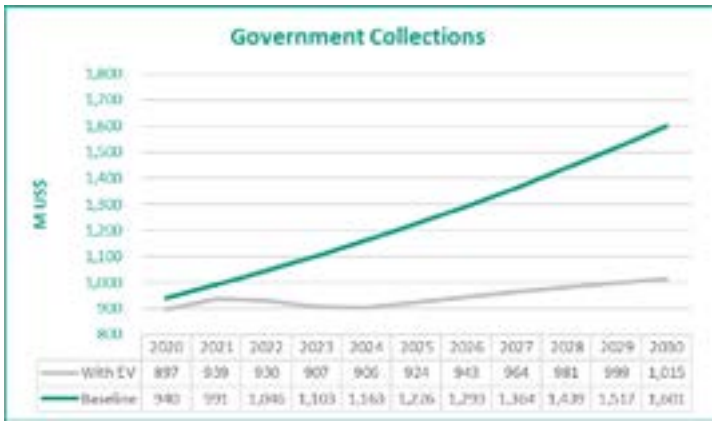
Figure 7: Impact of EV deployment on the Road Fund

Net impact of EV deployment on government revenue

The net impact of EV deployment is a net reduction in government revenue (Figure 8). During the initial years when EV deployment is in the nascent stage, the deficit is small, but it increases to about 36% (US$586 million) in 2030 when the number of EVs in the country grows substantially.

The analysis considers all revenue sources (vehicle sales, fuel sales and electricity sales) and revenue collection tools (excise tax, import duty, VAT, Road Fund, and other fees and taxes). The changes in EV prices post-2023, fall in fossil fuel demand and the tax collection linked to increased electricity usage defines the revenue curve for the EV scenario.

Figure 8: Net impact of EV deployment on government revenue



2.4.4 Summary

The TCO analysis for the baseline policy scenario (when no new policies to support EV deployment are introduced) establishes that EVs have a cost advantage over ICEVs (refer to Section 2.4) despite high capital expenditure, but the TCO differential is not significant until the crossover point is hit (i.e., when EVs' upfront purchase price is at par with equivalent ICEVs). Thus, to achieve fast EV deployment the government will have to design interventions to bring down the cost of EVs.

In the baseline scenario, EVs will result in a positive balance of payment but will also negatively impact government revenue streams, creating a deficit of US$3,278 million from 2020 to 2030. This will mainly be due to special excise tax rate on EVs, loss of revenue from reduced petroleum fuel sales and transport sector-related taxes and fees, and shrinkage of the Road Fund. In order to counter the revenue losses from the transport sector, the government will have to introduce specific fiscal measures. As such measures are applied, the ICEV and EV operating cost parameters will change, which is analyzed in the next sub-section of the report.

2.5 Proposed Policy Measures for EV Deployment

EV deployment will lead to a cumulative gross revenue deficit of US$3,278 million from 2020 to 2030. In this section, policy measures to support EV deployment and reduce the revenue losses to the government are analyzed. A TCO analysis was carried out to check the appropriateness of the approaches identified.

2.5.1 Policies for Revenue Replenishment

The direct revenue losses due to EVs can be recovered from EVs by applying the excise tax rates and Road Fund charges to EVs.

Phasing out and removal of the excise rate cut

Under the existing tax regime, a reduced excise tax rate of 3% has been prescribed for EVs, while the excise tax on imported ICEVs varies from 5% to 90% (depending on the vehicle type and engine capacity).

Table 22: Baseline excise rates and suggested excise rates in the EV scenario (in percentage)

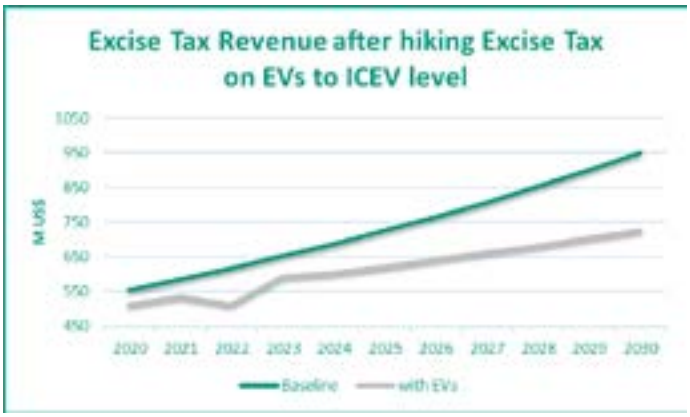
Tax type	2020	2021	2022	2023	2024	2025-2030
ICEVs (baseline)						
Two-wheeler	10-70%	20-70%	20-70%	20-70%	20-70%	20-70%
Car	25-90%	25-90%	25-90%	25-90%	25-90%	25-90%
Minibus	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%
9m bus	5%	5%	5%	5%	5%	5%
12m bus	5%	5%	5%	5%	5%	5%
EVs						
Electric bicycle	3%	3%	3%	*20.00%*	*20.00%*	*20.00%*
Two-wheeler	3%	3%	3%	*20-70%*	*20-70%*	*20-70%*
Car	3%	3%	3%	*25-90%*	*25-90%*	*25-90%*
Minibus	3%	3%	3%	*25.00%**	*25.00%**	*25.00%**
9m bus	3%	3%	3%	*5%*	*5%*	*5%*
12m bus	3%	3%	3%	*5%*	*5%*	*5%*

Notes:
* A special excise tax rate is recommended to maintain the cost advantage of electric minibuses and vans over their ICEV counterparts, considering their application for commercial purposes.
The numbers in blue italics font are the proposed excise tax rates.

Currently, EV prices are not competitive with ICEV prices, but considering technological advancements, EV prices are expected to fall considerably in 2023 (refer to Section 2.2 and Appendix 8 for details) and decrease at a slower rate after 2023. When EV prices are at par or lower than ICEV prices by 2023, it is suggested that the Lao government brings the excise taxes at par with the corresponding ICEVs. This will help to capture the excise losses to the government.

The increase in excise tax rate for EVs will reduce the deficit in government revenue but will not be able to completely recover the losses. Since excise tax is applied to the value of the vehicle, the gap in tax revenue between the EV and baseline scenarios will narrow initially with the increase in excise tax rate for EVs. But with the expected drop in EV prices, the gap will widen again, as shown in Figure 9.

Figure 9: Impact of raise in EV excise taxes to ICEV levels



Mileage fee for EVs

The Road Fund is charged based on the user pays principle. Logically, periodic road user charges should be levied upon EVs based on the odometer reading of the respective vehicle to help replenish the Road Fund.

A mileage-based user charge can be assessed by a periodic recording of the vehicle's odometer. However, there are two major concerns linked to this approach: (1) the malfunctioning of odometers or meter tempering; and (2) vehicle weight is not taken into consideration – both heavy and light users in the same vehicle segment are equally charged irrespective of the vehicle's physical impact on the road.

EVs are generally smarter than ICEVs for there are certain aspects of the vehicle that need to be communicated with the driver on a real-time basis (e.g., state of charge and optimized charging decision). In EVs, the recording of vehicle mileage will be tamperproof. Thus, odometer reading-based mileage charges can be levied as contributions to the Road Fund.

Various successful road fee-based systems exist. For example, Oregon State in the USA has introduced a GPS-enabled system that estimates the miles traveled by the vehicle and accordingly calculates the road user charges (but does not map vehicular movement) (Kirk and Levinson 2016). New Zealand has a more comprehensive road user charge collection system based on the distance traveled, and to account for the weight of the vehicles, nominal vehicular weight (not the actual weight) is considered (Kirk and Levinson 2016).

Based on the analytical model developed, estimates of the "per kilometer charges" to be collected from EVs have been calculated for different vehicle segments (Table 23). It should be noted that electric bicycles are exempted from any road fees due to logistical issues in collecting periodic fees.

Table 23: Suggested mileage fee for EVs

Road Fund for EVs	US$/km	LAK/km
Bicycle	0	0
Two-wheeler motorcycle	0.0010	9
Car	0.0061	54
Minibus/van	0.0061	54
Bus	0.0196	173

2.5.2 Impact of Revenue Replenishment Measures on EV TCO

In section 2.4, it is established that the TCO of EVs is lower than the TCO of ICEVs. But the increase in excise tax rate along with Road Fund charges will reduce the competitiveness of EVs. Thus, additional financing support measures will have to be introduced to maintain EV TCO competitiveness over ICEVs (discussed in detail in the next sub-section) and such support will require funding from the government.

2.5.3 Financial Incentives and Subsidies for Making EVs Cost Competitive

As discussed in Sections 2.2 and 2.4, EVs with high capital expenditure are technologically competitive and have a TCO advantage over ICEVs. But by applying revenue replenishment measures, such as bringing excise tax rates at par with ICEVs from 2023 and imposing road use charges on EVs, as well as levying a public benefit surcharge on fuel sales and increasing the electricity tariff from 2025 for EV charging (discussed below) – the relative TCO advantage of EVs shrinks.

Table 24: TCO differential between ICEVs and EVs after applying revenue replenishment measures (in percentage)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Two-wheeler	22%	24%	26%	19%	20%	22%	22%	23%	23%	24%	24%
Car	6%	16%	25%	17%	19%	20%	20%	20%	21%	21%	22%
Minibus/van	19%	22%	25%	16%	16%	16%	16%	16%	16%	16%	16%
9m bus	14%	16%	18%	19%	19%	19%	19%	19%	19%	19%	19%
12m bus	-11%	-2%	6%	14%	14%	14%	13%	13%	13%	13%	13%

Notes:

- The values presented are the percentage point difference between TCO_{EV} and TCO_{ICEV}.
- Red cells denote TCO_{ICEV} - TCO_{EV} = <20%.

Considering the technology transition barriers and uncertainties that EV users will be subject to, it is suggested that EV TCO remains at least 20% lower than ICEV counterparts. To improve the TCO of EVs, direct financial support to vehicle buyers will need to be provided. Such support is only expected to be required for the first few years as EV prices are falling sharply and are projected to stabilize in 2023.

A TCO-based approach is applied to compare the impact of replenishment measures on the cost competitiveness of EVs and corresponding ICEVs (refer to Section 2.4 and Appendix 3 for the different vehicle models considered in the analysis).

The TCO model is designed to arrive at an EV support program that results in a 20% advantage in favor of EVs. Based on this model, financial provisions for EV users are identified and analyzed. The government will require additional resources to fund such an approach.

2.5.4 Public Benefit Surcharge

The financing of government support for EV deployment will require a regular flow of funds. An additional tax is suggested – to be collected in the form of a surcharge on fossil fuel sales to the ICEVs. This charge is more of a feebate for it cross subsidizes the EVs by taxing the polluting ICEVs.

The quantum of funding requirement will change (rise) as the number of EVs increases in the vehicle mix and fuel sale drops over the years. Hence, the rate at which the surcharge is collected needs to be revised over time to match the financing support requirement for EV deployment.

Table 25: Suggested public benefit surcharge on fossil fuel

Public benefit surcharge	Rate and remark
Level 1	6% in 2020, and gradually increase to 10% in 2022
Level 2	10% from 2022 onwards

A surcharge of 6% starting in 2020 has been proposed, which can gradually be increased to 10% from 2022 onwards.

2.5.5 Financial Provisions for EV Deployment

The EV capital expenditure is currently high compared to the equivalent ICEVs. The current vehicle loan products are not fit to finance EVs. Thus, tailored loan products with specific features for EVs will have to be designed.

Financial institutions such as banks, non-banking financial companies and vehicle leasing companies will play a critical role in facilitating EV deployment in the country. Vehicle financing is rapidly growing in Lao PDR (post-2015) – in 2019, there were more than 25 institutions offering vehicle financing products. The two-wheeler and car segments are well catered to, while the larger, more expensive vehicles are serviced by loans with longer tenure. The features of existing ICEV loans offered by banks and other financial institutions are summarized in Table 26.

Table 26: Existing vehicle financing product features in Lao PDR

Terms	Two-wheeler	Car	Minibus	Bus
Interest rate per month	1.3-1.5%	1.1-1.3%	1.1-1.3%	
Lease (eq. declining balance)	1.6 -2.0%	1.6-1.8%	1.6-1.8%	
Loan (declining balance)		1.0-1.2%	1.0-1.2%	8-10%
Tenure (years)	3	5.5-6	5.5-6	6+

Financial institutions in the country have not experimented with EV financing, hence they are enthusiastic yet concerned about the following challenges that EV financing may pose:

- EV-focused financial products do not exist in the country – there is no experience in EV financing and the risks associated with such products;
- EV prices are falling fast, adding to the challenges with EV financing (residual value realization will be less);
- There is uncertainty around EV market size and its growth in the country (e.g., the EV infrastructure is missing and policies are to be announced); and
- Specific to individuals who will be first-time borrowers (especially true for electric bicycle owners), the lack of credit history or creditworthiness will be a challenge for financiers.

Despite these challenges, EV financing in Lao PDR is projected to grow fast. Financial institutions with business interests in vehicle financing will have to necessarily engage in EV financing. But participation in EV financing has high barriers, thus, financial institutions will have to be encouraged and incentivized to participate during the initial EV deployment phase in the country.

The proposed financing support mechanism focuses on reducing the financing cost of EV buyers and helps

safeguard the interest of EV financing institutions.

Interest subvention

A financing facility could be established for interest subvention and managed by the Ministry of Finance, MPWT or an appropriate public sector enterprise, partnering with banks and financial entities to promote EVs. The facility would be used to reduce the interest burden on EV loans. This would not only help make EVs more affordable but would also reduce financing risks.

It is suggested that 50% of the interest cost on the EV loan be provided as a grant and paid to the lender directly. Other features of the proposed interest subvention scheme include the following:

- Interest grant may be capped at 0.5% per month;
- Interest grant may be provided for a maximum duration of six years;
- The interest rate charged to a borrower may be capped; and
- The scheme could be availed until 2023.

Partial risk guarantee on bank financing of EVs

A dedicated fund would help contain the risk exposure of financial institutions in circumstances leading to borrowers failing to abide by contractual obligations. By partially sharing the credit risk exposure of participating banks, this financing facility would help financial institutions participate in EV financing. Key features of the fund include the following:

- **Risk cover** – The risk guarantee would be limited to 50% of the loan residual value for loans up to 80% of the purchase cost of the vehicle. Also, the risk guarantee would cover up to 50% of the financing portfolio of a participating lender. The fund would not support full risk exposure of the financial institution (avoiding perverse incentive).
- **Service charges** – The financing facility would offer such risk cover on payment of a low guarantee fee.
- **Refinancing support** – The fund would provide refinancing support for 20% of the vehicles and extending it for three years, thus the fund size would total up to about US$200 million.

The facility could be expanded to support new business models such as battery financing or charging stations, including battery swapping facilities.

Expectations post-2023

As discussed in the report, the EV market will be different after 2023 as:

- EV prices will fall considerably;
- EV technology will have evolved, and infrastructure will have been developed considerably, improving the acceptability of EVs as a substitute to ICEVs; and
- As the EV market matures, so will the demands from buyers. Equipped with EV experience, financial institutions will have enough information to develop mature EV financing products.

Hence, all suggested financial assistance is for three years only. Beyond 2023 the EV market will have matured enough to operate without external support.

Direct financing subsidy

The TCO analysis after interest subvention suggests that EVs in all vehicle segments will be highly cost competitive (20%), except for the 12m bus segment. These 12m buses will be operating on inter-city routes, thus, will require

high-capacity batteries, which explains why the capital expenditure for such buses will be very high compared to the ICEV counterparts. Specifically for electric 12m inter-city buses, a targeted subsidy is suggested in order to encourage transport service providers to switch to EVs.

Only electric 12m buses that are procured to cater to inter-city long distances will be eligible for such subsidy support. It is suggested that the subsidy contributes 30% of the vehicle cost, and as the price of electric buses falls, the subsidy can be withdrawn after three years (Table 27).

Table 27: Features of a direct financing subsidy mechanism

Subsidy features	
Eligible vehicle	**Electric 12m inter-city buses**
Grant support	30% of the vehicle cost
Number of years the capital subsidy is available	3 years

2.5.6 Financial Burden of the Subsidies Offered to EVs

The interest subvention and capital subsidy will be low during initial EV deployment, but will peak when EV penetration increases. As EV prices stabilize, subsidy support can be gradually withdrawn. Direct financial support for the electric 12m buses should peak in the third year and can be subsequently withdrawn.

Figure 10: Interest subvention and capital subsidy for EV deployment

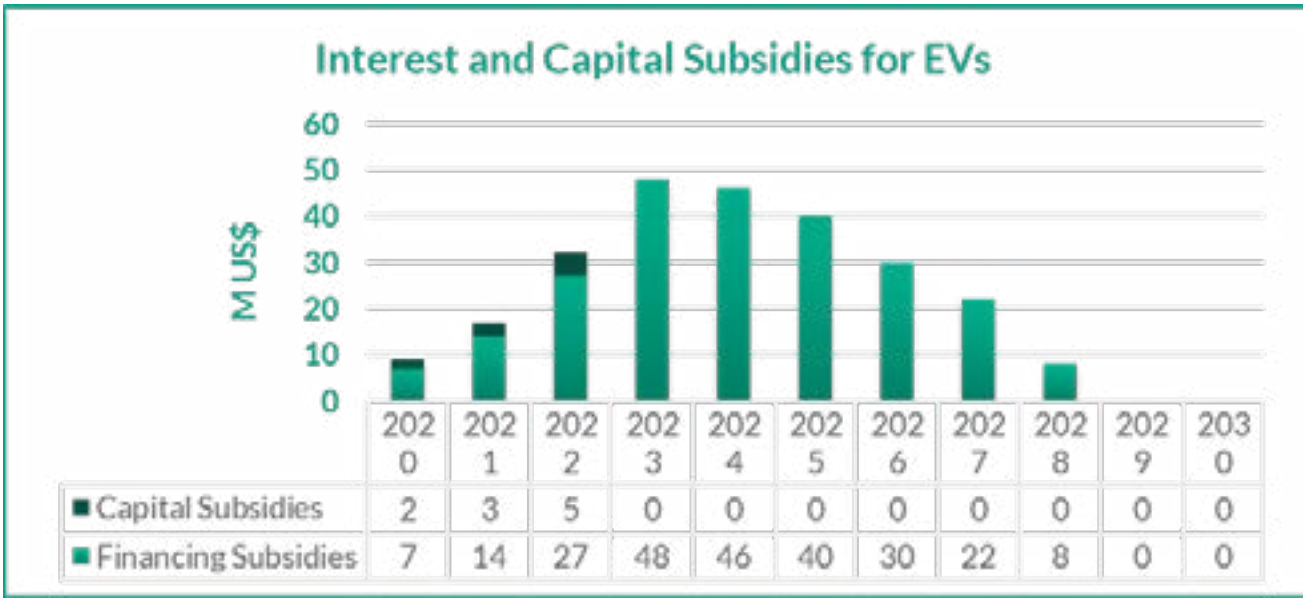


Figure 10 captures the financial burden of the interest subvention and capital subsidy schemes. As shown, assistance will peak in 2023 at US$48 million, and gradually decrease as EV-supporting provisions are withdrawn after 2023.

2.5.7 TCO Comparison

The combined impact of all financial provisions suggested (interest subvention for all EVs and capital subsidy for electric 12m inter-city buses) gives a considerable TCO advantage to EVs over ICEVs across the years (especially during the initial years) and is presented in Table 28.

Table 28: TCO differential between ICEVs and EVs after applying financial support measures (in percentage)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Two-wheeler	28%	30%	32%	25%	20%	22%	22%	23%	23%	24%	24%
Car	15%	24%	32%	25%	19%	20%	20%	20%	21%	21%	22%
Minibus/van	26%	28%	31%	23%	16%	16%	16%	16%	16%	16%	16%
9m bus	19%	21%	23%	24%	19%	19%	19%	19%	19%	19%	19%
12m bus	16%	22%	27%	18%	14%	14%	13%	13%	13%	13%	13%

Notes: The values presented are the percentage point difference between TCOEV and TCOICEV.

The financial support for EVs results in ensuring at least 20% TCO advantage for EVs over ICEVs, especially during the first three to four years of EV deployment. The TCO gap is comparatively low for vehicles purchased in 2020 but increases significantly beyond that. After 2023, when financial support is withdrawn, the TCO gap across vehicle segments shrinks but EVs remain more competitive than ICEVs.

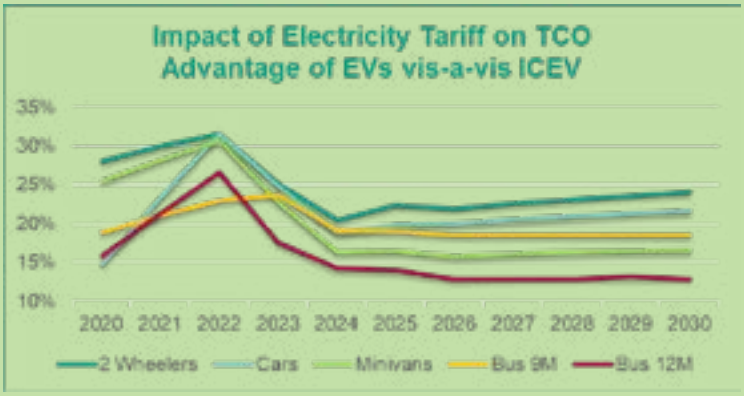
Box 1: Electricity Tariff and EV TCO Advantage

For all TCO analyses, estimation of the base tariff for home charging is LAK500/kWh and commercial charging is LAK650/kWh (as prescribed by EDL in 2019). The annual electricity tariff inflation is pegged with the projected foreign exchange depreciation rate, and is estimated by the consultant to be 1.908% per annum.

A sensitivity analysis carried out for ICEVs and EVs to assess the variances in TCO values with respect to increase in electricity tariff across vehicle segments shows that the variance in TCO for EVs is lower than the TCO for ICEVs for the tariff base rate of 2019. Also, after increasing the tariff to LAK1,000/kWh (tariff for commercial applications) after 2025, the EV cost advantage will still be above 15% (Figure 11). The exception will be for 12m buses, which may be given a special tariff.

The impending domestic power generation surplus in the country (expected in the coming years) can be profitably utilized locally if EVs are deployed on a large scale. Further, EVs can support the country's renewable energy programs if renewable energy sites are paired with EV charging. The introduction of EVs in the country will result in additional demand for electricity (estimated at 2,000GWh in 2030), thus the electricity sector utilities will witness a rise in revenue. This gain is estimated to be US$518 million during 2020-2030.

Figure 11: Impact of electricity tariff on EV TCO advantage



In the initial years, the existing tariff (LAK500/kWh for domestic consumers and LAK650/kWh for commercial chargers) supports the attractiveness of EVs and therefore should be continued.

Once EVs achieve the right momentum, increasing EV tariffs will be possible, with EVs' cost advantage being maintained.

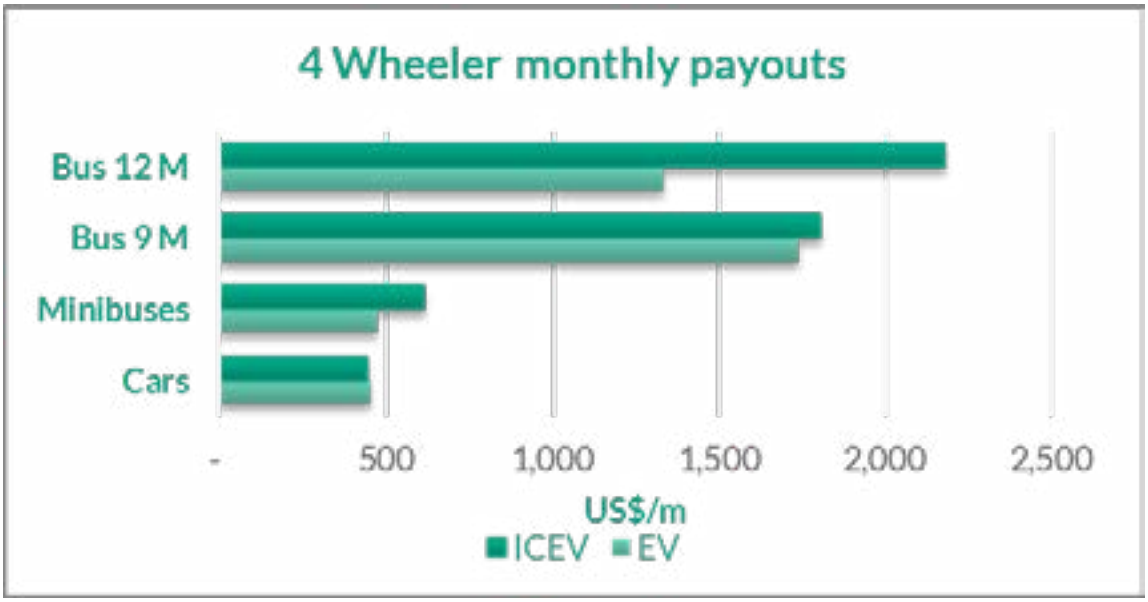
In the future, as the grid in the country becomes smarter, time-of-day tariffs can be considered for demand shift from peak to non-peak hours.

2.5.8 Impact of Financing Facility on EV Costs

The EV support provisions not only ensure TCOICEV > TCOEV, but EV buyers will be paying comparatively lower (and in some cases significantly lower) monthly payouts when servicing their vehicle loans.

In the scenario with 70% debt financing and financing support facility for EV buyers, the monthly payouts on the loans for EV buyers will be lower compared to the ICEV buyers for all vehicle segments (except for cars), even though the EV capital expenditure is higher compared to ICEVs. Thus, despite high capital expenditure, the cost burden on EV owners is less compared to ICEV owners.

Figure 12: Monthly payout on loan for an EV buyer compared to an ICEV buyer

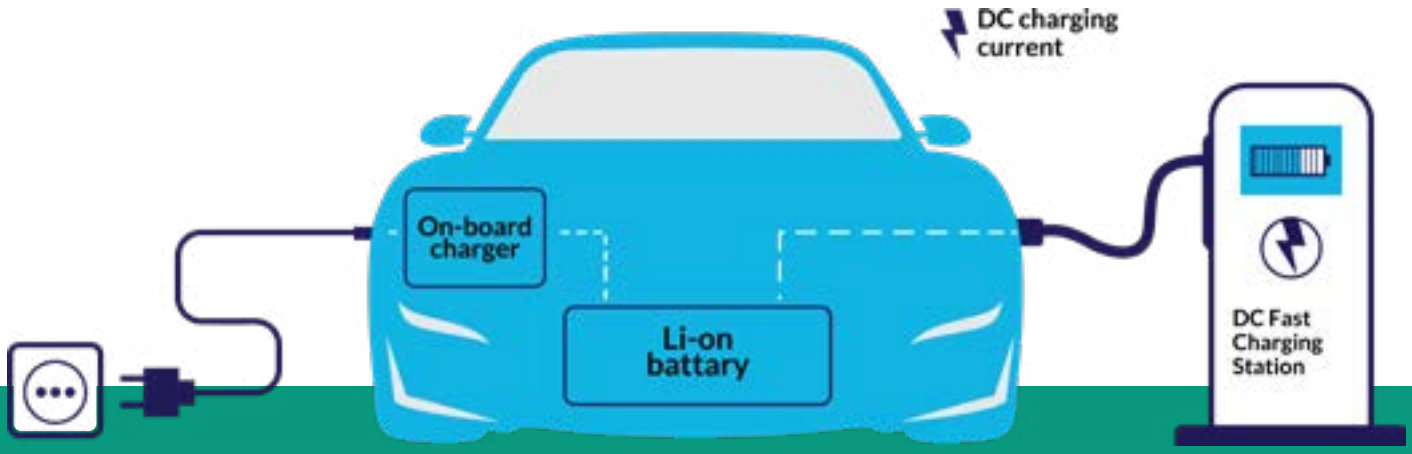


2.5.9 Summary

Despite the benefits associated with EVs and the EV TCO advantage over ICEVs, EV deployment will require government support to make the transition from ICEVs to EVs easier for vehicle owners.

This is witnessed across the globe and the degree of support extended to the sector varies between countries. For Lao PDR, the minimum threshold support is suggested (and quantified) and thus, EV deployment will largely depend upon the economic benefits derived by EV owners. The interventions will not only result in EV deployment, but positive economic and environmental benefits can also be derived by the community and the country.

All the policies and measures suggested are dynamic and are withdrawn when the capital expenditure of EVs falls. By such time, there will be a good number of EVs on the road in Lao PDR and the user experience along with the associated financial benefits will retain the momentum for EV deployment in the country.



3. Technical Standards for EVs

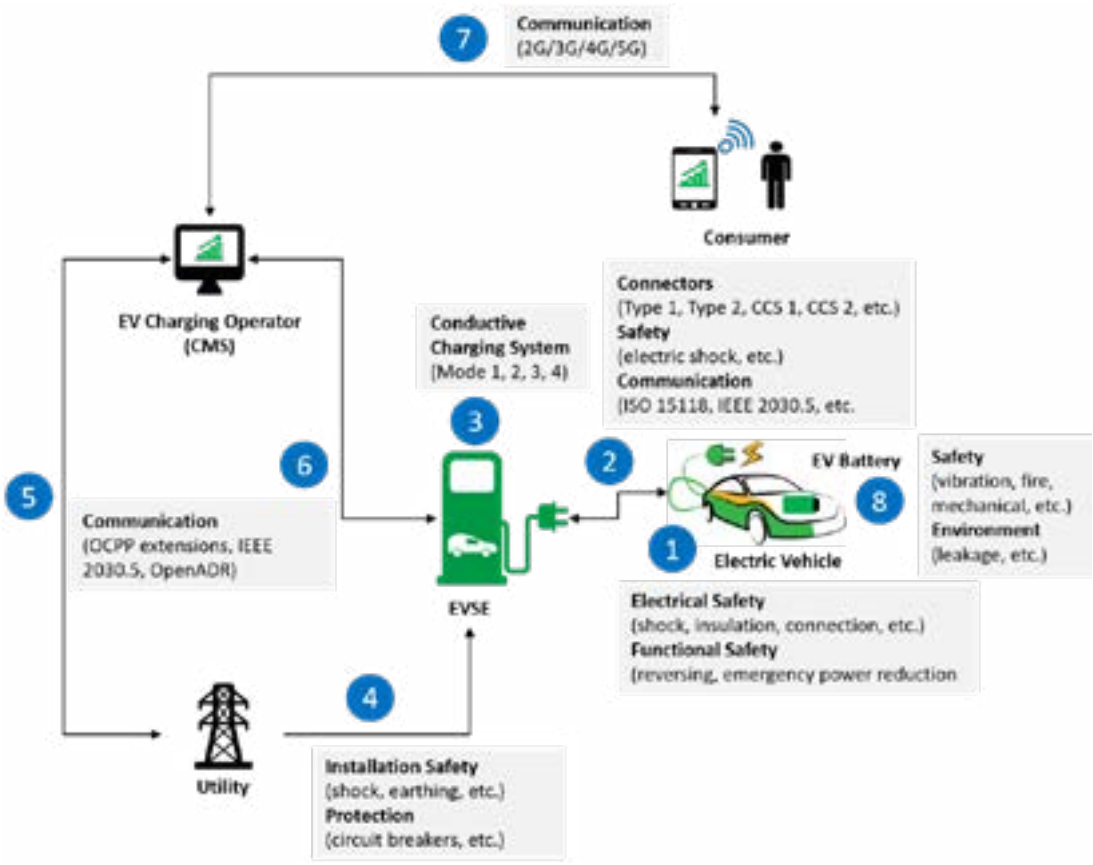
The selection and notification of the right technical standards around the EV ecosystem will be important for Lao PDR. This will enable various stakeholders, including EV original equipment manufacturers (OEMs), component OEMs (for batteries, chargers, connectors, etc.), charging infrastructure and services providers, power distribution companies, testing agencies and others to work coherently on executing the national charter and policies on EVs. The right technical standards will assist the Government of Lao PDR in the efficient and effective deployment of EVs, and enhance research and development, manufacturing capabilities and foreign investments. The technical standards will also promote EV safety, scalability, performance, reliability, affordability and security.

In order to provide recommendations for EV-related standards in Lao PDR, the following methodology is used:

- Development of an EV and essential ecosystem interaction framework to understand where standards are required;
- Benchmarking of existing key global EV standards to understand global trends; and
- Benchmarking of existing EV standards in select ASEAN countries to check for potential harmonization in standards.

3.1 EV and Essential Ecosystem Framework for Standards Development

Figure 13: EV and essential ecosystem framework for standards development

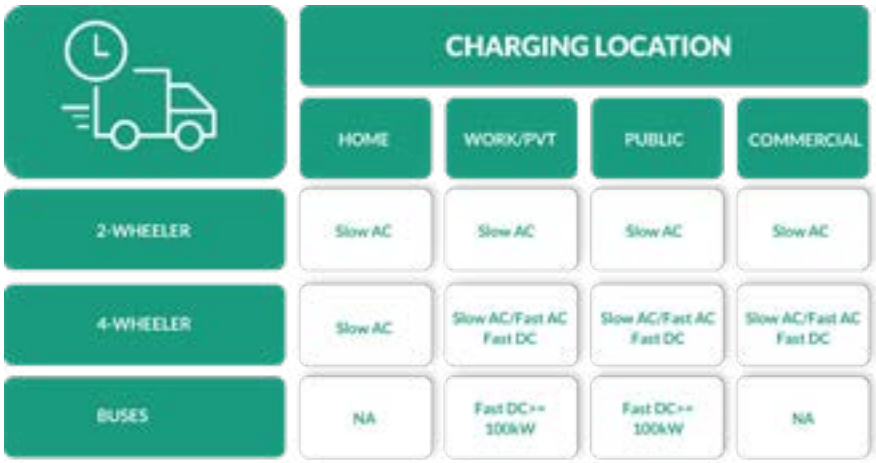


In Figure 13, the EV (#1) is connected to the EV supply equipment (EVSE) (#3) for charging. This EVSE may contain only alternating current (AC) guns, only direct current (DC) guns, or both AC and DC guns. The interaction between EV and EVSE (#2) for conductive charging is through a physical cable that provides electrical connectivity as well as digital communication. Once connection is established between EV and EVSE, charging starts.

The power rating of the EVSE and infrastructure requirement will depend on vehicle type (two-wheeler, four-wheeler or bus) and charging location (home, workplace, public or commercial). Figure 14 shows a decision matrix that can be used for the selection of EVSE type (slow AC, fast AC or fast DC). It should be noted that battery design and capacity (kWh) of the EV may limit the charging capacity of the EVSE. For example, if the EV battery size is 10kWh and EVSE power rating is 50kW, it does not mean that battery will charge at the rated capacity of 50kW. This is because the battery may not be designed to handle the rated power and may get damaged. To avoid this scenario, the battery management of EV will send a signal to the EVSE to lower the charging rate.

At the backend, the EVSE interacts with the utility grid (#4) for drawing power for charging. The utility grid interacts with the central management system (CMS) of the EV charging operator (#5) to manage its power demand and supply to the EVSE. The EVSE and CMS (#6) interact to exchange information related to charger's utilization, user, metering, billing and payment. Once the charging is completed, the bill is generated and a charging summary can be shared with the consumer over a mobile app. In real time, the consumer can interact with the EV charging operator (#7) to receive updates around charging locations, tariffs, slot availability, etc. The battery inside EVs (#8) is treated as a separate unit as there exist separate standards for battery functional performance testing, and it is one of the most important and costliest parts of EVs.

Figure 14: Decision matrix for charger selection



3.2 Benchmarking Global Standards for the EV Ecosystem

There are different EV-related standards defined by different standards-making global organizations like International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), Underwriters Laboratories (UL), the United Nations and others. Some key global standards for EVs are listed in Table 29 as per the framework provided in Section 3.1. These are the most commonly-used EV-related standards across developed and developing countries that are referred and notified (under different names and numbers) with any country-specific changes.

Table 29: Global standards for the EV ecosystem

No.	Unit	Coverage	Relevant standard
1	EV	a) Bicycle or Personal Mobility Device (PMD) – Electrical, Mechanical and Environmental Testing	UL 2272
		b) Motorcycle – Electrical and Functional Safety	UNECE R136 Part 1
		c) Car/Bus- Electrical and Functional Safety	UNECE R100 Part 1 UNECE R101 UNECE R85 UNECE R12/94/95/137
2	EV and EVSE	a) Communication Protocol	ISO 15118 IEEE 2030.5 IEC 61851-23 IEC 61851-24 (A,B,C)
		b) Safety and Protection	ISO 17409 (road vehicles) ISO 18246 (mopeds and motorcycles) IEC 62752 (mode 2) IEC 62955 (mode 3) IEC 61140
		c) Connector and Vehicle Inlet	IEC 62196 SAE J1772
3	EVSE	a) Conductive Charging System	IEC 61851-1 IEC 61851-22 IEC 61851-23

No.	Unit	Coverage	Relevant standard
4	**EVSE and Grid**	a) Safety and Electrical Installation	National Grid Code and Safety (country-specific) IEC 62335 (Circuit Breakers) IEC 61140
5	**Grid and EV Charging Operator**	a) Communication Protocol	IEEE 2030.5 Green Buttons OpenADR OCPP Extensions
6	**EV Charging Operator and EVSE**	a) Communication Protocol	OCPP OpenADR IEEE 2030.5
7	**EV Charging Operator and Consumer**	a) Communication	2G/3G/4G/5G
8	**EV Battery**	a) Motorcycle – Safety and Performance Testing	ISO 18243 UNECE R136 Part 2 IEC 62660
		b) Car/Bus – Safety and Performance Testing	ISO 12405-3 UNECE R100 Part 2 ISO 6469-1 IEC 62660

A brief coverage of the above-listed standards is provided in Table 30.

Table 30: Brief description of the global standards for the EV ecosystem

No.	Unit	Standard code	Standard name	Brief description
1.a	EV (bicycle and PMD)	UL 2272	Standard for electrical systems for personal e-mobility devices	• Covers all types of PMDs (hover-boards, one-wheel, two-wheel, x-wheels) • Covers electrical and fire safety testing methods for PMDs • Covers mechanical and environmental tests • Evaluates electrical drive train system + battery + charger system • Does not evaluate the performance of PMDs

No.	Unit	Standard code	Standard name	Brief description
1.b	EV (moped and motorcycle)	UNECE R136 Part 1	Uniform provisions concerning the approval of vehicles of category L with regard to specific requirements for the electric power train	• Specifies safety requirements for the electric power train of vehicles of category L with a maximum design speed exceeding 6km/hour, equipped with one or more traction motor(s) operated by electric power and not permanently connected to the grid, and the high voltage components and systems are galvanically connected to the high voltage bus of the electric bus train
1.c	EV (car and bus)	UNECE R100 Part 1	Uniform provisions concerning the approval of vehicles of categories M and N with regard to specific requirements for the electric power train	• Specifies safety requirements for the electric power train of road vehicles of categories M and N with a maximum design speed exceeding 25km/hour, equipped with one or more traction motor(s) operated by electric power and not permanently connected to the grid, and the high voltage components and systems are galvanically connected to the high voltage bus of the electric bus train • Does not cover post-crash safety requirements of road vehicles
2.a	EV and EVSE	ISO 15118	Road vehicles – Vehicles to grid communication interface	• Defines the communication protocol that a charging station and EV should use to charge the high voltage battery of EV • As part of the combined charging system (CCS), this standard covers all charging-related use cases across the globe, including both wired (AC and DC) and wireless charging applications and the pantographs that are used to charge large vehicles like buses • Enables the bidirectional flow of energy to realize vehicle-to-grid applications by feeding energy to the grid from EV when needed

No.	Unit	Standard code	Standard name	Brief description
2.b	EV and EVSE	ISO 17409 / TIS 2776	Electrically-propelled road vehicles –Connection to an external electric power supply (safety requirements)	• Specifies electric safety requirements for conductive connections of electrically-propelled road vehicles to an external electric power supply using a plug or vehicle inlet • Applies to vehicles with voltage Class B electric circuits[1] • Applies only to vehicle power supply circuits • Applies to dedicated power supply control functions used for the connection of the vehicle to an external electric power supply • Does not provide requirements for connection to a non-isolated DC charging station • May apply to mopeds and motorcycles if no dedicated standards for these vehicles exist
2.b	EV and EVSE	ISO 18246	Electrically propelled mopeds and motorcycles – Safety requirements for conductive connection to an external electric power supply	• Specifies safety requirements for conductive connection to an external electric power supply of electrically-propelled mopeds and motorcycles • Applies only to on-board charging systems between the plug or vehicle couplers and the rechargeable energy storage system (RESS) circuits[11] • Safety requirements for vehicles not connected to external power supply are specified in ISO 13063
2.b	EV and EVSE	IEC 62752 / TIS 2911	In-cable control and protection device for mode 2 charging of electric road vehicles (IC-CPD)	• Applies to in-cable control and protection devices for mode 2 charging of electric road vehicles, including control and safety functions • Applies to portable devices performing simultaneously the functions of detection of residual current, comparison of the value of this current with the residual operating value, and opening

[11] "Voltage Class B electric circuit" means an electric circuit with a maximum working voltage of >25V and ⩽1,000V AC or >60V and ⩽1,500V DC.

No.	Unit	Standard code	Standard name	Brief description
				of the protected circuit when residual current exceeds this value
2.b	EV and EVSE	IEC 62955	Residual direct current (RDC) detecting device to be used for mode 3 charging of EVs	• Applies to RDC detecting devices • Covers two different classes of RDC detecting devices to be used for mode 3 charging of EVs: o RDC monitoring device – suitable for isolation o RDC protective device – for use in fixed installation • The RDC detecting devices are intended to remove or initiate removal of the supply to the EV in cases where a smooth RDC equal to or above 6mA is detected • Can be used as guidance for devices for voltages up to and including 690V AC 50Hz, 60Hz or 50/60Hz, at a rated current not exceeding 250A • RDC detecting devices are intended to be used in AC circuits only. They are not intended for bilateral power flow between EVs and fixed installation
2.b 4.a	EV EVSE EVSE and Grid	IEC 61140	Protection against electric shock – Common aspects for installation and equipment	• Covers fundamental principles and requirements that are common to electrical installations, systems and equipment
2.c	EV and EVSE	IEC 62196	Plugs, socket outlets, vehicle connectors and vehicle inlets – Conductive charging of EVs	• Part 1: 2014 – General requirements • Part 2: 2016 – Dimensional compatibility and interchangeability requirements for AC pin and contact-tube accessories • Part 3: 2014 – Dimensional compatibility and interchangeability requirements for DC and AC/DC pin and contact-tube vehicle couplers

No.	Unit	Standard code	Standard name	Brief description
				• Intended for use in conductive charging systems that incorporate control means, with a rated operating voltage not exceeding: 690V AC, 50-60Hz, at a rated current not exceeding 250A; or 1,500V DC, at a rated current not exceeding 400A • Provides details of the various connector options that are available for both AC and DC charging. For AC charging, the options are Type 1 and Type 2 connectors, and for DC charging, the options are GB/T, CCS Combo 1, CCS Combo 2 and CHAdeMO. See Appendix 4 for details
2.c	EV and EVSE	IEC 62196-4	Plugs, socket outlets, vehicle connectors and vehicle inlets – Conductive charging of EVs	• Part 4 – Dimensional compatibility and interchangeability requirements for AC, DC and AC/DC vehicle couplers for Class II or Class III light EVs • Extends the technical specification IEC 62196-1 Part 1 • The maximum operating voltage is 120V at a nominal current of 60A • The final version of this standard is yet to be published
2.c	EV and EVSE	SAE J1772	SAE EV and plug-in hybrid EV conductive charge coupler	• A common EV/plug-in hybrid EV and supply equipment vehicle conductive charging method, including operational, functional and dimensional requirements for the vehicle inlet and mating connector
4.a	EVSE and Grid	IEC 62335 / TIS 2909	Circuit breakers – Switched protective earth portable residual current devices (SPE-PRCDs) for Class I and battery-powered vehicle operations	• The SPE-PRCD consists of a plug, a residual current device and a portable socket outlet

No.	Unit	Standard code	Standard name	Brief description
				• Applies to portable devices performing simultaneously the function of detection of residual current, comparison of the value of this current with the residual operating value, and opening the protected circuit when residual current exceeds this value • Addresses incorrect supply connections resulting in a hazard and/or supply failure
5.a 6.a	EV Charging Operator and Grid EV Charging Operator and EVSE	OCPP OpenADR IEEE 2030.5	Communication protocols for EV charging	• OCPP and extensions are communication protocols developed specifically for EV charging • OpenADR and IEEE 2030.5 are the most common standards for smart grid charging. These protocols can be extended to EV charging
8.a 8.b	Battery and Testing	IEC 62660	Secondary lithium-ion cells for the propulsion of electric road vehicles	• Part 1: Performance Testing – Specifies the test procedures to obtain the essential characteristics (capacity, power density, energy density, storage life, cycle life) of lithium-ion cells for vehicle propulsion applications • Part 2: Reliability and Abuse Testing – These tests are important for securing a basic level of performance and obtaining essential data on the reliability and abuse behavior of lithium-ion cells for use in various designs of battery systems and battery packs • Part 3: Safety Requirement – Intends to secure the basic safety performance of cells as used in the battery system under intended use and reasonably foreseeable misuse, during the normal operation of EVs

No.	Unit	Standard code	Standard name	Brief description
				• It is assumed that the cells are properly used in a battery pack within the limit of voltage, current and temperature as specified by the cell manufacturer • The safety performance requirements for lithium-ion battery packs and systems are defined in ISO 12405-3 (under development)
8.a	Battery and Testing	ISO 18243	Electrically-propelled mopeds and motorcycles – Test specifications and safety requirements for lithium-ion battery systems	• Specifies test procedures that determine the essential characteristics of performance, safety and reliability of lithium-ion battery packs and systems • The user is supported to compare the test results achieved for different battery packs or systems • Enables setting up a dedicated test plan for an individual battery pack or system subject to an agreement between customer and supplier. If required, the relevant test procedures and/or test conditions of lithium battery packs and systems are selected from the standard tests provided in this document to configure a dedicated test plan • Testing on the cell level is specified in IEC 62660 (all parts)
8.a	Battery and Testing	UNECE R136 Part 2	Uniform provisions concerning the approval of vehicles of category L with regard to specific requirements for the electric power train	• Part 2 – Safety requirements for RESS of category L vehicles with a maximum design speed exceeding 6km/hour, equipped with one or more traction motor(s) operated by electric power and not permanently connected to the grid

No.	Unit	Standard code	Standard name	Brief description
8.b	Battery and Testing	ISO 12405-3 (withdrawn)	Electrically-propelled road vehicles – Test specification for lithium-ion traction battery packs and systems	• Part 3: Safety Performance Requirement – Specifies test procedures and provides acceptable safety requirements for voltage Class B lithium-ion battery packs and systems, to be used as traction batteries in electrically-propelled road vehicles • This standard has been revised by ISO 6469-1:2019
8.b	Battery and Testing	ISO 6469-1:2019	Electrically-propelled road vehicles – Safety specification – Part 1: Rechargeable energy storage system	• Specifies safety requirements for RESS of electrically-propelled road vehicles for the protection of persons • Does not provide comprehensive safety information for manufacturing, maintenance and repair personnel • Requirements for mopeds and motorcycles are specified in ISO 13063 and ISO 18243
8.b	EV (car and bus)	UNECE R100 Part 2	Uniform provisions concerning the approval of vehicles of categories M and N with regard to specific requirements for the electric power train	• Specifies safety requirements for RESS of road vehicles of categories M and N, equipped with one or more traction motor(s) operated by electric power and not permanently connected to the grid • Does not apply to RESS whose primary use is to supply power for starting the engine, lighting and/or other vehicle auxiliary systems

3.3 Benchmarking EV Standards in ASEAN Countries

Some ASEAN countries with early EV deployments have notified their EV standards, referring to suitable global standards. Table 31 lists different EV standards adopted by four ASEAN countries –Indonesia, Malaysia, Thailand and Singapore.

Table 31: EV standards in select ASEAN countries

Standard description	**Singapore** (Toppan Leefung 2016)	**Thailand** (Automotive Product Working Group 2019)	**Malaysia** (Malaysia Automotive Robotics and IoT Institute 2019)	**Indonesia** (Sentany 2019)
National safety and testing standard for electric bicycles	**LTA Compliant**[12] **and UL 2272 Standard for Electrical Systems for Personal E-Mobility Devices** (Land Transport Authority, Government of Singapore 2019)		**MS 2514** Electric bicycle (<25km/hour)	
National safety and testing standard for electric motorcycles		**UNECE R136** (TIS 2952) L category vehicles	**MS 2688** Electric moped (25-50km/hour) **MS 2413** Electric motorcycle (>50km/hour)	
National safety and testing standard for electric cars and buses		**UNECE R100** M and N category vehicles	**UNECE R100** M and N category vehicles **MS 2688** Electric moped four-wheeler (25-50km/hour)	
EVSE charging standards	**TR 25: 2016**[13] EV charging system **AC Charging** IEC 62196 Type 2 **DC Charging** CCS Combo 2	**AC Charging** IEC 62196 Type 2 **DC Charging** CCS Combo 2	**AC Charging** IEC 62196 Type 2 **DC Charging** CCS Combo 2	**AC Charging** IEC 62196 Type 2 **DC Charging** CCS Combo 2
Global standards referred (and some nationalized)	**IEC 62196** Plugs, socket outlets, vehicle connectors and vehicle inlets	**IEC 62196 (TIS 2749)** Plugs, socket outlets, vehicle connectors and vehicle inlets	**MS IEC 62196** Plugs, socket outlets, vehicle connectors and vehicle inlets	

[12]LTA or Land Transport Authority Compliant implies weight ⩽20kg, width ⩽70cm and maximum speed ⩽25km/hr.
[13]Energy requirement from vehicle to grid is not considered in this revision.

Standard description	Singapore (Toppan Leefung 2016)	Thailand (Automotive Product Working Group 2019)	Malaysia (Malaysia Automotive Robotics and IoT Institute 2019)	Indonesia (Sentany 2019)
Global standards referred (and some nationalized)		**IEC 62196-2 (TIS 2749-2)** AC charge **IEC 62196-3 (TIS 2749-3)** DC charge		**IEC 62196-3** EVs **IEC 62196-4** Electric powered two-wheelers
	IEC 61851 EV conductive charging system	**IEC 61851 (TIS 61851)** EV conductive charging system	**MS IEC 61851** EV conductive charging system	**IEC 61851-1 / ISO 17409** EVs
	SAE J1772		**SAE J1772**	**ISO 18246** Electric powered two-wheelers
	IEC 62335 Charger protection device	**IEC 62335** (TIS 2909)		
	IEC 62752 Charger protection device	**IEC 62752** (TIS 2911)		
	ISO 17409 EV/EVSE power supply safety	**ISO 17409** (TIS 2776)		
	SS CP 5: 1998 Code of practice for electrical installation	**IEC 62955** Charger protection device		
National standard for battery testing		Work in progress	**MS IEC 62660** Lithium-ion testing for batteries	**ISO 12405-3 or UNECE R100 Part 2** for EVs **ISO 18243 or UNECE R136 Part 2** for electric two-wheelers

Table 32: Brief description of EV standards in ASEAN countries

No.	Unit	Standard code	Standard name	Brief description
1.a	EVs (bicycle or PMD)	MS 2514: 2015	Malaysian Standard for Electric Bicycles (Electric Pedal-Assisted Bicycles)	• Covers electric bicycles that move with the help of pedal and have a maximum speed of 25km/hour
1.b	EVs (moped)	MS 2688	Malaysian Standard for Electric Mopeds (Light EVs)	• Covers safety, performance and national standard compliance issues • Expanded from the initial two-wheelers category to serve the two-, three- and four-wheeled category vehicles within the 25-50km/hour speed range, as specified in the "Guidelines for Vehicle Type Approval" by the Road Transport Department of Malaysia
1.b	EVs (motorcycles)	MS 2413	Malaysian Standard for Electric Motorcycles	• Covers two-wheeled vehicles as per the L3 category of MS 1822, with a speed of more than 50km/hour • Covers general (Part 1), safety (Part 2) and performance (Part 3) specifications • The electric motorcycle and charging unit must comply with MS CISPR 12 and ISO 11451-2 for their electromagnetic emission and immunity test
2.a 2.b 2.c 3.a 4.a	EV and EVSE EVSE EVSE and Grid	TR 25:2016	Technical Reference for EV Charging Systems	• Applies to on- and off-board equipment for charging EVs in public and private car parks, public places, and private residential premises at voltages of up to 1,000V AC and 1,500V DC • Covers requirements for electrical installation, functional needs and safety, and connection to EVs
4.a	EVSE and Grid	SS CP 5: 1998	Singapore Standard Code of Practice for Electrical Installations	• Applies to the design, selection, erection, inspection and testing of electrical installations, other than those excluded by clause 110-02: Exclusion of Scopes

Some important insights based on Tables 31 and 32, and a literature review of the standards adopted by ASEAN countries are highlighted below:

- Thailand has adopted UNECE R136 for electric two-wheelers while Malaysia has defined its own standards for electric bicycles (with speed of less than 25km/hour), electric mopeds (with speed of 25-50km/hour) and electric motorcycles (with speed of more than 50km/hour).
- Malaysia is the first country among ASEAN countries to define standards for electric two-wheelers (including bicycles, mopeds and motorcycles) for all types of speed.
- In the last three years, Singapore reported over 90 fire accidents with PMDs due to non-conformity with safety standards. As a result, in September 2018, the Singapore Land Transport Agency announced UL 2272 as the safety standard for PMDs. By 2021, only PMDs that comply with the UL 2272 standard will be allowed to be ridden in Singapore.
- UNECE R100 is adopted as a safety standard for electric four-wheelers and buses by Malaysia and Thailand. Malaysia has defined standards for electric mopeds (four-wheelers) with vehicle speed of 25-50km/hour.
- For the charging system, AC Type 2 and CCS Combo 2 are accepted among all the leading ASEAN countries. The vehicle connector, inlet, pins, power rating and other parameters are discussed in Tables 33 and 34.

A brief comparison of SAE J1772 (Type 1) and AC Type 2 is highlighted in Table 33.

Table 33: Comparison between Type 1 and Type 2 connectors

Description	Type 1	Type 2
Vehicle connector		
Vehicle inlet		
Number of pins in vehicle connector	5	7
Vehicle connector pin description (left to right)	**Top row** • L1 – Line 1 • L2/N – Neutral **Middle row** • PP – Proximity Pilot • CP – Control Pilot **Bottom row** • PE – Potential Earth	**Top row** • PP – Proximity Pilot • CP – Control Pilot **Middle row** • L1 – Line 1 • PE – Potential Earth • N – Neutral **Bottom row** • L2 – Line 2 • L3 – Line 3
Power supply	Single phase	Single and three phase
Power level	16/32A 250V	Single – 70A 250V Three – 32/63A 380-480V
Typical power rating	3.7kW/7.2kW	3.7kW/7.2kW/22kW
Country	Mainly North America	Europe and the rest of the markets (India, ASEAN, etc.)

A brief comparison of CCS Combo-1 and CCS Combo-2 is highlighted in Table 34.

Table 34: Comparison between CCS Combo 1 and CCS Combo 2 connectors

Description	CCS Combo 1	CCS Combo 2
Vehicle connector		
Vehicle inlet		
Number of pins in vehicle connector	7	5
Vehicle connector pin description (left to right)	**Top row** • L1 – Line 1 • L2/N – Neutral **Middle row 1** • PP – Proximity Pilot • CP – Control Pilot **Middle row 2** • PE – Potential Earth **Bottom row** • DC+ • DC-	**Top row** • PP – Proximity Pilot • CP – Control Pilot **Middle row** • PE – Potential Earth **Bottom row** • DC+ • DC-
Power supply	Single phase	Single and three phase
Power level	Maximum 1,000V and 350A	Maximum 1,000V and 350A
Typical power rating	50kW/150kW/350kW	50kW/150kW/350kW
Country	Mainly North America	Europe and the rest of the markets (India, Australia, ASEAN, etc.)

In summary:

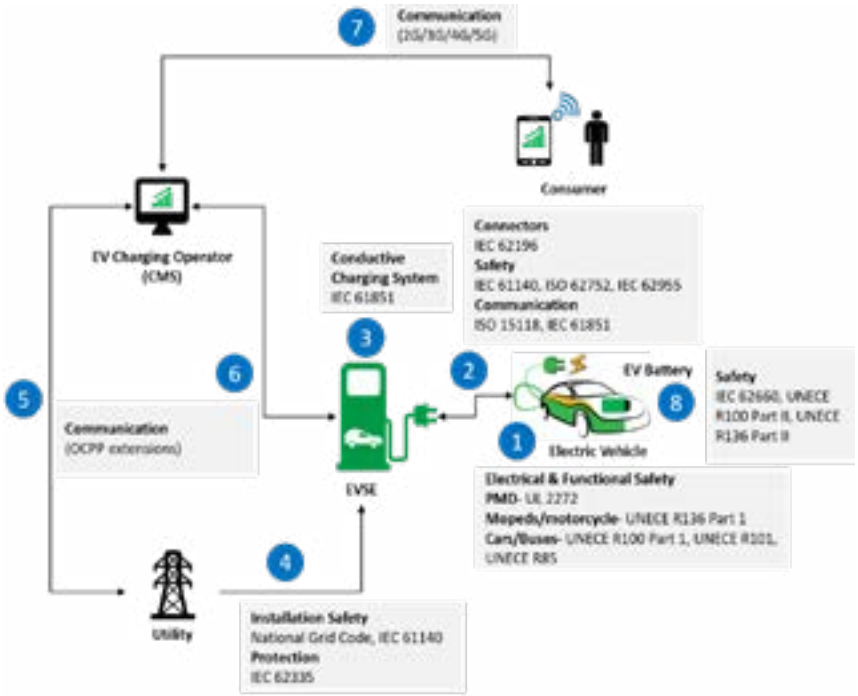
- Singapore has defined a single charging standard document TR 25:2016 and referred to relevant international standards. Malaysia and Thailand have nationalized individual international standards. For example, IEC 62196 is named as TIS 2749 in Thailand by the Standard Committee, and MS IEC 62196 by the Malaysia Standard Committee.
- For the EV conductive charging system, IEC 61851 is the accepted standard among all the ASEAN countries. For electric two-wheelers, ISO 18246 is the standard adopted for the conductive charging station by Indonesia.
- The other common charging standards adopted for charging infrastructure protection and safety are IEC 62335, IEC 62752 and ISO 17409.
- For AC slow charging, the common EVSE power ratings are 3.7kW/7.2kW/22kW. For DC fast charging, the most common EVSE power rating is 50kW. According to the survey of dealers carried out by the consultant, a few companies have imported electric cars for demonstration purposes whose battery capacity is 40kWh. In such case, the suitable charger options are AC slow charging (3.7kW/7.2kW/22kW AC) and DC fast charging (30-50kW DC).
- In addition to the standards discussed above, the local code of practice for electrical installation is to be followed for charging stations.

- The battery testing standards that are being adopted for electric four-wheelers or buses are MS IEC 62660 in Malaysia, and ISO 12405-3 or UNECE R100 Part 2 in Indonesia. Similarly, for electric two-wheelers the battery testing standard adopted is ISO 18243 or UNECE R136 Part 2 in Indonesia. Thailand is planning to prepare EV battery standards in accordance with the UN Regulation No. 100 and related standards used in Thailand.
- The risk of fire in EVs arises mostly from overcharging of the batteries, its manufacturing defects or physical damage. Battery safety standards must cover electrical, mechanical and environmental tests to ensure device and user safety in real scenarios. The standard UL 2272, UNECE R100 Part 2 and UNECE R136 Part 2 specify the following tests to ensure both vehicle and battery safety:
    - Electrical tests – Short circuit, open charge, over discharge, temperature, isolation resistance, imbalanced charging, etc.
    - Mechanical tests – Vibration, shock, crush, drop, handle loading, etc.
    - Environmental tests – Water exposure and thermal cycling.

3.4 Proposed EV Charging Standards for Lao PDR

Figure 15 shows recommended standards for Lao PDR's EV ecosystem.

Figure 15: Proposed EV charging standards for Lao PDR



3.4.1 Proposed EV Charging Standards for Two-Wheelers and Four-Wheelers

Electric Bicycles (PMDs)

Lao PDR can adopt the UL 2272 standard, as adopted by Singapore recently.

Rationale: It is expected that electric bicycles and scooter (with speed <25km/hour and weight ⩽20kg) will gain popularity, especially among school and college students. These slow-speed vehicles unless properly planned for traffic management, may pose traffic safety challenges. There have been reported cases of fire accidents in this vehicle segment primarily because of the poor quality and lack of checks and balances in the testing system. Therefore, it is suggested that Lao PDR adopts UL 2272, which is a standard for the electrical systems of PMDs. This standard does not specify performance parameters for PMDs, which is not required to be regulated, considering the application.

Supporting measures: Electric bicycles, especially those manufactured by new companies, face challenges of quality and safety, and many countries have experienced the cheap quality of imports. The proposed standard should be monitored on importers in Lao PDR, plus during routine traffic monitoring. Existing EVs before the date of notification should be allowed to continue.

Electric Mopeds and Motorcycles

Lao PDR can adopt UNECE R136 as a testing standard for electric mopeds and motorcycles, which includes two-wheelers and light-weight four-wheelers.

Rationale: The UNECE R136 defines a single regulation for L category vehicles. The definition includes two-wheelers and small vehicles with four wheels (low-power vehicles – L6 and L7, as per UNECE vehicle categories). This standard is equivalent to Thailand's TIS 2952 standard. Malaysia has adopted different standards for mopeds and motorcycles. However, Lao PDR can keep the same standard across L category vehicles, independent of any speed changes.

Supporting measures: Electric mopeds and motorcycles, especially those manufactured by new companies, face challenges of quality and safety, and many countries have experienced the cheap quality of imports. The proposed standard should be monitored on importers in Lao PDR, plus during routine traffic monitoring. Existing EVs before the date of notification should be allowed to continue. There can be a roadworthiness inspection certificate required after a moratorium of two years, and repeated every year for personal use vehicles. These numbers can be slightly aggressive for commercial use vehicles as they will run longer distances.

Electric Cars and Buses

Lao PDR can adopt UNECE R100 as a testing standard for both electric cars and buses. For measurement of electric energy consumption and range, UNECE R101 is suggested while UNECE R85 is suggested for measurement of net power and the maximum 30 minutes power of electric drive trains. In addition to these standards, post-crash safety standards like UNECE R12/94/95/137 for M1 category vehicles can be included.

Rationale: The UNECE R100 defines a single regulation for M and N category vehicles. This regulation covers vehicle safety requirements such as protection against electric shock, insulation resistance and connection of the vehicle to the main network. It also covers functional safety requirements such as running and stopping conditions, reversing and emergency power reduction. This standard is applicable to the type testing approval requirement for OEMs, and is unanimously accepted among ASEAN members.

Supporting measures: Periodic roadworthiness inspection should be done for M and N category EVs. The frequency of inspection should be carried out as per existing regulations.

EV Charging Standards

Lao PDR can adopt IEC 61851 (for EVSE system), IEC 62196 (for EV and EVSE connectors) and ISO 15118 (for communication between EV and EVSE) as the EVSE and charging standards.

For AC (public) charging, Type 2 connector can be made mandatory. For DC (public) charging, CCS Combo 2 can be made mandatory. For home charging, standard AC plugs can be used to supply power for charging.

The Open Charge Point Protocol (OCPP) and their extensions can be made standard for communication between EVSE to CMS and EVSE to grid.

Rationale: The IEC 61851 and IEC 62196 standards cover most used EV and EVSE communications and connectors for AC only, DC only and AC/DC charging. They support CCS, CHAdeMO and GB/T protocols for DC charging.

The suggested connectors – Type 2 for AC charging and CCS Combo 2 for AC/DC charging – have already been declared as national standards in Malaysia and Singapore. Thailand has also allowed these connectors. Since these

are the countries where Lao PDR imports most of its vehicles, keeping the same standards can help avoid duplicate efforts, focus on a single charging infrastructure, optimize EV development cost and accelerate EV adoption. It will also ensure technical interoperability at the country level.

There are vehicles in the Lao PDR market (primarily cars) that make use of other types of connectors like CHAdeMO and GB/T. Vehicles with these connectors may be allowed but can be made mandatory to have either AC Type 2 or CCS Combo 2 vehicle connectors to ensure the vehicles can be charged at any public charging station in the future. In the case of electric bicycles or two-wheelers, customized vehicle connectors (ensuring safety) can be allowed as an exception.

CCS Combo 2 uses power line communication between EV and EVSE. Most of the four-wheelers use control area network communication for their vehicle architecture and different modules of communication. CCS Combo 2 with power line communication will require separate hardware and cost while using a control area network-based protocol between EV and EVSE (like GB/T) will not.

Typical battery size, charger type, charger rating and type of connector for different vehicle segments for the above recommendations are provided in Table 35.

Table 35: Typical battery size, EVSE power rating and connector type by vehicle segment

Vehicle segment	Typical battery size (kWh)	Typical EVSE power rating (kW)	Typical charging connector to be used
Electric bicycle	<2	<0.25 DC	Customized (ensuring safety standards)
Electric moped or motorcycle	<4	<3.7 AC	AC Type 2 or customized
Electric car	<50	3.7/7.2/22 AC 30-50 DC	AC Type 2 or CCS Combo 2
Electric bus	<200	43.5 AC 50-200 DC	AC Type 2 or CCS Combo 2

There is relatively less work on standards for light EVs (<120V, which include electric two-wheelers and small/light electric cars). Type 2 connector (7cm in diameter) is oversized and more costly for electric two-wheeler charging power requirements. But given that Lao PDR does not have its own EV manufacturing industry, it may be good to follow other regional ASEAN countries at the expense of slightly higher EV cost impact. Countries like India, which has a similar mix of two-wheelers like Lao PDR is working on a custom standard for connectors and charging for light EVs. According to the survey of dealers carried out by the consultant, electric two-wheelers that are imported in Lao PDR comes with in-built Type 2 vehicle inlets (e.g., Sabai models).

Home and office charging for personal vehicles (electric two- and four-wheelers) can be carried out directly with AC three-pin outlets (slow AC charging). It will need a charging cable (provided by vehicle OEMs) that supports conventional AC three-pin plug at one end and supported charging socket (Type 2 or CCS Combo 2) at the vehicle end. These off-board portable chargers can be Mode-2 chargers with an in-cable control protection device. The EV user may need to upgrade its premises' electricity connection to a higher power supply (from single-phase to three-phase supply and/or to higher sanctioned fixed load connection) for charging, depending on the on-board charger power rating of the EV and battery size (kWh).

Even when Lao PDR achieves high EV adoption, home and office slow AC direct charging will not pose a risk to the grid if the right connection upgradation process is followed for EV owners. EV charging load should be like any load augmentation, and suitable diversity factor calculations can be designed and incorporated in EDL's Distribution Design Manual. Communication between the grid and EVSE for such home/office chargers may not be required. However, the proposed ISO 15118 supports the future adoption of vehicle to grid communication and transfer of power.

For public charging, EVSE should have the facility to authenticate users with mobile devices or radio-frequency identification, and accept payments using mobile money, and debit and credit cards. These are achievable with the proposed OCPP protocol between EVSE and CMS. Additionally, electrical protection and safety standards as required in the country code of practice for electrical installation should be followed. Singapore's TR 25:2016 standard and other global standards proposed above can be used as reference.

The use of open standards like OCPP and their extensions will ensure interoperability at the network level, which is critical for the development and scalability of the charging infrastructure and the EV ecosystem. Open standards will support seamless integration between different EV charging network operators (even in roaming) and payment gateways, and is future proof. The use of a single charging standard (Type 2 and CCS Combo 2) will ensure interoperability at the hardware level and support the development of a common charging infrastructure for connecting EV to EVSE.

The Open Smart Charging Protocol, which is compatible with OCPP and developed by the same organization – Open Charge Alliance – allows the grid operator to share load forecasting with the EVSE to plan its charging schedule without affecting the grid.

Supporting measures: Clearly defined processes and timely execution of new or upgraded electricity connection for EV charging from the distribution company will enable faster uptake of public charging stations, as well as home and office charging. The distribution company should be involved as an important stakeholder in developing the public EV charging infrastructure and in promoting home and office charging.

The type and number of chargers for public charging stations should be decided by the EVSE operator. The government can offer support with land lease and provisions for the public charging infrastructure and provide fiscal incentives for the development of public charging stations and home/office charging.

Battery Testing Standard

Lao PDR can adopt UNECE R136 Part 2 for two-wheeler battery testing and UNECE R100 Part 2 for four-wheeler battery testing.

Rationale: Malaysia and Thailand are members of the UNECE. Hence, they are bound to implement all automotive regulations defined by UNECE as part of the agreement. Malaysia has already implemented 100 out of 140 UNECE regulations. Indonesia has provided options to choose testing standard ISO 18243 or UNECE R136 Part 2 for two-wheeler battery testing, and ISO 12405-3 or UNECE R100 for four-wheeler/bus battery testing. These standards cover battery safety requirements and provide procedures for vibration testing, thermal shock testing, mechanical testing, fire testing, overcharge protection, over-discharge protection, over-temperature protection and external short-circuit protection. In order to promote the regional harmonization of EV standards, it is recommended that Lao PDR adopts UNECE regulations for battery testing.

3.4.2 Other Recommendations for Strengthening Standardization Efforts and Outcomes

- Only lithium-ion batteries should be allowed for all EVs by, for example, providing capital subsidies for EVs with lithium-ion batteries only. At present, most imported vehicles use lead-acid batteries, which are hazardous to the environment and have higher TCO than lithium-ion batteries.

- EV batteries come in different chemistries, sizes (current, voltage, kWh capacity), and pack designs (based on cooling requirements), depending on vehicle segment (electric two-wheeler or four-wheeler) and its use (vehicle range, speed, acceleration, charging time, discharging time and life cycle). Usually, these are internal choices made by the OEMs depending on their vehicle engineering and electric architecture. It is not advisable to control or regulate these factors.

- Worldwide, new battery technology development is driving energy density downward. China has defined a target energy density reduction over the years to stay ahead on battery manufacturing (Lima 2016). Lao PDR can consider aligning itself with the latest battery technologies and benefits by advantageously incentivizing more advanced batteries.

- Battery swapping has evolved as a good technology option in recent years, with India's success in the commercial deployment of battery swapping in their electric two-wheeler fleet. It has the potential to accelerate EV adoption and offers the following advantages:

    - Reduces upfront EV cost (battery is not part of the vehicle cost);
    - Reduces waiting time to charge the battery;
    - Improves vehicle efficiency as the battery size is standardized and small; and
    - Battery life is improved as it is charged under more controlled environment.

  Since two-wheelers are popular and sizeable vehicle segments in Lao PDR, battery swapping should be encouraged and supported in all policies.

- The local temperature and land topography (gradient) play an important role in ensuring battery performance and warranties. Lao PDR when adopting global standards should consider the local temperature, humidity and other local conditions. The IEC standards usually follow -25°C to 40°C temperature profile for different tests. A typical temperature range in Lao PDR is 10°C to +45°C (World Climate Guide 2018). Like India, Lao PDR in its customization of global standards can propose to extend temperature range to +50°C (or even 55°C as changed by India).

- Lithium-ion batteries have a second life after automotive use and can be re-purposed for storage and other applications. Waste batteries can be recycled for precious and other metals extraction. Lao PDR should encourage practical policy to drive battery disposal and its re-use and recycling. In addition to improving the environment, battery recycling can help increase the resale value of EVs and improve financing mechanisms.

- Lao PDR can establish an easy mechanism to register all kinds of EVs during the sales process. The registration fee can be waived to encourage adoption. The registration of model details including type of battery and compliance with UNECE R100 and R136 and other standards and regulations will allow strong tracking of EV sales and alignment with any new interventions.

3.5 EV Testing and Inspection Mechanism

There are generally two types of vehicle testing and inspection requirements:

1. **Type testing or homologation** – This is required when a vehicle manufacturer plans to launch a new vehicle (or variant) in the market. It is the confirmation that production samples will meet the desired and specified vehicle performance. It is undertaken by the OEM at required component and vehicle level, and once completed will apply to all vehicles of the same model.

2. **Roadworthiness inspection** – This is a periodic inspection to check the roadworthiness of the vehicles for road, traffic and environmental safety. The frequency of the inspection is designed depending on vehicle category, type and age.

3.5.1 Procedures for EV Type Testing Approval

A type approval certificate is a mandatory requirement by the government when a manufacturer is planning to launch a new vehicle of L, M or N category in the market. In this process, the applicant has to provide vehicle information along with the variant and version. In addition, the applicant needs to furnish several test reports issued by authorized testing laboratories, vehicle manufacturers, component suppliers and/or third-party testing agencies in compliance with the law.

EVs will have to undergo similar type approval tests like ICEVs as they use many common components, other than electric power train/drive, traction batteries and electronics. Table 36 shows the list of some key tests for type testing of EVs. These tests will differ across vehicle segments – two-wheeler, four-wheeler and bus.

Table 36: List of tests for type testing of EVs

1	**Safety**	Tire
2		Reflector
3		Horn installation
4		Horn
5		Lamps
6		Lighting and signaling devices
7		Head lamp assembly
8		Front and rear lamp indicator assembly
9		Front parking lamp assembly
10		Rear registration plate lamp assembly
11		Rear view mirror specifications
12		Windscreen wiping system
13		Speed governor
14		Fitment of reflective tape and reflectors
15		Flammability requirement
16		Wheel rim
17		Safety glass
18		Windscreen laminated safety glass
19		Side window and door glass
20		Back light and rear toughened glass
21		Strength of superstructure
22		Seat dimension measurement test
23		Interior fitting test
24		Rear under run protection device

25		Vehicle lateral protection side
26		Stability angle determination
27		Seat anchorage test
28	**Vehicle evaluation**	Vehicle physical verification
29		Vehicle weight
30		Brake test
31		Anti-lock braking system test
32		Steering effort test
33		Turning circle diameter test
34		Speedometer calibration
35		Noise test
36		Gradeability test
37		Interior noise test
38		Temporary cabin fitted on drive away chassis
39		Vehicle identification number
40	**Electronics**	Water effect test
41		Range test
42		Measurement of maximum power and 30 minutes power
43		Constructional and functional safety test
44		Measurement of electric energy test
45		Traction batteries
46		Electric shock test (if voltage greater than 48V)
47		Electromagnetic interference and electromagnetic compatibility test
48		Vehicle alarm system

The additional type approval tests for EVs are defined in UNECE R85, UNECE R100 and UNECE R101 for M and N category EVs. UNECE R100 Part 1 addresses the safety requirements of the electric power train, and UNECE R100 Part 2 addresses the safety requirements of the rechargeable energy storage system (RESS) of road vehicles with a maximum design speed exceeding 25km/hour, equipped with one or more traction motor(s) operated by electric power and not permanently connected to the grid. This regulation specifies the different test requirements, procedures and acceptance criteria to ensure the safety of the EV and RESS. Similarly, there is UNECE R136 that specifies the same tests for L category EVs.

A brief description of some key tests conducted under UNECE R100 Parts 1 and 2 are described in Table 37. For the complete list and methodology, the UNECE R100 standard should be referred.

Table 37: Tests covered under UNECE R100

Requirement type	Testing type	Description
EV safety requirement	Protection against electric shock	• If voltage is above 60V DC and 30V AC (i.e., high voltages), protect against direct contact with live parts of the power train by insulation, covers, protection grills, etc. • If voltage is less than 60V DC or 30V AC, no protection is required • Protection degree of at least IPXXD in passenger and load compartments, and IPXXB in other areas of the vehicle • Protection cover of live parts should be marked by a symbol as defined under the regulation
	Insulation resistance	• Insulation resistance between any exposed part and each polarity of the battery should have a minimum value of 500 ohms/V of the nominal voltage. The test procedure is described in the regulation
	Connection of the vehicle to the main network	• All exposed conductive parts should be provided with a proper earthing mechanism • The coupling system parts likely to be live should be protected against any direct contact in all operating conditions
	Traction battery	• No accumulation of potentially dangerous gas pockets • Proper ventilation in battery compartments containing battery modules • Traction battery and power train should be protected using properly-rated fuses or circuit breakers
Functional safety requirement	Running and stopping conditions	• A momentary indication should be given to the driver when: o The vehicle is in active driving possible mode or any further action is required to place the vehicle in active "driving possible mode" o The vehicle is still in active driving possible mode while the driver is leaving the vehicle o The battery level has reached a minimum state of charge
	Reversing	• An electric switch/key should allow vehicle reversing only when the vehicle is not moving at a forward speed not exceeding 5km/hour
	Emergency power reduction	• The user should be informed if vehicle performance is limited because of any reason (e.g., overheating of a component)

Requirement type	Testing type	Description
RESS safety requirement	Vibration	• Verify the safety performance of RESS under vibration conditions similar to those experienced under normal vehicle operations
	Thermal shock and cycling	• Assess the resistance of RESS to sudden changes in temperature similar to those experienced in actual environmental conditions
	Mechanical shock	• Verify the safety performance of RESS under inertial loads that may occur in vehicle crash conditions
	Mechanical integrity	• Verify the safety performance of RESS under contact loads that may be experienced in vehicle crash conditions
	Fire resistance	• Assess the resistance of RESS to exposure from a fire originating outside of a vehicle, to determine whether passenger or driver has sufficient escape time
	External short circuit protection	• Verify the performance of a device short circuit protection system to limit the consequences associated with short circuits
	Over-charge protection	• Assess the performance of a device overcharge protection system
	Over-discharge protection	• Assess the performance of a device discharge protection system
	Over-temperature protection	• Verify the performance of a device against internal overheating during operation, even when the device cooling system fails

Upon approval of all the tests, the vehicle should have an approval mark placed on or close to the vehicle data plate affixed by the manufacturer. The approval mark should be as per the guideline. Any further modification in the vehicle type should be notified to the competent authority. The authority should then issue an extension of approval letter once satisfied with the required documents. The vehicle approved under this regulation should be manufactured in conformation with the type approved. The competent authority can verify the conformity control methods applied in each production unit.

Implementation of United Nations regulations in ASEAN countries

The World Forum for Harmonization of Vehicle Regulations is a working party of the Sustainable Transport Division of UNECE. It has a total of 62 members with representation from both European countries (France, Germany, Spain, UK and others) and non-European countries (Australia, Japan, Russia, Malaysia, Thailand and others). Table 38 highlights the status of implementation of UNECE R100 and UNECE R136 in select ASEAN countries.

Table 38: UNECE R100 and R136 status in select ASEAN countries

Regulation	Singapore	Thailand[14]	Malaysia	Indonesia	Lao PDR
UNECE member	-	Yes, country code is E53	Yes, country code is E52	-	-
UNECE R100 (M and N category vehicle)	-	In progress	Implemented	Implemented (Part 2- Battery)	Not defined
UNECE R136 (L category vehicle)	-	TIS 2952	-	Implemented (Part 2- Battery)	Not defined

3.5.2 Recommendations for EV Type Testing in Lao PDR

Lao PDR has very limited automotive manufacturing, including EVs, and is mostly dependent on imports. It does not have any automotive type testing facility. Recently, the Government of Lao PDR has signed a memorandum of understanding with UMG Lao to explore the feasibility of an in-house vehicle testing facility that is being conceptualized by UMG Lao.

At present, the vehicle type approval is granted based on the simple technical requirement form submitted by the importer. The form captures basic information like brand, model, color, weight and engine capacity.

It is recommended that this form be modified to include additional details relevant to EVs, such as range, battery size, battery type, vehicle connector type and battery warranties. The modified version of the vehicle technical form is provided in Appendix 9. The form includes provisions to capture the testing standards followed by the vehicle or component manufacturers as discussed in Appendix 10. The type approval or permission for imports can continue to be granted based on this new form submitted by the vehicle OEMs or importers.

The EVs that are imported in Lao PDR are categorized as “clean energy vehicles” for import and taxation purposes. The Law on Land Transport should be amended for the inclusion of EVs across all vehicle segments (e-bicycle, e-moped, e-motorcycle, e-car, e-buses and others), including definitions, categorization, testing, registration, licensing, inspection and others. There already exists a National Transport Committee with representation from all key stakeholders and is led by MPWT with a dedicated Secretariat. It can take up required changes in the legislation for notifying testing and inspection mechanisms for EVs.

3.5.3 Procedures for EV Roadworthiness Inspection

The primary objective of the roadworthiness inspection (also referred to as periodic technical inspection) is to check that a vehicle is reliable and safe to be driven on roads without putting anyone at risk. The vehicle should meet the minimum standards required as per the regulations. These regulations vary across countries. Generally, the inspection scope includes testing of lights, steering, suspensions, horn, seatbelts, emissions, bodywork, doors, mirrors, brakes, wheels, wipers and fuel system.

For EVs, the roadworthiness inspection process will be similar to ICEVs except for the noise and emissions testing. However, there are some additional tests that may be required for EVs such as testing of batteries, connectors, traction motors, electric regenerative braking system and other critical components. There are not yet any established best practices for EV roadworthiness inspection, and it is a developing area (as EVs technology is still evolving). The frequency of roadworthiness inspection will vary across vehicle segments (two-wheeler, four-wheeler, bus) and applications (personal, commercial).

[14]The Thailand Automotive Institute and TUV Co from Germany signed an agreement to set up the first battery testing center for electric vehicles in Southeast Asia. Thai Industrial Standards Institute (TISI) to sponsor the procurement of testing instruments and tools. TISI is working out standards for electric vehicles based on relevant standards including the UNECE R100 standard.

3.5.4 Existing Roadworthiness Inspection Mechanisms in ASEAN Countries

Indonesia, Malaysia, Singapore and Thailand all have roadworthiness inspection procedures for ICEVs. Singapore has made some changes specific to EV inspection. Comparison of the roadworthiness inspection mechanisms between these ASEAN countries and Lao PDR is discussed below.

Singapore

Inspection authority and law: The Land Transport Authority is the agency responsible for roadworthiness inspection of vehicles, and there is an authorized inspection center for periodic inspections. Generally, inspection notices are sent by the Land Transport Authority when vehicle inspection is due. Vehicle owners can pay road taxes only when they hold a valid vehicle inspection certificate.

Inspection scope: A brief scope of the vehicle inspection across different vehicle types is shown in Table 39.

Table 39: Inspection category and scope for different vehicle segments in Singapore

No.	Inspection category	Examples	Petrol vehicle	Diesel vehicle	EV	Hybrid vehicle
1	**Lighting equipment** e.g., headlamps, stop lamps, directional indicators, reflectors	Examine the condition of the various types of lamps	√	√	√	√
		Examine the condition of the direction indicators	√	√	√	√
		Conduct headlamp intensity and alignment test	√	√	√	√
2	**Steering system** e.g., steering linkages, ball joints, power steering	Check for steering free play	√	√	√	√
		Examine the steering wheel hub, spokes and rim	√	√	√	√
3	**Braking system** e.g., brake pedal, brake hose/pipe/ cylinder	Check the physical condition of the service brake pedal	√	√	√	√
		Check for leaks in any part of hydraulic system	√	√	√	√
		Conduct roller brake test	√	√	√	√

No.	Inspection category	Examples	Petrol vehicle	Diesel vehicle	EV	Hybrid vehicle
4	**Suspension system** e.g., shock absorber coil/leaf springs	Examine the condition of coil springs of leaf/ springs	√	√	√	√
		Examine the security and amount of play at pins/ brushes and joints	√	√	√	√
5	**Tire and road wheels**	Examine the condition of the tires	√	√	√	√
		Examine the condition of road wheels	√	√	√	√
		Conduct wheel alignment test	√	√	√	√
6	**Engine and transmission** e.g., engine brackets/ mountings/oil leaks, propeller shaft	Examine the condition of the engine mountings	√	√	X	√
		Examine the condition of the propeller shaft	√	√	X	√
		Conduct exhaust emission test	√	√	X	√
7	**General items** e.g., engine/ chassis number, registration number plate, bodywork, windscreen/window glass	Visual examination of chassis number	√	√	√	√
		Visual examination of registration number plate	√	√	√	√
		Conduct noise level test	√	√	X	√

Source: *VICOM, Ltd.*

There are other additional statutory test requirements like diesel smoke test and hydrocarbon emission test. The EV inspection is similar to ICEV inspection except emission and noise testing.

Inspection frequency and fees: Table 40 gives a summary of inspection frequency and fees for various vehicle types in Singapore. The inspection fee is inclusive of taxes. If the vehicle fails the inspection test, then the re-inspection fee is generally 50% of the inspection fee.

Table 40: Inspection frequency and fees in Singapore

	Frequency			Inspection fees in Singapore Dollars (VICOM 2018)	
Vehicle age	**<3 years**	**3-10 years**	**>10 years**	**Inspection**	**Re-inspection**
Motorcycle and scooter	Not required	Annually	Annually	19.26	9.63
Car/Private hire car	Not required	Every 2 years	Annually	64.20	31.10
Taxi	Every 6 months	Every 6 months	N/A	64.20	31.10

Inspection time: It generally takes less than 15 minutes to inspect a petrol vehicle and less than 20 minutes for a diesel vehicle. The additional time for diesel vehicle is for the diesel smoke test.

Malaysia

Inspection authority and law: Puspakom, a privately-owned entity, is the main inspection center in Malaysia accredited by the Road Transport Department of Malaysia.

Inspection scope: The inspection is similar to that of the British Ministry of Transport test with checks on brakes, suspension, headlights, above and below carriage, emissions, identification, speedometer, side slip and tinted glass. On the Puspakom website, no specific guidelines are provided for EV inspection.

Inspection frequency and fees: It is mandatory for company-registered vehicles and commercial vehicles to undergo an annual inspection. For private vehicle owners, inspection is voluntary. The inspection fee is given in Table 41.

Inspection time: Generally, it takes less than 30 minutes to complete the inspection once the documentation is completed.

Table 41: Inspection frequency and fees in Malaysia

Vehicle type	Frequency	Inspection fee in Malaysian Ringgit (Puspakom 2019)
Motorcycle/Tri-motorcycle	Annually	35
Car	Annually	55
Taxi/Van/Jeep/Minibus	Annually	55

Thailand

Inspection authority and law: The Department of Land Transport is the agency responsible for roadworthiness inspection in Thailand. The tests are carried out at authorized private test centers. They can be identified by their official logo – a yellow gear on a blue circle. No reminders are sent by the department, and it is the responsibility of the vehicle owner to send their vehicles to authorized centers for inspection.

Inspection scope: The inspection is similar to that of the British Ministry of Transport test with checks on lights, steering, identification, indicators, tires, emissions, brakes and bodywork.

Inspection frequency and fees: Inspection must be carried out annually for motorcycles over five years old and cars over seven years old. The inspection fee is based on vehicle type and engine capacity (Table 42). The road tax sticker will not be issued by the Department of Land Transport unless an inspection certificate is produced by the vehicle owner.

Table 42: Inspection frequency and fees in Thailand

Vehicle type	Vehicle age	Frequency	Inspection fee in Thai Baht
Motorcycle	>5 years	Annually	300-400
Car	>7 years	Annually	2,000

Inspection time: Generally, it takes less than 30 minutes to complete the inspection once the documentation is completed.

Indonesia

Inspection authority and law: Vehicle inspection is carried out by examiners who meet the requirements set by the Government of Indonesia. Inspection is required for cars used for tourism, taxis and commercial vehicles, and a "KIR certificate" (right) is issued for those who pass the inspection, which costs IDR60,000. In Jakarta city, the Jakarta Transportation Agency is one of the agencies with the authority to issue KIR certificates.

Inspection scope: The inspection includes checks on emissions, turning radius, horn, lights, noise, tires, dentification, mirror, brakes, speedometer, suspension and side slip.

Inspection frequency and fees: The inspection is every six months for a fee of IDR75,000.

Inspection time: Generally, it takes 15 to 30 minutes to complete the inspection once the documentation is completed.

Inspection labels: An inspection sticker is placed on the upper left side of the vehicle's windshield when it passes the vehicle inspection test. A fee of IDR25,000 is charged to issue the sticker and seal (Ketut 2019).

Sticker

Metal Seal (5x5cm)

Metal seal on the license plate

Lao PDR

Inspection authority and law: The MPWT is in charge of determining the technical standard and the technical inspection regulations.

Inspection scope: The inspection includes checks on lights, steering, identification, indicators, tires, emissions,

brakes, bodywork and noise.

Inspection frequency and fees: Inspection must be carried out annually for motorcycles and cars over two years old. The inspection fee is based on vehicle type and engine capacity (Table 43) (J&C Group 2019)

Table 43: Inspection frequency and fees in Lao PDR

Vehicle type	Vehicle age	Frequency	Inspection fee in LAK
Motorcycle	>2 years	Annually	50,000
Car	>2 years	Annually	100,000

Inspection time: Generally, it takes less than 15 minutes to complete the inspection once the documentation is completed.

Inspection labels: An inspection sticker is placed on the vehicle's windshield when it passes the inspection. The sticker displays the month and year for the next inspection. There are three inspection stickers for different vehicle types.

Sticker design			
Color	**Yellow**	**Green**	**Blue**
Vehicle type	Motorcycle (two-wheeler)	Passenger car, pickup truck, SUV and minivan (not over 15 seats)	Truck (weighing 3.5 tons and more) and bus (16 seats and more)

3.6 Recommendations for Roadworthiness Inspection of EVs in Lao PDR

In Lao PDR, the institutional structure and mechanisms are already in place to conduct periodic roadworthiness inspection for ICEVs. The same can be extended for EVs with some modifications.

The roadworthiness inspection for EVs will be similar to ICEVs except for noise and emission tests. It is, however, advisable to conduct additional tests for EVs. The Russian Federation and the International Motor Vehicle Inspection Committee has suggested minimum requirements for periodic technical inspection of EVs. The list includes testing the visibility of the electrical hazard marking as per UNECE R100, electric regenerative braking system, electric power steering, electrical wiring, electric power train and RESS charging system. Table 44 describes the suggested inspection methodology and checks.

Table 44: Suggested inspection methodology and checks for EVs

No.	Item	Methodology	Reasons for rejection
1	Electrical hazard marking (as defined by UNECE R100 and R136)	Visual inspection	• Missing or cannot be found • Incomplete or illegible • Not in accordance with the vehicle documents or records
2	Electric regenerative braking system	Visual inspection	• Component is missing, damaged or corroded • Warning device malfunctioning • Warning device shows system malfunctioning
3	Electronic power steering	Visual inspection	• Warning device malfunctioning • Warning device shows system malfunctioning • Power assistance not working • Electrical wiring/connections corroded
4	Low voltage electrical wiring (as defined by UNECE R100)	Visual inspection with the vehicle over a pit or on a hoist, including inside the engine compartment (if applicable)	• Wiring inadequately secured – wiring likely to touch hot parts or rotating parts of the ground • Wiring slightly/heavily/extremely deteriorated (in relevant parts for braking and steering) • Damaged or deteriorated insulation – likely to cause a short-circuit, imminent risk of fire or formation of sparks
Electric power train (as defined by UNECE R100)			
5.1	RESS (e.g., traction batteries)	Visual inspection with the vehicle over a pit or on a hoist, including inside the engine compartment when appropriated	• Not in accordance with requirements • Inadequately secured • Damaged or corroded components • Leaking • Shields not in place or damaged • Damaged or deteriorated electrical insulation
5.2	RESS management system if fitted/required (e.g., range information, state of charge indicator, battery thermal control)	Visual inspection when possible	• Not in accordance with requirements • Warning device malfunctioning • Warning device shows system malfunctioning • Components missing or damaged • Operation of RESS ventilation/cooling system impaired e.g., blocking of ventilation holes or ducts or fluid leaks
5.3	Electronic converters, motors and change control, and wiring harness and connectors	Visual inspection with the vehicle over a pit or on a hoist, including inside the engine compartment when appropriated	• Not in accordance with requirements • Inadequately secured • Damaged or corroded components • Shields not in place or damaged • Damaged or deteriorated electrical insulation

No.	Item	Methodology	Reasons for rejection
5.4	Traction motor(s)	Visual inspection with the vehicle over a pit or on a hoist, including inside the engine compartment when appropriated	• Not in accordance with requirements • Inadequately secured • Damaged or corroded components • Shields not in place or damaged • Damaged or deteriorated electrical insulation
5.5	Auxiliary power equipment (e.g., heating, defrosting)	Visual inspection with the vehicle over a pit or on a hoist, including inside the engine compartment when appropriated	• Not in accordance with requirements • Inadequately secured • Damaged or corroded components • Shields not in place or damaged • Damaged or deteriorated electrical insulation
5.6	Service disconnect device	Visual inspection and voltage absence check, where possible without disassembling	• Inadequately secured • Damaged or corroded components • Shields not in place or damaged • Damaged or deteriorated electrical insulation • Voltage presence
5.7	"Active driving possible mode" indicator and associated information signal if the driver leaves vehicle in active driving possible mode if fitted/ required	Visual inspection and by operation if possible	• Indicator/information signal not fitted in accordance with requirement • Indicator/information signal not functioning properly
5.8	"State of drive direction" indicator if fitted/ required	Visual inspection and by operation	• Indicator not fitted in accordance with requirement • Indicator not functioning properly
RESS external charging system if fitted/required			
5.9.1	Charging cable(s) if fitted/required	Visual inspection if possible	• Not in accordance with requirements • Damaged or corroded components • Damaged or deteriorated electrical insulation
5.9.2	Vehicle charging immobilization interlock if fitted/required	Visual inspection and by operation if possible	• Not in accordance with requirements • Warning device malfunctioning • Warning device shows system malfunctioning • System not functioning

No.	Item	Methodology	Reasons for rejection
5.9.3	Vehicle inlet charging connection if fitted/ required	Visual inspection	• Inadequately secured • Damaged or corroded components • Shields not in place or damaged • Damaged or deteriorated electrical insulation • Inadequate weather sealing of vehicle inlet charging connection or charge cable interface
5.9.4	Vehicle electrical chassis (protective earth) and inter-charging protective earth connection if fitted/ required	Electrical continuity check	• Not in accordance with requirements • Continuity check failed

For EVs, a new roadworthiness inspection label can be designed (new color). This can give a unique identity to EVs and a sense of new vehicle ownership to users. For vehicle registration, a green color plate is suggested.

The roadworthiness inspection fee can be kept relatively low for EVs. The roadworthiness inspection certificate can be made mandatory for the payment of annual road taxes. The inspection can also be made mandatory for the renewal of insurance. They can ease private companies' access to EV financing and help address issues like post-sales service, which are key concerns for owning EVs in Lao PDR.

The existing roadworthiness inspection infrastructure and trained personnel for ICEVs can be utilized for EVs as well, with some additional training.

4. Raising Public Awareness

Despite the advantages of EVs over ICEVs in several dimensions such as TCO, low emissions and ease of driving, EV adoption rates remain low. Scaling up EVs will require significant investments in awareness generation and ensuring that the initial experience of consumers is good across all dimensions – quality, cost, service and financing.

A consumer study was undertaken in Lao PDR by GGGI to understand the awareness and perception of EVs, and the challenges of EV adoption in the country. The study focused on motorcycles[15] and covered 177 respondents across students, business owners and government officials. Some of the key takeaways from the study include the following (GGGI 2019):

- Only 45% of the government employees are aware of EVs, and less than 20% are aware in the private sector. The awareness was found to be highest among students (70%);
- Evidence on lifecycle cost saving (25%) and more public charging stations (21%) have been cited by respondents as the top two factors for promoting EVs in the country;
- Limitations of travel distance (19%) and availability of charging (18%) are the top two challenges in owning an EV;
- High upfront cost (31%), uncertain resale value (15%) and unfavorable loan terms (15%) are important financing issues faced by EV owners;
- Actual EV users cite charging issues (45%) and battery-related problems (33%) as important operational issues for EVs; and
- Social media and the Internet (50%), friends and families (25%) and dealers' advertisement (17%) are preferred channels to access information. Newspapers and magazines (8%) are the least preferred channels.

The outcomes from this study, as well as experience from other countries, have been incorporated to develop a public awareness plan for EVs in Lao PDR.

[15] Two-wheelers constitute the largest proportion of total vehicles on road in Lao PDR.

4.1 Program for Generating Awareness and Creating a Market Pull (PACE)

Four components of PACE have been identified to develop a focused awareness generation program for EVs in Lao PDR:

1. Wide dissemination of government **P**olicy and incentives for owning EVs;
2. Highlight and validate the **A**dvantages and benefits of EVs;
3. **C**reate a demand for EVs, including awareness about what product, charging and financing options exist; and
4. **E**cosystem development through awareness generation and training for various stakeholders.

A detailed profile of some of the PACE components is provided in Appendix 6.

4.1.1 Wide Dissemination of Government Policy and Incentives for Owning EVs

EV vision and mission: The country needs to define the vision and mission for EV deployment to build investor and user confidence, and guide them on the country's approach to supporting the EV sector.

EV targets: EV targets derived from the EV vision and mission needs to be set to show Lao PDR's commitment to growing the EV sector.

Fiscal and non-fiscal incentives: The technology and policy risks will shape the decision of potential EV buyers. The various incentives designed for EV sector growth need to be translated into an easy-to-understand message that tips the buying decision in favor of EVs. Bold communication and stricter enforcement of non-fiscal incentive measures, like EV-only zones, will help influence the buying behavior of businesses like taxi operators.

4.1.2 Highlight and Validate the Advantages and Benefits of EVs

The EV user experience needs to be clearly communicated, and the benefits associated with EVs need to be quantified and presented to influence buying behavior – demonstrating that EVs are a clear winner over ICEVs when it comes to operational cost and comfort. Also, there is an added feel-good factor for the environmental contribution made by the user.

The most critical benefits to EV users include:

- **Lower TCO** – Although capital expenditure for EVs is higher, their TCO is lower compared to ICEVs. EV buyers need to understand the vehicle cost vis-à-vis battery capacity they opt for, and the battery services available that can reduce overall capital expenditure of the vehicle, e.g., battery-swapping option. To accelerate EV deployment, vehicle purchase decision will have to be shifted from current capital expenditure to the TCO approach, and this needs to be conveyed to buyers in simple terms.
- **Low maintenance requirement** – When compared with ICEVs, EVs have lower maintenance requirements since the number of moving parts in EVs is considerably low. The relative maintenance cost advantage of EVs need to be made available to buyers and users.
- **Easy and smooth ride** – Test rides are critical in helping buyers get first-hand experience of EVs' ride quality.
- **Freedom from pollution and noise** – EVs can reduce local air pollutants, improve air quality and lessen noise pollution leading to cleaner and quieter neighborhoods. The micro-impact of EVs is a service to self and society.

4.1.3 Create a Demand for EVs

A number of strategies are described in this sub-section to create demand for EVs.

Creating web resources on EV products, cost/performance data, certifications, charging infrastructure providers, location of public charging stations and financing options are essential for rapid EV uptake. Social media and digital promotion of EVs can be very effective in Lao PDR, as well as in other places.

The promotion of government's adoption of EVs as part of government procurement, and incorporation of EVs in government-owned fleets, including public buses, vehicles for municipal utilities like garbage collection and cleaning, and vehicles for government departments is essential. The government is the largest fleet owner and customer for vehicles, therefore, inclusion of EVs presents a good business case as vehicle usage is high, and the program can be implemented at different levels. For example, the Vientiane Capital State Bus Enterprise, the public transport company, can introduce electric buses in its fleet for city-level transportation and interstate long routes. Urban local bodies can play a critical role in promoting clean transportation within city limits (especially applicable to cities that want to preserve their pristine setting and promote tourism).

It is important to set up public charging stations in places that are highly visible and frequented (e.g., tourist spots, important government buildings, leisure parks, movie halls, universities and shopping malls). The high presence of charging stations reduces the anxiety of potential buyers regarding access to public charging infrastructure. It also generates customer interest.

Commercial taxis and e-commerce delivery operators can be targeted as part of the awareness generation program. The TCO of EVs will be lower for these operators due to their higher operating distances, and EV adoption rates are likely to be higher among them. The government may consider special subsidies and financial support for commercial taxis and e-commerce delivery operators, and awareness can be promoted through customer meets, with suppliers and financial companies. Taxis are easily visible and used by multiple users, allowing users to experience EVs before buying. Similarly, e-commerce delivery has intensive user connections and can encourage EV adoption among the general public.

Supporting aggregation is another important strategy for scaling up demand. This can be achieved through eliciting customer interest and organizing customer meets for quick processing of purchase/financing applications during the meet. Aggregation creates a buzz as people notice such events. It gets better terms for customers and reduces customer acquisition costs for suppliers. At the same time, customers perceive lower risk in adopting new technologies. Aggregation can be organized by well-known financial companies, utility (EDL), or a focused government department for promoting EVs.

EDL, the utility company, plays a major role in promoting EVs in the country as the company has direct consumer connections and direct business interest in promoting EVs as consumers of electricity. EDL will also play a key role in setting up the charging infrastructure. EDL's EV program may cover the following aspects:

- Opening charging stations at their bill collection or customer relationship centers, distribution transformers, and other key government locations;
- Helping to set up home or private charging stations at residences and commercial centers, owned by EDL or in partnership with charging infrastructure providers;
- Providing prompt electrical connections for EV charging at homes, offices and public charging locations;
- Raising awareness of their EV program through email and mobile messaging campaigns;
- Providing customer support by managing a portal where customers can get information on EV products and financing options, book EV trials and register their interest in aggregated procurement;
- Directly offering financial support for EV purchases or supporting the availability of financing from banks and leasing companies.

The organization of EV trials enables users to directly experience vehicle performance, which can give confidence to users and bring down anxieties related to charging and batteries. Positive EV trials is a good way to generate word-of-mouth promotion. Such trials can take different forms:

- Short rides for 15-20 minutes around showrooms or display places;
- Longer duration lease arrangements for 15-30 days;
- EV test drive missions covering long distances (thousands of kilometers) over several weeks can be planned to cover the different cities of Lao PDR. This is to showcase that EVs can be used for long-distance (inter-city) commute and reduce fears related to the range and charging time. Such events can be organized in collaboration with private agencies and OEMs to promote their product and brand. In each city, a test drive for the general public and media interaction sessions can be organized to garner publicity; and
- Various EV experience tours for tourists can be organized. For example, using EVs inside areas of tourist significance like animal parks, temples and monuments, creating EV-only zones in congested areas of cities, and partnering with the hospitality industry to offer tours and packages using electric bicycles and other EVs.

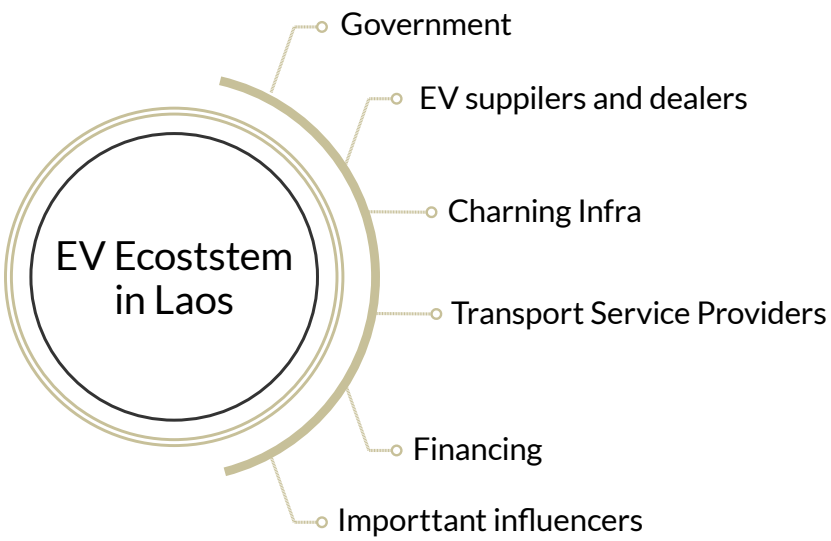
Engaging celebrities and influencers can create a strong positive user interest, especially in the initial phases of introducing EVs.

Unique registration plates (e.g., green) for EVs will make EV users stand out and will be very effective in generating user interest. Such registration plates will also help in implementing preferential access policies such as preferred parking spots or entry into restricted zones. Providing priority parking or access rights in areas of traffic congestion can be very important for vehicle users, especially for commercial vehicles, as this directly impacts vehicle earning and customer comfort.

4.1.4 Ecosystem Development

The EV ecosystem in Lao PDR includes the government, EV supply chain stakeholders, EV charging system and its participants, transport sector service providers, vehicle financing institutions and influencers (Figure 16). In order to develop the EV ecosystem, the awareness and technical capacity of the different stakeholders in the EV ecosystem will need to be built.

Figure 16: Key stakeholders of the EV ecosystem in Lao PDR



More specifically, the key stakeholders include the following:

- Government
  - MPWT
  - Ministry of Finance
  - Ministry of Energy and Mines
  - Ministry of Science and Technology
  - Other ministries
  - EDL
  - Vientiane Capital State Bus Enterprise
  - Urban local bodies

- EV suppliers, distributors and dealers
  - Importers
  - Potential manufacturers

- Charging infrastructure
  - Equipment suppliers
  - Contractor/system integrators for setting up charging infrastructure
  - Charging infrastructure service providers/charge point operators

- Transport service providers
  - Private bus operators, including fleet operators
  - Private taxi operators
  - E-commerce delivery or logistics companies
  - Individual drivers who provide services through owned/rented vehicles

- Financial institutions
  - Leasing companies and banks
  - Insurance companies

- Influencers
  - Transport experts
  - Multilateral organizations
  - Universities
  - Research institutes
  - Consultants
  - Think tanks

The broad outline of PACE with timelines and primary responsibilities for government or a private entity is shown in Table 45.

Table 45: Broad outline of PACE

S.No.	Activity Name	Short Term (< 1Y) - G+P	Medium Term (1-3 Y)
P1	Exhibition / Summit/ Conference / Awards	G+P	G+P
P2	Workshops		P
P3	Bulk Procurement Program (fleet programs)	G	G+P
P4	EV Test Drives (showrooms)	P	P
P5	EV Test Drive Mission (Example: 10 days Lao city tour)	P	
P6	EV Experience Tour (Example: Tourist place, City tour)	G+P	P
P7	EV Web Portal	P/G	P
P8	Setting up Public Charging Stations (at important locations)	G+P	P
P9	EDL EV program		G
P10	EV Entrepreneurship Programs		G+P
P11	EV Technician Training Program		G+P
P12	Webinars	P	P
P13	EV Registration Plate (Green Plates)	G	G

Notes:

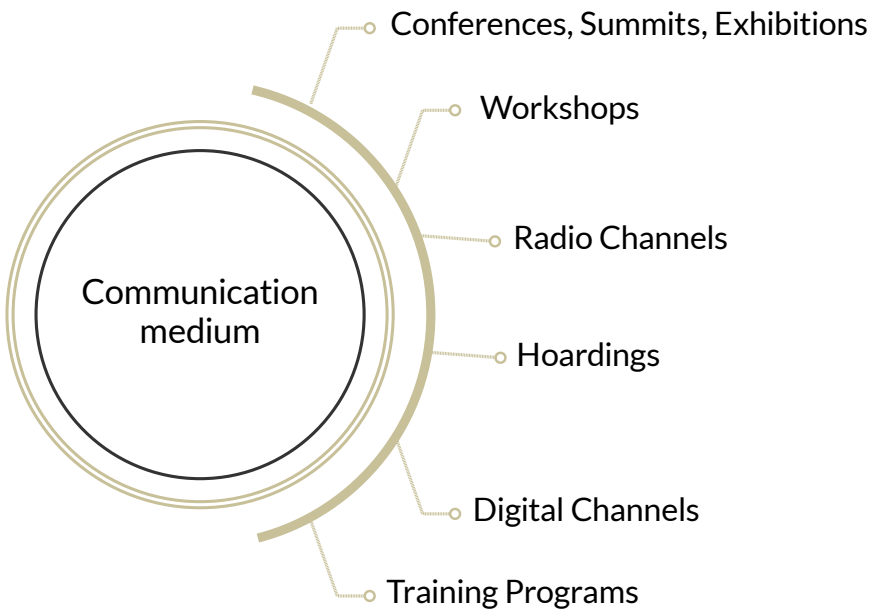
High Importance Medium Importance

G = Government
P = Private

4.2 Communication Channels

Communication channels for EV awareness generation are summarized in Figure 17. Newspaper and print media ads are not included here because of the feedback received in Lao PDR that they are not very effective.

Figure 17: Communication medium for EV awareness generation



4.2.1 Conferences, Summits, Exhibitions, Awards

Conferences and summits can bring all the stakeholders together. A series of knowledge-sharing sessions can be organized to keep users updated on policy, technology and emerging market trends. In parallel, exhibitors can display their products and service offerings to policymakers, customers, influencers and other ecosystem members for improved understanding of EV solutions.

Awards can play a supporting role by identifying and recognizing individuals, organizations and businesses that contribute to EV development in the country. Such events primarily led by the private sector and appropriately supported by the government are well received and covered by the media.

4.2.2 Workshops and Roundtables

Focused and targeted consultation workshops can be organized to bridge the technical understanding and information gap between stakeholders. Workshops and roundtables can also be effective in providing constructive feedback to policymakers. For instance, a workshop with a financial institution can help address the problem of resale value or loan repayment terms.

4.2.3 Highways and Street Hoardings

Display hoardings and banners are some traditionally effective ways used by both government and the private sector to catch the attention of the general public. The reach of this campaign is limited and depends upon population density and traffic volume of the selected location. In cases where hoarding space is open for advertisement, it can be made mandatory to promote EVs or other green technology with an advertising agency name.

4.2.4 Radio Channels

Radio channels may be used to announce new products and financing schemes, and share user experience. These are very effective both in urban and rural areas.

4.2.5 Digital Channels

Various digital media to promote EVs can be managed either by a government entity or outsourced to a private contractor. A digital communication strategy can include:

- A portal that shares information on:
  - Government policies;
  - EV benefits – Environmental benefits, macro-economic gains and direct financial benefits to the consumer communicated in easy-to-understand animated videos, interactive figures, text, etc.;
  - EV-related products and services (EVs, charging infrastructure, financing, etc.) with answers to buyers' queries related to the EV sector. It can include a platform to connect potential buyers and users with EV product and service providers;
  - User experience and validations;
  - Procurement and aggregation programs; and
  - EV registrations. It can include a fully-automated system for registering electric bicycles (a mechanism to be defined by MPWT).

Social media promotion (e.g., on Twitter, Facebook, Instagram, YouTube and WhatsApp): Short videos on user experiences, special EV services and EV products can be shared on various social media channels. In the survey conducted by GGGI (GGGI 2019)

4.2.6 Training Programs

EV technical training programs: As EVs are new to the country, the technical know-how on the sector is limited. Technical programs will help promote sectoral growth, and participation of EV service providers and supporting industries. Two types of academic/certification programs are suggested: (1) EV entrepreneurship program; and (2) EV technician program. An outline of the suggested technician training program is provided in Section 5. The final training program design and curriculum needs to undergo technical review by industry experts.

EV entrepreneurship programs: A series of entrepreneurship programs (both online and offline) can be organized to promote business opportunities in EVs. The active participation from both the government and the private sector will be required. These programs should be aimed at creating new job opportunities for youths. Some of the entrepreneurship themes that can be covered under this program include:

- EV market potential and business opportunity across the vehicle value chain (e.g., setting up charging infrastructure, EV servicing and electric taxis). This will help individuals and institutions understand the business opportunities and risks, and facilitate private sector participation in the EV sector;
- Opportunities in lithium-ion batteries manufacturing and recycling, including safety aspects and environmentally-friendly recycling; and

Design and manufacturing of brushless DC motor and controller for EV application.

5. EV Technical Training

The EV technician training program will be an important aspect of the Lao PDR EV deployment approach. This is because the country has an acute shortage of skilled human resources. According to the two-wheeler consumer and dealership survey undertaken by GGGI, post-sales service support is one of the major concerns for owning an electric motorcycle (GGGI 2019). Lao PDR needs more than 500 automotive technicians each year to meet automotive industry growth, but can supply only about 200 automotive technicians annually, most of whom are graduates from the Lao-German Technical School (The Nation 2017). Therefore, the skills development program needs to be actively pursued by the Ministry of Labor and Social Welfare through partnerships with the private sector. This initiative will also help upgrade the skills of the institutions and technicians authorized to conduct vehicle roadworthiness inspections.

The objectives of the EV technician training program will be to:

- Re-skill existing technicians by adding new skills;
- Provide new job opportunities in the automobile industry. These job opportunities can be in the field of manufacturing, technical sales, service support, etc.; and
- Create a better post-sales service ecosystem in Lao PDR.

The components of the EV technician training program can include the following:

- Training by OEMs
    - Lao PDR lacks the capabilities required to manufacture vehicles in the country. As a result, it is completely dependent on vehicle imports to meet its demand. Therefore, skill upgradation of technicians through a training program is also the responsibility of OEMs selling EVs in the Lao PDR market;
    - Training can be provided in cities where OEMs are selling EVs. This will help address concerns related

to post-sales service and spare parts availability;

- Training can be targeted at dealers, service stations and spare parts providers;
- If possible, the government can make it mandatory for OEMs to provide training to technicians. The OEMs may be asked to submit a training report regularly.

- Training by private players
  - EV training courses can be designed by private players with support from the government. The training can be a mix of hands-on and theoretical sessions;
  - For hands-on training, classroom sessions are preferred. The cost of such courses is generally high because of the course design. Their duration can be one to six weeks;
  - For theoretical sessions, e-learning platforms are preferred. They can be easily delivered at a lower cost with higher outreach and no location constraint. The duration of such courses can be less than a week;
  - A completion certificate can be issued by the training partner or government to endorse the training course;
  - Some suggested training courses include:
    - Basics of EV and its components
    - Guide to the technical inspection of EV
    - EV sales, servicing and maintenance
    - EV charging station design, engineering and installation
  - The training courses can be customized for different job roles that include equipment assemblers (electrical and mechanical), machine tool operators, mechanics, electrical power-line installers and others.
- Training by the government
  - Regular short training courses on vehicle roadworthiness test to upgrade the knowledge of technicians conducting vehicle inspection can be organized; and
  - Authorization certificates can be issued to vehicle inspection partners, which can be renewed every two years.

6. Summary of Policy Recommendations

6.1 Financial Measures to Promote EVs

- Provide capital subsidy of up to 30% for EVs that use high battery capacity (e.g., 12m buses), until 2022.
- Provide interest subvention of 50% of interest levied on loans granted to EV buyers for up to six years (capped at 5% per annum), until 2023.
- Promote a partial risk guarantee facility (with an estimated fund size of US$200 million) to reduce the risk exposure of participating financial institutions and finance 20% of EVs for at least three years.

6.2 Fiscal Measures for EV Deployment

- Feebate on fossil fuel: To improve the revenue balance and make polluters pay to meet the revenue deficit, a tax of 6% on fossil fuel is suggested in 2020. This can be gradually increased to 10% by 2022, and remain at that level thereafter.

6.3 Taxation Measures for EVs

Excise tax rates:

- Continue providing excise tax rate concessions during the initial phase of EV deployment to ensure TCO competitiveness of EVs over ICEVs.
- Withdraw excise tax rate concessions when battery prices fall and EVs become cost-competitive with ICEVs (from 2023). A special rate may be allowed for vehicle segments that are more costly to operate (e.g., the case of minibuses for transport use).

Road Fund:

- For replenishment of the Road Fund, collect a mileage fee for EVs based on a “per kilometer charge” for EVs. The proposed rates are as follows:

Road Fund for EVs	US$/km	LAK/km
Bicycle	0.0	0
Two-wheeler motorcycle	0.0010	9
Car	0.0061	54
Minibus/van	0.0061	54
Bus	0.0196	173

Road tax:

- Establish a kW (motor capacity) and vehicle class-based road tax for EVs (a similar approach is being used in Singapore).

6.4 EV Imports

- Continue to grant type approval or permission for imports based on test reports and type testing certificates submitted by the vehicle OEMs as per Lao PDR-approved international technical standards.

6.5 EV Registration

- Register all EVs just like for ICEVs and base registration charges on EV class and motor capacity.
- For electric bicycles, waive registration charges and licensing renewal requirements.
- Refer to Appendix 7 for more details on recommendations for registration of EVs.

6.6 Aggregated EV Procurement

- Promote government procurement that supports EVs through government-owned public bus fleets and ministries.

6.7 EV Charging Stations

- Simplify procedures for establishing EV charging stations. For high-capacity home charging, and public and business charging, online application and permission processes need to be established. This should be supported by post-installation verification and third-party technical inspection of installations.
- Prioritize space allocation for public charging stations at defined rates to ensure that there is private sector interest in charging infrastructure development.
- EDL can take the lead in public charging infrastructure development. Major cities and important routes should have charging infrastructure to support inter-city commute by EVs.
- Develop data-sharing arrangements.
- Develop a protocol for peak-load management to prepare the country for high EV penetration.

6.8 EV Batteries

- **EV battery specification:** Only promote lithium-ion batteries for all kind of EVs.
- **Battery performance:** Customize global standards to meet local conditions. The IEC standards usually follow -25°C to 40°C temperature profile for different tests. A typical temperature range in Lao PDR is 10°C to +45°C. Like India, Lao PDR in its customization of global standards can propose to extend temperature range to +50°C (or even 55°C as changed by India).
- **Battery recycling:** Identify a public sector enterprise for used battery buy-back and sale for secondary use (e.g., storage applications). A precious metal recovery program (from waste batteries) can be designed. Battery recycling can help increase the resale value of EVs, improve financing mechanisms and ensure environmental quality.

- **Battery swapping technology:** Promote battery swapping, which will reduce vehicle upfront cost and waiting time for charging, and improve vehicle efficiency and battery life. EV projections show that two-wheeler battery will be a sizeable market in Lao PDR, and India has shown success in the commercial deployment of battery swapping in their electric two-wheeler fleet.

6.9 Electricity Tariffs

- Continue the proposed tariff of LAK500/kWh for EV charging in the initial years to support the attractiveness of EVs.
- Increase EV charging tariffs once EVs achieve the right momentum to maintain its cost advantage.

6.10 Awareness Generation Measures

- Provide preferential access to EVs at tourist hotspots (e.g., in historical places and monuments);
- Introduce unique registration plates for EVs to support targeted interventions (e.g., preferential access and parking);
- Establish a dedicated fund to support EV awareness generation for three years.

Recommended policy measures to promote EV deployment in Lao PDR are summarized in Table 46.

Table 46: EV policy measures matrix for Lao PDR and select ASEAN countries

	Policy Area	Lao PDR	Malaysia	Thailand	Singapore	Indonesia
1	**Overarching vision document**					
	EVs					
2	**Mandates (general)**					
	• Government procurement					
	• Transition to EVs (sales)					
	• Transition to EVs (vehicle stock)					
3	**Taxes (concessions)**					
	• Customs duty					
	• Excise tax (concessional rates)					
	• VAT					
	• Annual road tax (exempt for certain vehicle class)					
4	**Capital subsidies on sale of EVs**					
5	**Income tax credits**					
6	**Road Fund charges (collected from EVs)**					
7	**Registration of vehicles/licensing/permits**					
	• Mandatory registration for all class of vehicles					
	• Registration based on motor capacity (kW)					
	• Special registration plate					
8	**Feebates**					
	• Special tax on fossil fuels					
	• Additional parking charges for ICEVs					
	• Additional road tax or registration tax on ICEVS					

	Policy Area	Lao PDR	Malaysia	Thailand	Singapore	Indonesia
	• Special tax on commercial vehicle fares					
	• Additional VAT on the sale of ICEVS					
9	**ICEV scrapping incentives/buy-back programs**					
10	**Preferential access rights**					
	• Right to enter defined city areas					
	• Right to enter in restricted times					
	• Preferential parking rights					
	Charging infrastructure					
11	**Capital subsidies**					
	• Public charging stations					
	• Swap stations					
	• Private charging stations					
12	**Mandates**					
13	**Special charging tariff**					
14	**Fixed or demand charges for charging infrastructure stations**					
15	**Financing the EV sector (EVs, charging infrastructure)**					
	• Interest cost subvention					
	• Partial risk guarantee					
	• Battery financing					
	• Operating lease					
	• Financial lease					
16	**Battery disposal**					
	• Post-life buy-back programs					
	• Extended dealer/producer responsibility					
17	**Manufacturing**					
	• Special economic zones					
	• Income tax waivers					
	• VAT, customs duty, excise tax waivers					
	• Special access to government procurement programs					
	• Capital subsidies					
	• Low-cost financing					

Notes:

Proposed for Lao PDR

Existing in Lao PDR

Provision exists

Draft provision

Appendix

Appendix 1: Stakeholder Consultation – List of Institutions and Office Bearers

No.	Institution	Concerned official	Designation
1	Department of Transport, Ministry of Public Works and Transport (MPWT)	• Dr. Bounta Onnavong • Mr. Stefan Ekelund • Mr. Khamathideth Manikham	• Director General • Urban Transport Advisor • Deputy Director
2	EV Laos Company	• Mr. Bounleuth Luangpaseuth • Mr. Thongchan Santhasith	• CEO of Luangpaseuth Cooperation • Deputy Director
3	Department of Import and Export, Ministry of Industry and Commerce	• Dr. Keomorakoth Sidlakone	• Deputy Director
4	Department of Tax and Custom, Ministry of Finance	• Ms. Viengkhone Chindavone	• Head of Legislation Division
5	Vientiane Capital State Bus Enterprise	• Mr. Keovanphone Vonethyvongsy	• Director General
6	Division of Public Works and Transport, Vientiane Capital	• Mandate Staff	
7	Department of Road, MPWT	• Ms. Duangtavanh • Mr. Xong Ver	• Deputy Head of Planning Division • Technical Staff, Technical Division
8	Department of Standardization and Metrology, Ministry of Science and Technology	• Mr. Bounhome Phanouvong • Mr. Phouthasak Baochanh	• Director of National Standards Certification and Quality Inspection Center • Deputy Director of Standard Division

8	Krungsri Leasing	• Mr. Viboon Jirapatanakul • Mr. Pawach Kulteerajesada	• Managing Director • Head of Product Marketing and Public Relations
9	Suzuki	• Mr. Inpone Soundala	• Accounting and Human Resources Manager
10	Institute of Renewable Energy Promotion	• Mr. Khammanh	-
11	Vehicle Inspection Center, MPWT	• Mandate Staff	
12	Lao Automotive Association	• Mr. Saneu Chounlamany	• President
14	UMG Lao (Vientiane Testing Facility)	• Mr. Chalongchai Chayutrapong	• Director/CEO
15	World Bank	• Mr. Sombath Southivong • Mr. Chanin Manopiniwes	• Senior Infrastructure Specialist • Senior Infrastructure Economist

Appendix 2: Primary Survey Summary

Manufacturing and Assembly

Based on information from primary and secondary sources, two-wheelers are not manufactured in Lao PDR, but many two-wheeler brands are assembled in the country. The Japanese brands, Honda, Suzuki and Yamaha, previously imported components from suppliers in Malaysia and Thailand in completely knocked down form, but later, few of them shifted to semi-knocked down imports. The same is the case with the Chinese and Korean (Kolao) brands of motorcycles, which import semi-knocked down components into Lao PDR and assemble them locally. The assemblers' local content is about 40% for Honda, 20% for Kolao, and 60% for most Chinese firms (Oraboune 2011).

Vehicle Importers and Dealers

All importers interviewed use Thanaleng (20km from Vientiane) as the point of import in Lao PDR. Almost all the vehicles are imported through Thailand, except for a few models of electric two wheelers that enter Lao PDR through Vietnam. The Friendship Bridge (built over the Mekong river) between Nongkhai (Thailand) and Thanaleng (Lao PDR) is the most common route followed by importers. After the initial inspection of documents, the vehicles are then sent to the Lao customs warehouse at Thanaleng, where imports are inspected and approved for entry.

From the consultant's survey with dealers in Lao PDR, it was observed that irrespective of the place of origin of the ICE two- and four-wheelers, they enter Lao PDR through Thailand. Electric bicycles are the only exception, entering Lao PDR through China, Vietnam and Thailand. Also, the buses that are imported from the Philippines enter the country through Vietnam.

Table 47: Details of surveyed two-wheeler dealers

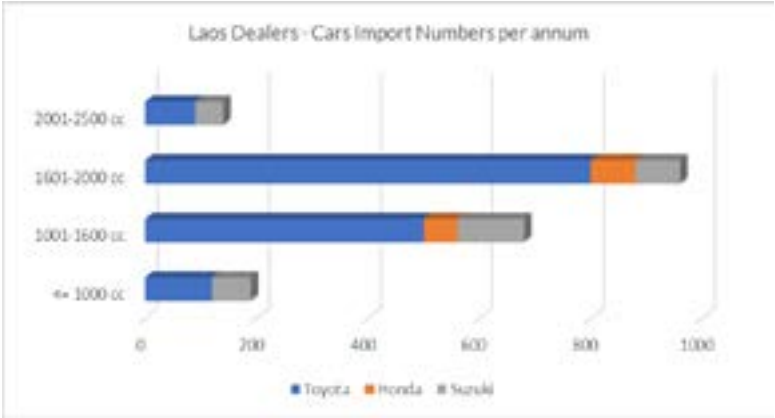
Name of respondent	Name of importing agency	In business since	Vehicles imported	City/province based in
Mr. Boualay	Lao Toyota Thongkhankham	1992	Four-wheelers	Vientiane
Ms. Muit	Honda New Chip Xieng	2012	Two- and four-wheelers	
Mr. Inphone	Suzuki-Laos KPN	2012	Four-wheelers	
Ms. Xu	Electric motorcycle – Sabai	2016	Electric two-wheelers	
Ms. Sone	Saisavanh Motor	2012	Buses	
Mr. Sisongkham	Hino representative Laothani Sole Co. Ltd.	2012	Buses	

Table 48: Details of surveyed four-wheeler dealers

Dealer company	Imported from	Import route followed
Toyota Cars	Thailand, Japan, Malaysia	Malaysia/Japan–Thailand–Lao PDR
Honda Cars	Thailand, Japan, India, Malaysia, Indonesia	Malaysia/Japan/India/Indonesia-Thailand–Lao PDR
Suzuki Cars	Thailand, Japan, India, Indonesia	Japan/India/Indonesia–Thailand–Lao PDR
E-Sabai two-wheelers	China	China–Lao PDR, China–Thailand/Vietnam–Lao PDR
Honda two-wheelers	Thailand	Thailand–Lao PDR
Buses	Japan, Thailand, Philippines	Japan–Thailand–Lao PDR Thailand–Lao PDR Philippines–Vietnam–Lao PDR

Lao PDR permits cars of various engine displacements, some with ⩽ 1,000cc and few even with ⩾5,000cc. Based on the survey with dealers, the most popular segment is between 1,601cc and 2,000cc (Figure 18). These numbers represent only the sedan and sports utility vehicle (SUV) models, but not the pickup trucks that are imported in bigger numbers than sedans and SUVs.

Figure 18: Number of cars imported per annum, by engine displacement



Vehicle Taxes and Fees

Table 49: Summary of taxes and fees for vehicles in Lao PDR

S.No	Vehicle Type	Engine Capacity	Make	Custom Duty			Excise Duty	VAT	Vehicle Registration Costs (Kip)	Annual Road Tax (Kip)	Technical Inspection (Kip)	Licensing Fee (Kip)	Final price to the customer (USD)
				ASEAN (ATIGA)	ACFTA (with China)	Normal & WTO							
1	Motor Cycles	<= 50 cc	HONDA, YAMAHA, SUZUKI, and Vespa KOLAO (both diesel and gasoline)	0%	20% (10% from 2020)	50%	20%	10%	NA	NA	NA	NA	1819
2		51-110 cc		0%	0%	40%	20%		88000	10000	10000	18600	1364
3		111-150 cc					30%		88000	20000	10000	18600	2501
4		151-250 cc					40%		NA	50000	NA	NA	3411-5458
5		251-500 cc					60%		NA	100000	NA	NA	NA
6		>= 501 cc		0%	0%	40%	80%		NA		NA	NA	NA
7			Clean Energy	0%	0%	40%	5%		NA	NA	NA	NA	NA
8			Spare Parts	0%	0%	5-20%	5%						
9	Cars (including SUVs and Pickups)	<= 1000 cc	Chinese	0%	0%	20%	25%	10%	NA	100000	NA	NA	NA
10		1001-1600 cc	TOYOTA, HONDA, SUZUKI, KIA, HYUNDAI, MAZDA, MG, FORD, Mercedes Benz, BMW...				30%		91000	150000	10000	21000	230000
11		1601-2000 cc					35%		91000	200000	30000	21000	330000
12		2001-2500 cc					40%		91000	250000	30000	21000	550000
13		2501-3000 cc					45%		91000	300000	30000	21000	1800000
14		3001-4000 cc					70%		100000	350000	30000	21000	NA
15		4001-5000 cc					80%		100000	400000	30000	21000	NA
16		>= 5001 cc					90%		NA	500000	NA	NA	NA
17			Clean Energy				10%		NA	NA	NA	NA	NA
18	Medium Transport Vehicles (10-35 seating)	Empty Wt: 3.5-15 tons	Fuel Diesel/Bus, Trucks	0%	0%	20%	8%	10%	100000	400000	30000	21000	409000
19			Clean Energy				5%		NA	NA	NA	NA	NA
20	Large transport vehicles (>= 36 seating)	Empty Wt: 15-50 tons	Fuel Diesel/Bus, Trucks	0%	0%	20%	5%	10%	110000	500000	40000	21000	1830000
21			Clean Energy				5%		NA	NA	NA	NA	NA
22	Transport vehicles		Spare Parts	0%	0%	10%	5%						

The various taxes and fees levied on different vehicle segments have been compiled from various sources in Table 49. Lao PDR has varying customs duty rates under the free trade agreements it is bound to, such as the ASEAN Trade in Goods Agreement, ASEAN-China Free Trade Agreement and World Trade Organization Most-Favored Nation tariff rates. There are also ASEAN agreements with other countries like India (AIFTA), and Australia and New Zealand (AANZFTA).

The excise tax also varies and is based on the vehicle's engine displacement (VDB Loi 2016), while VAT is 10% for all the vehicles (PricewaterhouseCoopers 2018).

The dealers and the Ministry of Public Works and Transport (MPWT) provided the data for one-time vehicle registration cost and annual taxes like road tax (paid annually), technical inspection and licensing fee (both to be renewed every five years).

The dealers also provided the final vehicle prices (for the different categories) that they offer to customers, but none of the dealers revealed their profit margin. It should be noted that all these prices, taxes and fees are for new unused models and not second-hand or resold vehicles.

Vehicle Registration

The imported vehicles are initially registered in the name of the importers by the Customs Department, after the application form (IM4) has been filled by the importer and the registration charges have been paid to the Customs Department. This one-time vehicle registration cost is passed on to customers along with vehicle registration.

Driving License

There is no requirement for verification of customers' driving license before selling the vehicle. However, the dealers could not provide any information on license requirements for a few vehicle types, e.g., ⩽50cc internal combustion engine vehicles (ICEVs) and smaller capacity electric vehicles (EVs).

The driving license has to be renewed every five years for any vehicle type and it costs around LAK90,000-100,000, depending on the vehicle type and engine displacement.

Vehicle Insurance

Public or government-owned insurance agencies are not present in Lao PDR. The vehicle riders have few private insurance options from companies like Lao-Viet Insurance, Allianz General Lao, Toko Assurance and Vientiane Insurance. The insurance premiums per annum for the full coverage of a new car are around US$500-1,000, US$150-200 for a new two-wheeler and US$800-1,300 for a new bus.

Based on the vehicle owner survey carried out by the consultant, 80-90% of the vehicles that are more than two years old do not opt for full coverage or are denied full coverage by the insurance agencies. Such vehicle owners have to opt for low-quality insurance, often with a low premium amount (e.g., third-party coverage mostly in the range of US$200-400 per annum for cars, US$50-100 for two-wheelers and US$500-800 for buses).

Vehicle Financing

Details on the type and percentage of vehicle financing by customers vary from dealer to dealer and vehicle type. Table 50 shows details on vehicle financing based on dealers' responses.

Table 50: Summary of vehicle financing in Lao PDR

Company	Financing source	Period of loan and interest rate
Toyota Cars	1) Own finance: 80% 2) Maruhan Bank: 10% 3) Microfinance institute: 10%	7 years @ 0.35% 5 years @ 0.52% 3 years @ 0.49% 1-year loans are also taken
Honda Cars	1) Own finance: 50% 2) Private banks: 15% 3) Microfinance institute: 15%	7 years @ 0.39% 5 years @ 0.50% 3-year and 1-year loans are also taken
Suzuki Cars	1) Own finance: 65% 2) Private banks: 20% 3) Microfinance institute: 15%	7 years @ 0.55% 5 years @ 0.52% 3 years @ 0.49%
Honda two-wheelers	1) Own finance: 90% 2) Private banks/microfinance institute: 10%	1.8-2.6% (GGGI 2019) 0.39-0.50% (as per Honda vehicle dealer)
E-Sabai	1) Own finance: 100%	2.6-2.99% (GGGI 2019) As per E-Sabai, all vehicles were bought through own financing
Buses	1) Own finance: 90% 2) Private banks: 5% 3) Microfinance institute: 5%	2-5 years @ 0.51-0.6%

Vehicle Testing Facilities

According to MPWT, there are no vehicle testing facilities in Lao PDR. The Division of Public Works and Transport (DPWT, a subsidiary of MPWT at the provincial or municipality level) is responsible for conducting technical

inspections of vehicles every five years to renew their registration.

The only official document for vehicle testing is the "Regulation on Technical Standards of Vehicles and Accessories of Vehicles Authorized for Import, Registration, Assembly and Use in Lao PDR", dated November 11, 2002.

Technical experts and relevant machinery are non-existent for a vehicle testing facility in Lao PDR, and there are no safety regulations, components and vehicle labeling yet for EVs.

Financial Institution

The consultant visited the Mahuran Japan Bank Lao on September 5, 2019 to better understand how vehicles are financed in Lao PDR.

The bank finances all types of vehicles, but not EVs since they have not been demonstrated commercially yet in Lao PDR. The customer has to make a down payment of at least 20% of the vehicle cost to the dealer and the rest is financed by the bank at an average rate of 0.54% per month, with the maximum loan period of six years.

Appendix 3: Technical Specifications and Cost Trends for EV Types Identified for TCO Analysis

The technical specifications and cost trends for each electric vehicle (EV) type (selected models) are provided below. All cost estimations consider excise tax rates at 3% for EVs.[16] All other taxes are the same for internal combustion engine vehicle (ICEVs) and EVs.

Electric Bicycles

Electric bicycles are a potential mode of low-cost transport for users like students, office-goers and those who would like to shift from manual bicycles to a low-speed motorized option.

The electric bicycle model considered for analysis is the "Ancheer City Commuter", a lithium-ion battery-powered model from China. This is a basic electric bicycle with speed of less than 25km/hour.

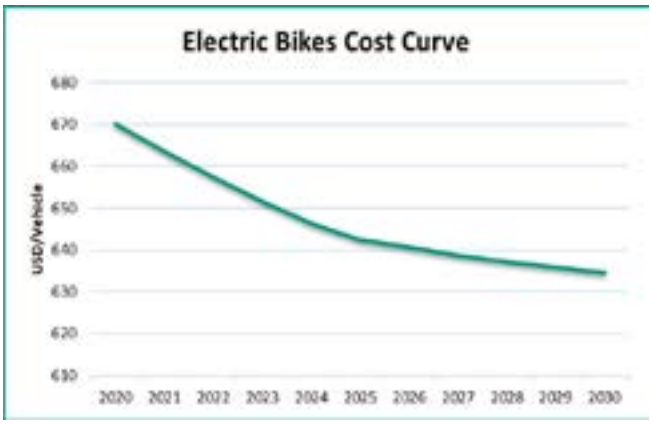
Such low-speed electric bicycles are not governed by the road transportation law in the country and are exempt from road taxes, inspection and licensing. Electric bicycles need to be registered to keep track of their numbers in the country, but no fees are charged.

Electric Bicycle Price and Trend

The 2020 market price of the Ancheer City Commuter is US$670. This model operates with a 0.3kWh lithium-ion battery – the low battery capacity limits bicycle speed and range.

The electric bicycle market price over the coming years is shown in Figure 19. It is projected that technological advancement will result in a sharp fall in battery prices, and this will reduce electric bicycle prices in the coming years.

Figure 19: Price trend for electric bicycles in Lao PDR



Two-Wheelers

For two-wheelers, comparison is made between a 110cc ICEV model and a 2kWh EV model. In Lao PDR, two-wheelers with engine displacements of 110cc and 115cc are most popular with the highest sales number in Lao PDR (Asian Development Bank 2012) (GGGI 2019).

[16]Based on Lao PDR's draft Law on Taxation dated July 10, 2019.

Table 51: ICEV and EV models considered for TCO analysis

	Bike (low speed variant)		Two wheeler		Car		Mini-bus		Bus- 9 meter		Bus- 12 meter	
Electric vehicle	Ancheer City Commuter Bike		Niu M+		Mine SPA1		EMS MB 16		BYD K7		BYD C9	
	Battery capacity	0.3	Battery capacity	2 kWh	Battery capacity	30 kWh	Battery capacity	36 kWh	Battery capacity	80 kWh	Battery capacity	324 kWh
	Road road price for 2020	US$ 670	On road price for yr 2020	US$ 1340	On road price for yr 2020	US$ 38,000	On road price for yr 2020	US$ 39,950	On road price for yr 2020	US$ 155,973	On road price for yr 2020	US$ 299,137
	Vehicle life	10	Vehicle life	20 years	Vehicle life	20 years	Vehicle life	20 years	Vehicle life	20 years	Vehicle life	20 years
	Battery life	1000	Battery life	1600 cycles	Battery life	2300 cycles	Battery life	2300 cycles	Battery life	5000 cycles	Battery life	5000 cycles
	Battery type	Li-ion	Battery type	Li-ion	Battery type	Li-ion	Battery type	Li-ion	Battery type	Li-ion	Battery type	Li-ion
	Fuel efficiency	75	Fuel efficiency	33.8km/ kWh	Fuel efficiency	6 km/kWh	Fuel efficiency	1.9 km/kWh	Fuel efficiency	1.1 km/kWh	Fuel efficiency	0.7 km/ kWh

ICE vehicle	Honda Wave		Toyota Corolla Altis		Toyota Hiace		Model not specified		Model not specified	
	Engine capacity	110 cc	Engine capacity	1600 cc	Engine capacity	2500 cc	Engine capacity	Equivalent to 9m EV bus	Engine capacity	Equivalent to 12m EV bus
	On road price for yr 2020	US$ 1365	On road price for yr 2020	US$ 30,900	Road price for yr 2020	US$ 43,000	Road price for yr 2020	US$ 143,275	On road price for yr 2020	US$ 173,275
	Vehicle life	10 years	Vehicle life	15 years	Vehicle life	15 years	Vehicle life	20 years	Vehicle life	20 years
	Fuel	Gasoline	Fuel Gasoline and diesel (80%, 20%)		Fuel	Diesel	Fuel	Diesel	Fuel	Diesel
	Fuel efficiency	60 km/lit	Fuel efficiency	9.6 km/lit	Fuel efficiency	9.2 km/lit	Fuel efficiency	4 km/lit	Fuel efficiency	3 km/lit

Since Honda is the preferred two-wheeler brand in Vientiane, the ICEV model chosen for total cost of ownership (TCO) analysis is the 110cc model of Honda Wave that costs about US$1,365.

For the equivalent EV, Niu M+, a Chinese lithium-ion two-wheeler, is chosen for TCO analysis, after considering factors such as battery performance (range, maximum speed and battery life), its popularity across the globe, and market presence in the Association of Southeast Asian Nations (ASEAN) region (NIU 2018).

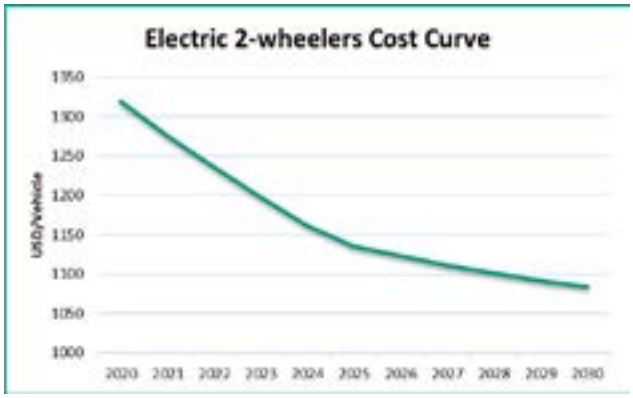
It should be noted that the EV model selected for TCO analysis is different from the electric two-wheeler that is available and popular in Lao PDR. This is because following discussions with electric two-wheeler dealers, it was found that all electric motorcycles sold in Lao PDR either run on lead-acid batteries or lithium-ion batteries that have lesser charging cycles.

Electric Two-Wheeler Price and Trend

The 2020 market price of the Niu M+ is US$1,340 (inclusive of all taxes applicable to EVs). This model operates with a 2kWh battery, with a range of 75km – the daily travel distance of most two-wheeler users in Lao PDR is not more than 50km (GGGI 2019).

The electric two-wheeler price over the coming years is shown in Figure 20. The sharp fall in the price of lithium-ion batteries will result in a corresponding sharp fall in electric two-wheeler prices. Current projections estimate that electric two-wheeler prices will stabilize after 2025.

Figure 20: Price trend for electric two-wheelers in Lao PDR



Cars

For cars, comparison is made between a 1,600cc ICEV model and a 30kWh EV model. Since Toyota dominates the car market in Lao PDR, with a share of over 40% (Focus-2-Move 2020), the commonly-used Toyota Corolla Altis is selected for TCO analysis.

For the equivalent EV, Mine SPA1 is chosen. This is a Thailand-made car that has already received more than 4,500 orders – currently, the number of electric cars on Thai roads is about 1,500) (Hampel 2019). Considering its deployment in huge numbers in its ASEAN neighbor, this electric car is expected to make in-roads into Lao PDR shortly.

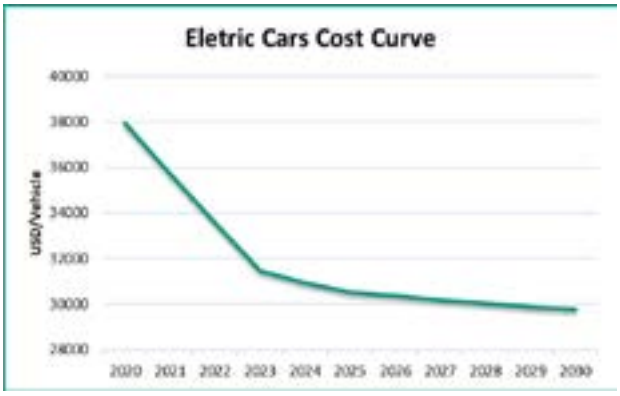
Electric Car Price and Trend

The Mine SPA1 considered for TCO analysis has a battery capacity of 30kWh, with a range of about 200km/charge. This range sufficiently covers the average distance of 42km traveled in a day by cars in Lao PDR,[17] thus, the battery size is justified and a balance between price and driving range is achieved.

The electric car market price over the coming years is shown in Figure 21, and similar to other EV segments, electric car prices are projected to fall sharply. Current projections estimate that electric car prices will stabilize after 2023.

[17]Calculated from the "average kilometers traveled per annum" values in Lao PDR Energy Statistics 2018 report (Ministry of Energy and Mines 2018)

Figure 21: Price trend for electric cars in Lao PDR



Minibuses/Vans

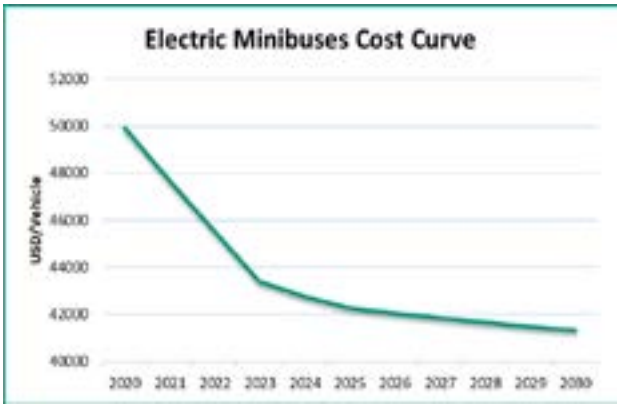
Minibus/van, as a segment, is chosen for commercial and public intra-city travel (about 50km per day)[18] in Lao PDR. For this segment, comparison is made between a 2,500cc ICEV model and a 36kWh model. For the ICEV, the 15-seat Toyota Hiace is chosen for TCO analysis since Toyota is a favored brand in the country. The only EV equivalent that is available is the EMS MB 16, a 16-seat configuration model that is available in the Netherlands.

Electric Minibus/Van Price and Trend

To optimize the balance between price and driving range, the battery capacity of the original EMS MB 16 is reduced from the actual model's 72kWh to 36kWh for intra-city use in Lao PDR. This makes the model an ideal fit for medium-range intra-city commuting of 50-75km/day. The cost of the vehicle is based on the adjusted battery capacity.

Similar to other EV types, the electric minibus market price over the coming years is projected to fall sharply and stabilize after 2023 (Figure 22).

Figure 22: Price trend for electric minibuses/vans in Lao PDR



9m Bus

Two separate bus segments – 9m and 12m – have been analyzed for intra-city and inter-city travel, respectively.

For the electric 9m bus, comparison is made between an 80kWh model and an equivalent ICE bus with matching specifications. The BYD 9m bus with an optimized battery size to support intra-city travel of 50-80km/day in Lao PDR is chosen. The 9m ICE bus chosen costs about US$30,000 less than the 12m ICE bus.

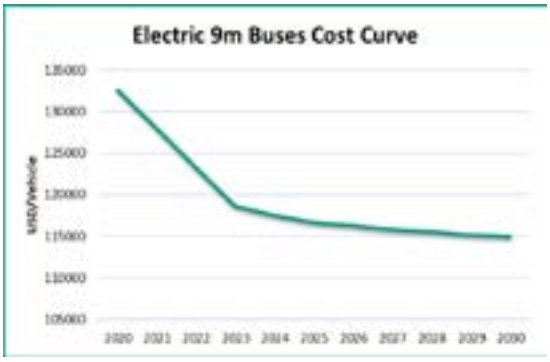
Electric 9m Bus Price and Trend

[18]Calculated from the "average kilometers traveled per annum" values in Lao PDR Energy Statistics 2018 report (Ministry of Energy and Mines 2018)

In estimating the electric 9m bus price, the battery capacity of the original BYD 9m bus model is reduced from the actual model's 180kWh to 80kWh for intra-city use in Lao PDR. This makes the model an ideal fit for medium-range intra-city commuting of 50-75km/day. The cost of the vehicle is based on the adjusted battery capacity.

The electric 9m bus market price over the coming year is shown in Figure 23. The sharp fall in battery prices will result in a corresponding sharp fall in bus prices. Current projections estimate that electric 9m bus prices will stabilize after 2023.

Figure 23: Price trend for 9m buses in Lao PDR



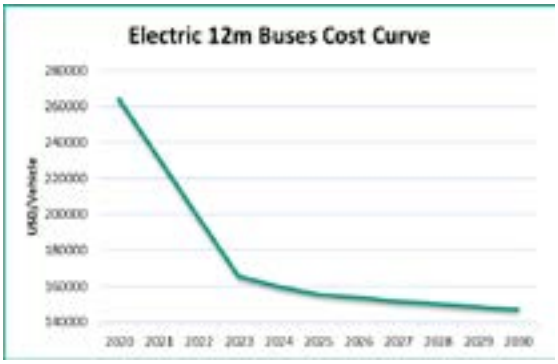
12m Bus

The 12m bus segment is specifically considered for long distance inter-city commute. Electric 12m buses require big battery size, making them more costly compared to other public transport vehicles like the minibuses and the 9m buses, considered for intra-city travel. Comparison is made between a 324kWh electric 12m bus model and an equivalent ICE bus with matching specifications.

Electric 12m Bus Price and Trend

The electric 12m bus market price over the coming years is shown in Figure 24. The sharp fall in battery prices will result in a corresponding sharp fall in bus prices. Current projections estimate that electric 12m bus prices will reduce substantially until 2023 and stabilize after 2025.

Figure 24: Price trend for 12m buses in Lao PDR



Summary

EVs are advanced and technologically superior to ICEVs, but currently, the latter has the cost advantage. Batteries contribute about 30-40% of EV cost, and battery prices are fast falling. It is projected that EV prices across vehicle segments will stabilize after 2023. At present, the EV choices available to users are limited, but vehicle manufacturers across the globe plan to add new EV models – in a recent car exhibition in Lao PDR, more than five EVs were launched. EVs will certainly become more and more competitive in the coming years as their uptake increases.

Appendix 4: Global EV Charging Standards

The development of charging standards has primarily been led by four economies – China, Europe, Japan and USA. The standards defined by these economies are well known around the globe and accepted among regulators. The selection of a particular standard is largely determined by local market conditions, such as the influence of key original equipment manufacturers (OEMs) in the market, the percentage of vehicle market share (for two- and four-wheelers), associations and road conditions. The selection can also be influenced by international agreements signed between economies.

Table 52: Global standards for connectors and chargers

Charger Type	Level	Current	Power	China	Europe	Japan	North America
Slow Chargers	Level 1	AC	≤ 3.7 kW	Devices installed in private households, the primary purpose of which is not recharging electric vehicles			SAE J1772 Type 1
	Level 2	AC	> 3.7 kW and ≤ 22 kW	GB/T 20234 AC	IEC 62196 Type 2	SAE J1772 Type 1	SAE J1772 Type 1
	Level 2	AC	≤ 22 kW	Tesla Connectors			
Fast Chargers	Level 3	AC (3 Phase)	> 22 kW and ≤ 43.5 kW		IEC 62196 Type 2	SAE J3068 (under development)	
	Level 3	DC	Currently < 200 kW	GB/T 20234 DC	CCS Combo 2 Connector (IEC 62196 Type 2 & DC)	CHAdeMO	CCS Combo 1 Connector (SAE J1772 Type 1 & DC)
	Level 3	DC	Currently < 150 kW	Tesla connectors			

Source: *Global EV Outlook Report 2017*

The following observations can be made on charging standards:

- The standards are defined for **two types of chargers** – slow chargers and fast chargers.
- The **levels** define the output power rating of the chargers.
- For **AC slow chargers**, the most common type of socket and connectors are –
  - *GB/T 20234 AC*
  - *IEC 62196 Type 2 Connector* – (Commonly referred to as Mennekes) is selected by the European Commission as the official charging plug within the European Union
  - *SAE J1772 Type 1*
  - *Tesla Connectors* – It is interesting to note that Tesla (OEM) has defined its own charging standard that is used across all countries except Europe.
- For **AC fast charger**, the commonly-used socket and connector is IEC 62196 Type 2.
- For **DC fast chargers**, the options that are available for socket and connectors are –
  - *CCS Combo 1* – This is widely used in the USA
  - *CCS Combo 2* – This is widely used in Europe and ASEAN countries like Malaysia
  - *CHAdeMO* – This is widely used in Japan and countries developing DC fast chargers
  - *GB/T 20234 DC*
  - *Tesla Connectors.*

Images of the different vehicle connectors and inlets are shown in Table 53. Note that for AC charging, on-board chargers are required to convert AC to DC power.

Table 53: Global standards for vehicle connectors and inlets

Standard name	AC/DC	Connector	Vehicle inlet	Rating
a. IEC 62196 Type 2	AC			32/63A 380-480V 3 phase **or** 70A 250V 1 phase
b. CCS Combo 2	AC + DC			Max. 350A Max. 1,000V
c. SAE J1772 Type 1	AC			16/32A 250V 1 phase
d. CCS Combo 1	AC + DC			Max. 350A Max. 1,000V
e. GB/T 20234 AC	AC			32A 1 phase 220V 3 phase 440V
f. GB/T 20234 DC	DC			Max. 250A Max. 750V
g. CHAdeMO	DC			Max. 200A Max. 600V
h. Tesla Connectors	DC			~ 250A ~ 480V

Appendix 5: UNECE Vehicle Categories

Category	Description
L	**Motor vehicles with less than four wheels** (but does include light four-wheelers).
L1	A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine not exceeding 50cm^3 and whatever the means of propulsion a maximum design speed not exceeding 50km/hour.
L2	A three-wheeled vehicle of any wheel arrangement with an engine cylinder capacity in the case of a thermic engine not exceeding 50cm^3 and whatever the means of propulsion a maximum design speed not exceeding 50km/hour.
L3	A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine exceeding 50cm^3 or whatever the means of propulsion a maximum design speed exceeding 50km/hour.
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 50cm^3 or whatever the means of propulsion a maximum design speed exceeding 50km/hour (motorcycles with sidecars).
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 50cm^3 or whatever the means of propulsion a maximum design speed exceeding 50km/hour.
L6	A vehicle with four wheels whose unladen mass is not more than 350kg, not including the mass of the batteries in case of EVs, whose maximum design speed is not more than 45km/hour, and whose engine cylinder capacity does not exceed 50cm^3 for spark (positive) ignition engines, or whose maximum net power output does not exceed 4kW in the case of other internal combustion engines, or whose maximum continuous rated power does not exceed 4kW in the case of electric engines.
L7	A vehicle with four wheels, other than that classified for the category L6, whose unladen mass is not more than 400kg (550kg for vehicles intended for carrying goods), not including the mass of batteries in the case of EVs and whose maximum continuous rated power does not exceed 15kW.
M	**Vehicles having at least four wheels and used for the carriage of passengers** (e.g., a standard car with 2, 3, 4 doors).
M1	Vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9 (larger than standard car e.g., London Cab / E7 type vehicle 8 seat + driver).
M2	Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tons (bus).
M3	Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tons (bus).
N	**Power-driven vehicles having at least four wheels and used for the carriage of goods.**
N1	Vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tons (pickup truck, van).
N2	Vehicles used for the carriage of goods and having a maximum mass exceeding 3.5 tons but not exceeding 12 tons (commercial truck).
N3	Vehicles used for the carriage of goods and having a maximum mass exceeding 12 tons (commercial truck).

Appendix 6: List of EV Public Awareness Initiatives

No.	Category	Communication channel	Primary ownership	Key target audience	Key messages	Areas of concern to address	Message formats	Importance
P1	**Information dissemination tools (public)**	**Exhibition, summit, conference, awards** (all in one)	• Lead by the private sector and supported by government	• Government departments (transport, energy, etc.) • Standards and testing institutes • OEMs/dealers • Charge point operators • EV fleet operators • Banks • Leasing companies • Insurance companies • Research and development institutes • Multilateral institutions • Consultants • General public • Contractors • Media	• Government vision document • Government policy and incentives • Benefits of owning an EV	• Government policy and incentives • EV market potential • EV technology, trend and its working	• Product brochures • Videos • Knowledge papers • Email campaigns • Flyers and leaflets • Website • Hoarding	High

No.	Category	Communication channel	Primary ownership	Key target audience	Key messages	Areas of concern to address	Message formats	Importance
P2	**Information dissemination tools (private)**	**Workshops**	• The private sector, mainly OEMs and service providers	• Banks • Leasing companies • Insurance companies	• Government policy and incentives • Benefits of promoting EVs	• Resale value • Attractive loan terms	• Presentations • Knowledge papers • Product brochures	High
P3	**EV fleet programs**	**Bulk procurement program** (fleet programs)	• Government • Private sector • Fleet operators	• OEMs	• Reducing global carbon footprint using sustainable technology	• Low business volume because of high vehicle price • Leading by example. Early adaptor and trendsetter		High
P4	**EV drive experience**	**EV test drives** (showrooms)	• OEMs • Dealers	• Government departments • General public • EV fleet operators	• Promote EV as a comfortable and easy-to-ride intra-city vehicle • Highlight the benefits of owning an EV	• Show evidence of lifecycle cost saving • Charging by electricity (solar)	• Product brochures • Flyers and leaflets	Medium
P6	**EV Tourism Experience**	**EV experience tour** (e.g., tourist place, city tour)	• Government • Private sector • Fleet operators	• General public	• Promote EV as a comfortable and easy-to-ride intra-city vehicle	• Low public awareness		High
P7	**Information dissemination tools (public)**	**Highway and street advertisement** (focused marketing campaign)	• OEMs • Dealers • Charge point operators • Fleet operators	• All	• Highlight the key value proposition of a product or service offering	• Low public awareness	• Flyers • Hoarding	Low

No.	Category	Communication channel	Primary ownership	Key target audience	Key messages	Areas of concern to address	Message formats	Importance
P8	**EV charging experience**	**Setting up public charging stations** (at important locations)	• Charge point operators • OEMs • With support from government	• Transport department (bus stop, railway, etc.) • Business owners (pump stations, malls, etc.) • EV fleet operators	• Promote easy and quick battery charging as a service	• Lack of charging infrastructure/ battery charging • Travel distance	• Flyers and leaflets • Live demonstration	High
P9	**Information dissemination tools (public)**	**EDL EV program**	• EV owners	• General public • Business owners (pump stations, malls, etc.) • Charge point operators • OEMs	• Benefits of owning an EV • Battery charging locations	• Easy and low-cost charging • Travel distance	• Flyers • Direct email • Website	Medium
P10	**Information dissemination tools (public)**	**EV entrepreneurship program**	• Both the government and the private sector to take lead in capacity building	• Entrepreneurs • Student • Educational institutes • Consultants • Private sector	• Government policy and incentives • Business opportunities in EV • EV technology, trend and its working	• New business and job opportunities	• Knowledge papers • Training manuals • Videos • EV products (hands-on experience)	High

No.	Category	Communication channel	Primary ownership	Key target audience	Key messages	Areas of concern to address	Message formats	Importance
P11	**Information dissemination tools (public)**	**EV technician training program**	• Both the government and the private sector to take lead in capacity building	• Technicians	• EV inspection, repair and maintenance • EV technology, trend and its working	• Skill upgradation	• Training manuals • EV products (hands-on experience)	Medium
P12	**Information dissemination tools (private)**	**Webinars**	• Private sector • Multilateral institutions • Research and educational institutes	• Government departments • OEMs/dealers • Banks • Entrepreneurs • Consultants • Contractors	• Government policy updates • EV market potential and business opportunities • EV technology, trend and its working • EV user feedback	• Bridging knowledge gaps (via case studies)	• Knowledge papers • Presentations	Medium
P13	**Information dissemination tools (public)**	**EV registration plate** (green plates)	• Government	• General public		• Raising public awareness and making EV popular by giving different color vehicle registration number plate		Medium

Appendix 7: Case for Registration of Vehicles

The interventions suggested will make it necessary to have all EVs (except electric bicycles) registered with the transport authority for the following reasons:

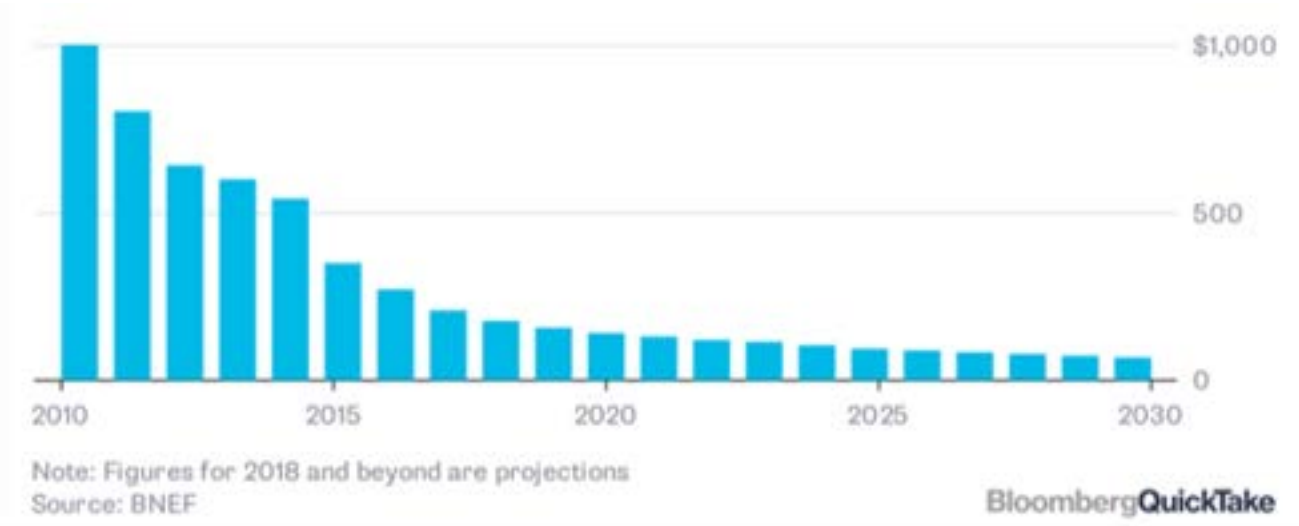
- To collect road user charges from two-wheelers (otherwise not possible);
- To bring financial institutions on board for EV financing and obtaining subsidies – Vehicle traceability will be essential for these purposes (not possible under the current scenario where certain vehicles are not registered);
- For electric two-wheel riders to obtain a driving license (this will be the condition for availing bank financing); and
- For vehicle insurance and third-party insurance.

	Road Fund collection	Bank financing	Vehicle insurance	Driving license	Subsidy support
Road Fund collection		Not required	Not required	Not required	Not required
Bank financing			Required	Required	Required
Vehicle insurance				Required	Not required
Driving license					Not required
Subsidy support					

Appendix 8: Battery Price Trend

Battery prices are falling fast. Figure 25 shows the falling cost of storing a kilowatt-hour of electricity.

Figure 25: Cost of storing a kilowatt-hour of electricity from 2010 to 2030



Appendix 9: Sample Vehicle Technical Approval Form

LAO PEOPLE'S DEMOCRATIC REPUBLIC

PEACE INDEPENDENCE DEMOCRACY UNIT PROSPERITY

Ministry of Public Works and Transport
Department of Transport

Reference No: _____ DOT
Date: _____ Vientiane

Vehicle Technical Approval

Reference to Land Traffic Law (amend) Issues No. 23/NA, Dated 12 Dec 2012
Reference to Import License No: _____ DIMEX **Date:** _____
Reference to Request Letter No: _____ **Date:** _____

The Department of Transport grants the Import Vehicle Technical Approval to:

Company: _____ **Telephone No:** _____

Address: _____ **Fax No:** _____
_____ **Email:** _____

for the following products:

1. Specifications:

Classifications	Country of Origin	Model	Model	Motor Rating (kW)	Technical Condition
					◻ 80% ◻ 100%
Steering	**Height (mm)**	**Length (mm)**		**Width (mm)**	**Seat**
◻ Left ◻ Right					
Model Year	**Gross Weight (kg)**	**Curb (kg)**	**Battery Weight (kg)**	**Axle**	**Wheel**
Energy	◻ Pure Electric	◻ Hybrid	◻ Petrol	◻ Diesel	◻ Gas
Connector Type (Vehicle Inlet)	◻ Type 1 ◻ Type 2 ◻ CHAdeMO	◻ CCS1 ◻ Others	◻ CCS2	◻ GB/T AC	◻ GB/T DC
Battery Cycles (numbers)	**Warranty (years)**	**Warranty (km)**	**Battery Size (kWh)**	**Range (km)**	**Electricity Consumption (Wh/km)**
Battery Chemistry	◻ Lead-acid ◻ LFP	◻ NMC	◻ LTO	◻ Others	
EV charger included with the vehicle?		◻ No	◻ Yes	**Charger rating (kW)**	

Purpose of Import	◻ Permanent	◻ Temporary

Vehicle Identity

No.	Motor No.	Engine No. (if Hybrid)	Chassis No.	Battery No.	Color
1					
2					
3					
...					
...					
...					
30					

Remark
1. Please provide the test reports/certification details as per **Appendix 10**
2. The vehicle must be imported before: _____
3. Border: _____

Director General

Appendix 10: Provisions for Which Test Reports/Certification Details to be Submitted by the Vehicle Manufacturer

This form is required to be filled by the vehicle manufacturer in addition to the vehicle technical approval form in Appendix 9. The purpose of the form is to capture the testing standards followed by the vehicle manufacturer or a component supplier in order to comply with the vehicle and components safety and performance. The tentative list of subjects for which test reports are required to be submitted is given below.

No.	Subject	Testing standard (please mention the testing standard followed)	Test lab name and country
1	Tire		
2	Reflector		
3	Horn installation		
4	Horn performance		
5	Lamps		
6	Lighting and signaling devices		
7	Head lamp assembly		
8	Front/rear lamp indicator assembly		
9	Front parking lamp assembly		
10	Rear registration plate lamp assembly		
11	Rear view mirror specifications		
12	Windscreen wiping system		
13	Speed governor		
14	Fitment of reflective tape and reflectors		
15	Flammability requirement		
16	Wheel rim		
17	Safety glass		
18	Windscreen laminated safety glass		
19	Side window/door glass		
20	Back light/rear toughened glass		
21	Strength of superstructure		
22	Seat dimension measurement test		
23	Interior fitting test		
24	Rear under run protection device		
25	Vehicle lateral protection side		
26	Stability angle determination		
27	Seat anchorage test		
28	Vehicle physical verification		
29	Vehicle weight		
30	Brake test		
31	ABS testing		

No.	Subject	Testing standard (please mention the testing standard followed)	Test lab name and country
32	Steering effort test		
33	Turning circle diameter test		
34	Speedometer calibration		
35	Noise test		
36	Gradeability test		
37	Interior noise test		
38	Temporary cabin fitted on drive away chassis		
39	Vehicle identification numbering		
40	Water effect test		
41	Range test		
42	Measurement of maximum power and 30 minutes power		
43	Constructional, functional safety test		
44	Measurement of electric energy test		
45	Traction batteries		
46	Electric shock test (if voltage greater than 48V)		
47	Electromagnetic interference and electromagnetic compatibility test		
48	Vehicle alarm systems		
49	Others		

In some cases, there is a possibility that a specified subject or test certificate may not be applicable or available with the vehicle manufacturer or importer for a specific reason. In such a case, the concerned importer is required to give an undertaking that the vehicle imported at Lao PDR comply with international safety and performance standards.

References

ALMEC. 2014. *The Preliminary Works for the Technical Cooperation on Low-Emission Transport System in Lao PDR*. Japan International Cooperation Agency. https://openjicareport.jica.go.jp/pdf/12182978.pdf.

Ashaari, Amin. 2019. "No new initiatives to promote usage of hybrid and fully electric vehicles in Malaysia." *Soya Cincau*. 23 April. Accessed September 6, 2019. https://www.soyacincau.com/2019/04/23/electric-vehicle-incentives-malaysia/.

Asian Development Bank. 2012. "ASEAN–China Free Trade Area and the Competitiveness of Local Industries: A Case Study of Major Industries in the Lao People's Democratic Republic." ADB Working Paper Series No. 98.

Asian Development Bank. 2019. "Lao People's Democratic Republic National Road 13 Improvement and Maintenance Project." Manila.

Asian Development Bank. 2015. "Lao People's Democratic Republic: Road Sector Governance and Maintenance Project." Manila.

Audenhove, François-Joseph Van, Guillaume Rominger, Alexei Korn, Aurelia Bettati, Nicolas Steylemans, Michael Zintel, Andrew Smith, and Sylvain Haon. 2018. *The Future of Mobility 3.0*. Arthur D Little. https://www.adlittle.com/sites/default/files/viewpoints/adl_uitp_future_of_mobility_3.0_1.pdf.

Automotive Product Working Group. 2019. "EV Charging Systems - Standards in Thailand." *29th Meeting of the ACCSQ*. March.

Chareonsong, Pornpimon. 2014. "E-waste Management in Thailand." *Presentation made at the 4th International E-waste Management Network (IEMN) Workshop*. July. https://19january2017snapshot.epa.gov/sites/production/files/2014-08/documents/thailand_country_presentation.pdf.

Coren, Michael J. 2019. "Researchers have no idea when electric cars are going to takeover." *Quartz*. 18 May. Accessed February 19, 2020. https://qz.com/1620614/electric-car-forecasts-are-all-over-the-map/.

CTN News. 2019. *Toyota Opens Vehicle Battery Recycling Plant in Central Thailand*. 1 September. Accessed September 10, 2019. https://www.chiangraitimes.com/thailand-national-news/auto/toyota-opens-vehicle-battery-recycling-plant-in-central-thailand/.

Dunseith, Bradley. 2017. "Import and Export Procedures in Laos – Best Practices." *ASEAN Briefing*. 25 July. Accessed October 6, 2019. https://www.aseanbriefing.com/news/import-and-export-procedures-in-laos-best-practices/.

Fehrenbacher, Katie. 2020. "2020 will be a key year (and decade) for electric vehicles." *GreenBiz*. 8 January. Accessed February 23, 2020. https://www.greenbiz.com/article/2020-will-be-key-year-and-decade-electric-vehicles.

Focus-2-Move. 2020. *Laos - The auto industry recovers after three years*. 1 February. Accessed February 7, 2020. https://focus2move.com/lao-vehicles-sales/.

GGGI. 2019. "Gasoline Powered Motorcycle and Electric Motorcycle Consumer and Dealership Survey: Lao PDR Report." Seoul.

Gitano, Horizon. 2018. "Light Duty Electric Vehicle Standards in Malaysia." *Clean Air Asia*. October. Accessed November 11, 2019. https://cleanairasia.org/wp-content/uploads/2018/10/Gitano-Light-Duty-Electric-Vehicle-Standards-in-Malaysia.pdf.

Grütter, Jürg M., and Ki-Joon Kim. 2019. *E-Mobility Options for ADB Developing Member Countries*. Manila: Asian Development Bank. https://www.adb.org/sites/default/files/publication/494566/sdwp-060-e-mobility-options-adb-dmcs.pdf.

Hampel, Carrie. 2019. "Thailand: Energy Absolute unveils electric car." *Electrive.com*. 20 June. Accessed September

20, 2019. https://www.electrive.com/2019/06/20/thailands-energy-absolute-unveiled-its-mine-mobility-electric-car/.

Harman, Alan. 2018. "Thailand Promoting EV Purchases, Charging Network." *Wards Auto*. 8 February. Accessed August 22, 2019. https://www.wardsauto.com/engines/thailand-promoting-ev-purchases-charging-network.

International Energy Agency. 2017. "Global EV Outlook 2017." https://www.cleanenergyministerial.org/sites/default/files/2018-07/GlobalEVOutlook2017.pdf.

J&C Group. 2019. *Vehicle Technical Inspection*. 5 November. Accessed November 12, 2019. https://jclao.com/vehicle-technical-inspection/.

Ketut. 2019. "Indonesia car license." *Top Bali*. Accessed October 2, 2019. https://topbali.com/indonesia-tourism-licensed-car/.

Kirk, Robert S., and Mark Levinson. 2016. *Mileage-Based Road User Charges*. Washington DC: Congressional Research Service.

KPMG. 2018. *Electric Vehicles Industry Focus*. Bangkok: KPMG. https://assets.kpmg/content/dam/kpmg/th/pdf/2018/02/th-electric-vehicles-industry-focus.pdf.

Land Transport Authority, Government of Singapore. 2019. *Adoption of the UL2272 Certification for Motorized PMDs*. 15 October. Accessed February 20, 2020. https://www.lta.gov.sg/content/dam/ltaweb/corp/GreenTransport/2018/UL2272/ul2272_certified_pmds.pdf.

Largue, Pamela. 2018. "Thailand unveils new investment package for EV companies." *Smart Energy International*. 7 September. Accessed September 29, 2019. https://www.smart-energy.com/industry-sectors/business-finance-regulation/thailand-ev-companies-investment-growth/.

Lim, Adrain. 2018. "SP Group to build largest public electric vehicle charging network by 2020." *The Straits Times*. 19 June. Accessed September 18, 2019. https://www.straitstimes.com/singapore/transport/sp-group-to-build-largest-public-electric-vehicle-charging-network-by-2020.

Lima, Pedro. 2016. *China starts replacing LiFePO4 with NMC for EVs*. 6 October. Accessed October 12, 2019. https://pushevs.com/2016/06/10/china-starts-replacing-lifepo4-with-nmc-for-evs/.

Lye, Gerard. 2019. "Thailand government to remove excise duty on electric vehicles from 2020 to end-2022 – batteries likely next." *Paultan.org*. 14 March. Accessed November 8, 2019. https://paultan.org/2019/03/14/thailand-government-to-remove-excise-duty-on-electric-vehicles-from-2020-to-end-2022-batteries-likely-next/.

Malaysia Automotive Robotics and IoT Institute. 2019. "Electric Vehicle Charging Development."

Malaysian Investment Development Authority. 2017. *Plan targets to make Malaysia marketing hub for EVs by 2030*. 15 August. Accessed August 21, 2019. http://www.mida.gov.my/home/4234/news/plan-targets-to-make-malaysia-marketing-hub-for-evs-by-2030/.

Markets and Markets Research. 2019. *Electric Vehicle Market*. June. Accessed February 20, 2020. https://www.marketsandmarkets.com/Market-Reports/electric-vehicle-market-209371461.html.

Medimorec, Nikola. 2019. *E-Mobility Trends and Targets*. Partnership on Sustainable Low Carbon Transport. https://slocat.net/publications/e-mobility-trends-and-targets/.

Ministry of Energy and Mines. 2018. *Lao PDR Energy Statistics Report*. Vientiane: Government of Lao PDR.

Ministry of Planning and Investment. 2016. *Law on Investment Promotion*. 17 November. Accessed September 6, 2019. http://www.laoservicesportal.gov.la/index.php?r=site%2Fdisplaylegal&id=284.

MPWT. 2012a. *Law on Land Traffic*. 12 December. Accessed October 5, 2019. http://www.laoservicesportal.gov.la/index.php?r=site%2Fdisplaylegal&id=235.

—. 2012b. *Law on Land Transport*. 12 December. Accessed September 5, 2019. http://www.laoservicesportal.gov.

la/index.php?r=site%2Fdisplaylegal&id=212.

—. 2002. *Regulation on the Technical Standard of Vehicles and Accessories of Vehicles.* 11 November. Accessed September 5, 2019. http://www.laoservicesportal.gov.la/index.php?r=site%2Fdisplaylegal&id=196.

Nangoy, Fransiska, and Bernadette Christina. 2019. "Indonesia aims to start electric vehicle production in 2022." *Reuters.* 18 July. Accessed November 14, 2019. https://www.reuters.com/article/us-indonesia-electric/indonesia-aims-to-start-electric-vehicle-production-in-2022-idUSKCN1UD1OG.

Nanthavong, Khamphone. 2015. *Electricity Pricing in the Residential Sector of Lao PDR.* Vientiane: MECON Project. http://www.meconproject.com/wp-content/uploads/report/%5BTask%206-Electricity%20pricing%20in%20the%20residential%20sector%5D%20Lao%20PDR%20country%20report.pdf.

Ng, Nicole. 2020. "Do Electric Vehicles Make Financial Sense in Singapore? Here's How Electric, Hybrid And Petrol Cars Compare." *Dollars and Sense.* 20 February. Accessed February 21, 2020. https://dollarsandsense.sg/evs-make-financial-sense-singapore-heres-electric-hybrid-petrol-cars-compare/.

NIU. 2018. *Small Electric Scooter.* Accessed September 14, 2019. http://niuthailand.com/.

Oraboune, Syviengxay. 2011. "Lao PDR's Industrial Development Policy and Intermediate Goods Trade." Chap. 8 in *Intermediate Good Trade in Asia: Economic Deepening through FTAs/EPAs*, edited by Mitsuhiro Kagami, 267-296. Bangkok: Bangkok Research Center, IDE-JETRO. https://www.ide.go.jp/library/English/Publish/Download/Brc/pdf/05_chapter8.pdf.

Parpart, Erich. 2019. "Charging the EV market." *Bangkok Post.* 1 July. Accessed August 22, 2019. https://www.bangkokpost.com/business/1704860/charging-the-ev-market.

PricewaterhouseCoopers. 2018. "Promoting electric mobility in Lao PDR." Vientiane.

Puspakom. 2019. *Routine Inspection.* Accessed October 12, 2019. https://www.puspakom.com.my/routine-inspection/.

Roux, Nadea le, and Anculien Schoeman. 2016. "A Comparative Analysis of the Design of Special Economic Zones: The Case of South Africa, Malaysia and Indonesia." *Journal of Economic and Financial Sciences* 9 (3): 749-768.

See, Sharon. 2020. "Charged up: Singapore's journey to the future of cars begins now." *The Business Times.* 22 February. Accessed February 25, 2020. https://www.businesstimes.com.sg/brunch/charged-up-singapores-journey-to-the-future-of-cars-begins-now.

Sentany, Bayu. 2019. *Development of xEV Component Testing Facility.* Bandung: Balai Besar Bahan dan Barang Teknik.

Silviana, Cindy, and Gayatri Suroyo. 2019. "Indonesia plans incentives to boost electric vehicle industry." *Reuters.* 1 August. Accessed November 6, 2019. https://www.reuters.com/article/us-indonesia-electric/indonesia-plans-incentives-to-boost-electric-vehicle-industry-idUSKCN1UR4FE.

Suhartono, Harry, and Viriya Singgih. 2019. "Indonesia Plans Auto-Rules Overhaul to Form Electric-Car Hub." *Bloomberg.* 1 August. Accessed August 23, 2019. https://www.bloomberg.com/news/articles/2019-07-31/indonesia-plans-overhaul-of-auto-rules-to-form-electric-car-hub.

The Manila Times. 2019. *Hyundai PH, ,EVAP push for electric vehicle adoption, incentives.* 25 June. Accessed September 6, 2019. https://www.manilatimes.net/2019/06/25/weekly/fast-times/hyundai-ph-evap-push-for-electric-vehicle-adoption-incentives/574270/.

The Nation. 2017. *Lao automotive industry in need of more technicians.* 3 April. Accessed February 28, 2020. https://www.nationthailand.com/business/30311178.

Toppan Leefung. 2016. *Technical Reference for electric vehicle charging system.* Accessed October 12, 2019. https://www.singaporestandardseshop.sg/Product/SSPdtDetail/d0f65145-e555-4c19-a796-3c05ceb24fab.

Trading Economics. 2019a. *Laos Balance of Trade.* Accessed Jan 20, 2020. https://tradingeconomics.com/laos/balance-of-trade.

—. 2019b. *Laos Exports*. Accessed December 6, 2019. https://tradingeconomics.com/laos/exports.

—. 2019c. *Laos Imports*. Accessed December 6, 2019. https://tradingeconomics.com/laos/imports.

Tran, Chung Duc, and Stefan Petrus Salhofer. 2018. "Analysis of recycling structures for e-waste in Vietnam." *Journal of Material Cycles and Waste Management* 20: 110–126.

Transport & Environment. 2019. *Electric Surge- Carmakers's Electric Car Plans Across Europe 2018-2025*. Brussels: European Federation for Transport and Environment AISBL .

VDB Loi. 2016. "Laos Tax Booklet." Vientiane. http://www.vdb-loi.com/wp-content/uploads/2017/04/Lao-Tax-Booklet-2016.pdf.

VICOM. 2018. *Inspection Price and Schedule List*. Accessed October 3, 2019. https://www.vicom.com.sg/Our-Services/Vehicle-Inspection/Inspection-Price-and-Schedule-List.

Water Resources and Environment Adminstration. 2009. *Agreement on the National Environmental Standards*. Vientiane: Prime Minister's Office.

Wei-han, Chen. 2017. "EPA encourages public to practice battery recycling." *Taipei Times*. 17 February. Accessed September 14, 2019. http://www.taipeitimes.com/News/taiwan/archives/2016/02/17/2003639575.

Wentker, Marc, Matthew Greenwood, and Jens Leker. 2019. "A Bottom-Up Approach to Lithium-Ion Battery Cost Modeling with a Focus on Cathode Active Materials." *Energies* (Multidisciplinary Digital Publishing Institute) 12 (3): 504.

World Climate Guide. 2018. *Climate Laos*. Accessed September 16, 2019. https://www.climatestotravel.com/climate/laos.

Yongpisanphob, Wanna. 2017. *Thailand and the development of electric vehicles*. Research Intelligence: Krungsri Research. https://www.krungsri.com/bank/getmedia/c1891723-15be-46f4-a776-b6b6d115b06d/Research_Intelligence_03_EV_EN.aspx.

Zakiyya, H, Y Distya, and R Ellen. 2017. "A Review of Spent Lead-Acid Battery Recycling Technology in Indonesia: Comparison and Recommendation of Environment-friendly Process." *The 2nd Annual Applied Science and Engineering Conference*. Bandung: IOP Conf. Series: Materials Science and Engineering.

ABOUT THE GLOBAL GREEN GROWTH INSTITUTE

The Global Green Growth Institute was founded to support and promote a model of economic growth known as "green growth", which targets key aspects of economic performance such as poverty reduction, job creation, social inclusion and environmental sustainability.

Headquartered in Seoul, Republic of Korea, GGGI also has representation in a number of partner countries.

Member Countries: Australia, Cambodia, Costa Rica, Denmark, Ethiopia, Fiji, Guyana, Hungary, Indonesia, Jordan, Kiribati, Republic of Korea, Mexico, Mongolia, Norway, Papua New Guinea, Paraguay, Philippines, Qatar, Rwanda, Senegal, Thailand, United Arab Emirates, United Kingdom, Vanuatu, Vietnam

Operations: Cambodia, China, Colombia, Ethiopia, Fiji, India, Indonesia, Jordan, Lao PDR, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Nepal, Peru, Philippines, Rwanda, Senegal, Thailand, Uganda, United Arab Emirates, Vanuatu, Vietnam

Follow our activities on

Global Green Growth Institute Lao PDR

GGGI Lao PDR

www.gggi.org

The Global Green Growth Institute
19F Jeongdong Building 21-15, Jeongdong-gil Jung-gu, Seoul, Republic of Korea 04518