Policy Action Plan

Development of low-emission mobility policies

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Prepared by

ENVELOPS

Acknowledgement

Based on the United Nations Climate Technology Centre & Network (UN CTCN) Technical Assistance (TA) program requested by the General Secretariat of the National Council for Sustainable Development of the Cambodia Ministry of Environment, the Korean National Designated Entity (NDE) Ministry of Science and ICT and Green Technology Center Korea (GTC-K) has appointed Envelops Co. Ltd., to develop low-emission mobility policies action plan.

The Government of Cambodia, with the increased reliance on road transportation along with the economic development, faces a number of challenges in their transition to a sustainable development pathway and reducing GHG emissions and air pollution in the Country. Cambodia's Intended Nationally Determined Contributions (INDC), set a goal to promote hybrid cars, electric vehicles and bicycles among its mitigation actions and require the development of low-emission mobility policies to reach this target.

With the current COVID-19 Pandemic situation, Envelops wasn't able to visit Cambodia for data collection and site survey. With the full support from Cambodia Ministry of Environment, Dr. Hak Mao and Mr. Sophal Leang, Envelops was able to gather data and information from line ministries of Cambodia and utilize the data to develop this document. Technical advisor Dr. Joonho, Ko and Social and Environment expert Mr. Sanghoon Lee have assisted in analyzing the data.

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Glossary

AS	Alternative Scenario
BAU	Business as Usual
CCAP	Climate Change Action Plan
CCCA	Cambodia Climate Change Alliance
CCCP	Climate Change Action Plan of Cambodia
CCCSP	Cambodia Climate Change Strategic Plan
CDC	Council for Development of Cambodia
CTCN	Climate Technology Center & Network
EIA	Environmental Impact Assessment
ESS	Energy Storage System
EV	Electric Vehicle
FGD	Focus Group Discussion
GHG	Green House Gas
ICE	In Combustion Engine
INDC	Intended Nationally Determined Contribution
IPP	Independ Power Producer
KII	Key Informant interview
MOF	Cambodia Ministry of Economy and Finance
MOE	Cambodia Ministry of Environment
MOWA	Cambodia Ministry of Women's Affair
MPWT	Cambodia Ministry of Public Works and Transportation
NAE	National Accredited Entity
NDC	Nationally Determined Contribution
PPA	Power Purchase Agreement
SDG	Sustainable Development Goals
SESA	Strategic Environment and Social Assessment
UNFCCC	United Nations Framework Convention on Climate Change
UPS	Uninterrupted Power Supply
USD	United States Dollar
VKT	Average daily vehicle kilometers travelled

Executive Summary

This Action Plan supports the implementation of Cambodia's INDC targets for the transport sector. The support is achieved through reviewing of Cambodia's INDC, relevant policies and regulation (Chapter 2); Cambodia's transport sector growth, emission and Business as Usual (BAU) Scenario (Chapter 3); Impact Analysis of Two alternatives E-Mobility Scenarios (Chapter 4); Barriers to electric mobility in Cambodia (Chapter 5); and Actions for electric mobility in Cambodia (Chapter 6).

Based on the BAU Scenario of the transport sector two alternatives scenarios were analyzed;

- Alternative Scenarios #1: Introducing E-Motorcycles
- Alternative Scenarios #2: Introducing Electric Cars and buses

Analysis method includes; GHG emission reduction impact analysis, Lifecycle cost analysis, Environmental and health impact analysis and Socio-economic impact analysis & gender assessment. With these various analyses, a final multivariate comparative analysis was performed by mapping out the three scenarios (BAU, AS#1 and AS#2) to identify the key barriers and enabling conditions for the policy action plan.

The key barriers/gap identified are as follow,

- Data and information gap: Lack of current E-Mobility policy and public awareness in Cambodia
- Policy and planning gap: Lack of incentive programs for the customers and business entities for E-mobility
- Institutional gap: Requirement of a dedicated body to implement and enforce E-Mobility policies
- Technical capacity gap: Need to strengthen technical backgrounds for E-Mobility of the decision makers in Cambodia
- Financial gap: Lack of E-Mobility investment
- Market and Infrastructure Gap: Lack of business entity and electricity supply

With the technical, social, environment and gender analysis, and the identified barriers/gap, Action areas, and enabling conditions were recommended to implement E-Mobility in Cambodia. This recommendation will assist the policy decision makers of line ministries of Cambodia to prepare policies for E-Mobility to reach the INDC goal of the transport sector.

I. INTRODUCTION

1. Background

The Government of Cambodia submitted its Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) ahead of COP 21 in Paris in 2015, proposing an emission reduction of 27% based on the BAU by 2030. The Government of Cambodia recognizes that the high level of dependence on imported fossil fuel poses several challenges in their transition to a sustainable development pathway and reducing GHG emissions and air pollution in the country.

Cambodia's GDP has grown by 7.7% annually since 1995 and the speed of urbanization was also rapid in parallel to the GDP growth. Bythe previous study, the urbanization pace and scale will rise to reach the rate of 36% in 2050. As an example, the capital of Cambodia, Phnom Penh, is facing significant urban growth recognized by the fact the population has been reached 2 million with the economic expansion. Due to economic growth, also the number of vehicles has been growing rapidly in Cambodia.

In 2020, the Ministry of Public Works and Transport of Cambodia (MPWT) announced that the registered vehicles have risen 13% in one year due to the economic expansion and rising incomes. The number of newly registered vehicles in 2020 was 640,183 in total. Especially, the motorcycle was 531,269 which is 83% of the total. According to the annual report from MPWT, there have been more than 5 million registered vehicles in Cambodia and it has been increased by more than 300,000 to 400,000 vehicles year in year.

The transport sector is expected to account for an increasingly larger share of greenhouse gas (GHG) emissions in Cambodia. With the rise in the number of vehicles on the road and the fuel composition of Cambodia's energy mix, there have been concerns raised over the emissions and air quality degradation in urban areas in the country. Total final energy consumption in Cambodia grew by an annual average of 6.9% during 2010–2015. Final energy consumption in 2015 was 3.4 million tons of oil equivalent, comprising 50.5% petroleum products, 36.0% biomass, 13.1% electricity, and 0.4% coal. The transport sector is responsible for nearly half (46%) of final energy consumption.

There is a high potential for a positive impact on GHG emissions by switching conventional vehicles to E-mobility. The preparation of a policy action plan for E-mobility is designed to boost action and investment for electric transportation in Cambodia, thereby significantly reducing greenhouse gas (GHG) emissions from the transport sector.

Transitioning away from the general internal combustion engine (ICE) vehicle to electric vehicles will contribute to reducing GHG emissions in the congested urban area, together with significant co-benefits such as reduction of noise, and positive impacts on public health; especially, the air pollution problem in Cambodia which has been discussed as one of Cambodia's top environmental concerns during the recent visit of UN Environment's Executive Director's to Cambodia's Ministry of Environment also will be improved.

2. Goal and objectives

The overall goal of this Action Plan is to facilitate the Government of Cambodia to map out the most effective and feasible action to introduce E-Mobility, as a viable means to contribute to the country's achievement of its GHG emission reduction target in the transport sector under the country's NDC targets. The Actions identified would need to be integrated in Cambodia's overall sustainable, and low-emission transport policies.

The Plan has the following objectives:

(1) Undertake a comprehensive review of the current situation of Cambodia's transport sector from the country's NDC achievement perspective: Assess the performance, and identify challenges, and barriers in achieving Cambodia's transport sector NDC.

(2) Assess the feasibility and viable options of introducing e-Mobility in Cambodia as an effective means to the country's transport sector NDC.

(3) Identify and consult key stakeholders in Cambodia, including relevant ministries, and government agencies, public institutions, and private sector entities (business sector, consumer groups; Collect and integrate feedbacks to the final Plan and,

(4) Build the capacity of government partners, civil society and transport operators to support and advance the transport provisions of the NDC.

Mitigation actions and reduction targets in key sectors in Cambodia NDC are as follows;

Table 1. Mitigation actions in key sectors in Cambodia NDC

Sector	Priority action	Aggregate reduction by 2030
Energy Industry	National grid connected renewable energy generation (solar energy, hydropower, biomass and biogas), and connecting decentralizaed renewable generation to the grid. Off-grid electricity such as solar home systems, hydro (pico, mini and micro). Promoting energy efficiency by end users.	1,800(16%)
Manufacturing Industry	Promoting use of renewable energy and adopting energy efficiency for garment factories, rice mills, and brick kilns.	737(7%)

Sector	Priority action	Aggregate reduction by 2030
Transport	Promoting mass public transport. Improving operation and maintenance of vehicles through motor vehicle inspection and eco-driving, and the increased use of hybrid cars, electric vehicles and bicycles.	390(3%)
Other	Promoting energy efficiency for buildings and more efficient cookstoves. Reducing emissions from waste through use of biodigesters and water filters. Use of renewable energy for irrigation and solar lamps.	155(1%)
Total		3,100(27%)

3. Structure of the Report

Excluding the introduction and conclusion, this action plan report is divided into six parts, as outlined below:

(1) Overview of Cambodia's NDC targets, Relevant Policies and Regulations (Chapter 2)

- Background of NDC under the Paris Agreement, Cambodia's NDC and transport sector target and action plan is presented, followed by the country's relevant policies and regulations.

(2) Transport Sector Growth, Emissions and BAU Scenario (Chapter 3)

- Overview of Cambodia's transport and energy sector is presented. BAU scenario is briefly introduced with its potential impacts.

(3) Impact Analysis of Two Alternatives E-Mobility Scenarios (Chapter 4)

- Two alternative scenarios (two different pathway to the electrification of Cambodia's transport) will be introduced with relevant impact analysis. At the end of the chapter, a comparative impact assessment matrix is presented in the summary of the assessments of each of the Scenarios (BAU, Alternative Scenario (AS) #1 and #2)

(4) Barriers to electric mobility in Cambodia (Chapter 5)

- Key barriers to Cambodia's E-Mobility are presented into 6 groups: (1) Data and information gap; (2) Policy and planning gap; (3) Institutional gap; (4) Technical capacity gap; (5) Financial gap; (6) Market and infrastructure gap.

(5) Actions for electric mobility in Cambodia (Chapter 6)

- Key Actions Areas (Policy Options) are presented as Primary/Secondary Action Areas and Enabling Conditions for consideration.

4. Methods and engagement process

This Policy Action Plan has been prepared in the step-by-step approach as follows:

(1) Review of NDC and related policy, plans, strategies, and initiatives in Cambodia

(2) Identification of key stakeholders in Cambodia & key parameters for scenario (policy alternative) building

(3) Establishment of Business-As-Usual (BAU) and two alternative policy option scenarios for Impact Analysis. The analysis includes the following four components:

- (Sub-) Step 3.1: GHG emission reduction impact analysis
- (Sub-) Step 3.2: Lifecycle cost analysis: A comparison of three Scenarios (BAU, AS#1 & AS#2) in terms of the cost effectiveness on GHG emission reduction
- (Sub-) Step 3.3: Environmental and health impact analysis
- (Sub-) Step 3.4: Socio-economic impact analysis & gender assessment

(4) Multivariate Comparative Analysis: Mapping of the three Scenarios (BAU, AS#1 & AS#2) based on the findings of the above-mentioned analysis (identification of key barriers and enabling conditions)

(5) Key Stakeholder Consultation: Consult key policymakers and other relevant stakeholders in Cambodia for review of the analysis findings & validation and adoption of the optimum scenarios (policy options and overall implementation roadmap)

(6) Preparation of Draft Action Plan

(7) Validation of the Final Action Plan

5. Stakeholders and consultation

5.1. Key stakeholders in Cambodia

The table below presents a list of key stakeholders in Cambodia with respective engagement level in relation to development and implementation of the E-Mobility National Action. Key line ministries for implementation of E-Mobility was involved from the beginning of this project.

Table 2. List of stakeholders and planned level of Engagement

Stakeholder	Relevance	Purpose of Engagement	Level of Engagement (for Plan development) (Inform/Consult/Involve/Collaborate)
I. Government Bodies			
National Council for Climate Change (NCCC)	Inter-Ministerial coordinating body	Align the E-Mobility Action Plan with the country's Climate Change and Sustainable Development Plans and Strategies	Consult (Workshop)
Department of Climate Change (DCC)	Coordinating body of the NCCC (involving around 20 ministries)		Consult (FGD)
(National Council for Sustainable Development, NCSD)	Inter-Ministerial coordinating body		Consult (Workshop)
Ministry of Environment (MoE)	CTCN NDE/ GCF NDA	Leading agency of the NCCP / Project Proponent	Lead and coordinate overall consultation activities
Environmental Impact Assessment (EIA) Department (in MoE)	EIA approval and Environmental Permit issuance agency	SESA[1] & EIA review and environmental Permit issuance for project(s)	Consult (KII)
Ministry of Interior (MoI)	Driving License & Vehicle Registration management	Relevant laws and regulation development for E-Mobility (Enabling condition development)	Involve (Data collection & E bike registration and licensing policy development: KII, FGD)
National Committee for Sub-National Democratic Development/ Secretariat	GCF AE (Head is also the Secretary of the Ministry of Interior)	Potential Partner for project(s) development for GCF Funding	Involve (KII)
Ministry of Public Works and Transport (MPWT)	Vehicle registration, Technical inspection, Driver's License, Transport Licensing	Relevant laws and regulation development for E-Mobility (Enabling condition development)	Involve (Data collection & E bike registration and licensing policy development: KII, FGD)

[1] Cambodia has not introduced SESA as mandatory mechanism for development of policies, plans and programs yet. The country is in the process of formulating relevant laws and regulations.

Stakeholder	Relevance	Purpose of Engagement	Level of Engagement (for Plan development) (Inform/Consult/Involve/Collaborate)
Provincial/Municipal Department of Public Works and Transport (Phnom Penh & Siem Reap)	Local body of MPWT	Data collection & status check on the vehicle registration, Driver's license on Motorcycles in Cambodia/PP and SR (City level plan and pilot project development)	Consult (Data collection & future planning status check (KII (and/or FGD))
Ministry of Finance (MoF)	Overall government budget administration & execution	Budget allocation for the implementation of the Plan	Involve (KII)
General Department of Customs and Excise of Cambodia (GDCE)	Tariff policy regulations	Relevant laws and regulation development for E-Mobility (Enabling condition development)	Consult (Data collection & law & policy formulation, as required) (KII and/or FGD))
General Department of Taxation (GDT)	Tax policy regulations	Relevant laws and regulation development for E-Mobility (Enabling condition development)	Consult (Data collection & law & policy formulation, as required) (KII and/or FGD))
Ministry of Energy and Mining	Managing and administering the provision of electric power in Cambodia/ Issuing licenses, providing services, approving and enforcing the operating standards for holders.	Electricity service units in some provinces remain under the authority of the provincial authorities but are funded by the Ministry of Energy and Mining. Relevant laws and regulation development for E-Mobility (Enabling condition development)	Involve (KII & FGD on Electricity Policy and Price)
Ministry of Women's Affairs (MoWA)	Mainstreaming gender into climate change response measures into existing policies and laws and sector climate change strategic plans (SCCSPs).	Gender mainstreaming in E-Mobility Plan	Consult (KII)
II. International Stakeholders			

Stakeholder	Relevance	Purpose of Engagement	Level of Engagement (for Plan development) (Inform/Consult/Involve/Collaborate)
Korea Ministry of Science and ICT	CTCN NDE for Korea	Provided funding for this policy action plan	Involve (KII or FGD)
III. Development Cooperation Communities			
Global Green Growth Institute (GGGI)	Implementation partner for CCAP 2016~2018/ Action 7: Low carbon resilient urban development initiatives: Green Urban Development Program.	CCAP implementing partner reg. transport electrification	Involve (FGD & Workshop)
Green Climate Fund (GCF)	Financier of climate change projects in developing countries	Potential financier for E-Mobility pilot project in Cambodia	Consult (FGD or KII)

II. CAMBODIA'S NDC TARGETS AND TRANSPORT SECTOR POLICY

1. Cambodia's Nationally Determined Contribution

1.1. Introduction

Given the growth of the transport sector, its reliance on fossil fuels and its contribution to national greenhouse gas emissions, developing a mechanism to address climate change in Cambodia's transport sector is crucial. Cambodia's NDC is a mechanism which provides a critical target for the transport sector. This target, as well as the process and role of the NDC at national and global levels, are presented below.

1.2. UNFCCC's Nationally Determined Contribution

The NDCs embody efforts by each country to reduce national emissions and adapt to the impacts of climate change. It is the principal mechanism of the Paris Agreement, adopted by 196 parties of the UNFCCC, during the 21st Conference of the Parties, in December 2015. As such, NDCs constitutes the primary mechanism through which global action to combat climate change is taking place. The Paris Agreement entered effect in November 2016.

The Paris Agreement deals with greenhouse gas mitigation, and climate change adaptation and financing. The overall goal of the Paris Agreement is to keep global temperature rise, measured against pre-industrial levels, aiming at limiting warming to 1.5 to 2 degrees Celsius above pre-industrial levels. The Paris Agreement starts in 2020.

Under the Paris Agreement (Article 4, paragraph 2), the NDC mechanism requires each country to prepare, communicate and maintain successive NDCs that it intends to achieve for the contribution to global action for climate change. Countries are expected to report on this contribution regularly. However, there is no mechanism to enforce compliance with targets and goals set by countries under their NDCs.

1.3. Cambodia's Nationally Determined Contribution

Cambodia made climate change policy since the accession to the UNFCCC in 1996. Explicit efforts have been made in mainstreaming climate change into national and sub-national planning. For example, Cambodia has developed and implemented the Climate Change Strategic Plan 2014-2023 (CCCSP), and associated action plans developed by each relevant ministry. These plans are Cambodia's first-ever comprehensive national policy documents that illustrate not only the country's priority adaptation needs, but also provide roadmaps for the de-carbonization of key economic sectors and the enhancement of carbon sinks. Further, Cambodia has developed a Green Growth Policy and Roadmap, Second National Communication to the UNFCCC, Ministry of Environment (unpublished) which sets the path to stimulate the economy through low carbon options, savings and creating jobs, protecting vulnerable groups and improving environmental sustainability. Cambodia NDC was developed by the MOE and was submitted to the UNFCCC.

Cambodia NDC described mitigation actions and reduction aggregation in each key sector: energy, manufacturing, transport, and others. Thus Cambodia NDC aims to:

- Reduce 390 Gg CO2eq (3%) in the transport sector by 2030
- Promoting mass public transport,
- Improving operation and maintenance of vehicles through motor vehicle inspection and eco-driving, and
- Increased use of hybrid cars, electric vehicles and bicycles.

Target estimates of emissions of GHGs and removals of CO2 (including transport sector) are based on data reported in the draft Second National Communication (SNC) developed by the Government of Cambodia. The GHG inventory used Tier 1 methodologies set out in the IPCC 1996 Guidelines, IPCC default emission factors, and country-specific activity data from 2000. Increased use of electric vehicles is one of the strategies to achieve NDC in Cambodia.

2. Associated Policies and Regulations in Cambodia

2.1. Introduction

In Cambodia NDC, priority action for the transport sector is rather general and does not provide detailed action plans to achieve its targeted GHG reduction amount While promoting low carbon transport (such as hybrid, electric vehicles and Motorcycles), there is no concrete action plan yet. In fact, achieving NDC goals in transport section largely depend on the implementation of the country's existing policy and regulations in a range of relevant sectors. This indicates that the E-Mobility policy action plan needs to be developed in alignment with the existing policies, regulations, and development plans of the interconnected areas, particularly in transport and energy section. In addition, Cambodia's overall climate change and sustainable development framework should be considered as overarching (cross-cutting) themes.

2.2. Transport Policy and Regulation

Relevant policies and regulations in the transport sector to E-Mobility include, among other: 1) Fiscal policy on imported vehicles; 2) Vehicle Tariff rates; 3) Climate Change Action Plan (Transportation Sector) and: 4) Green Logistics Policy (draft, 2019). The policies presented in the table below set the overall direction for the development of the sector, specify goals and targets, outline initiatives and principles, and demonstrate vision and forward-thinking from the government.

Table 3. Cambodia Transport Policy and Plans relevant to E-Mobility

Ministry (relevant stakeholder)	Associated policy
Ministry of Public Works and Transport	Fiscal Policy on Imported Vehicle
	Vehicle Tariff Rates
	Climate Change Action Plan (Transportation Sector) (2014)
	Green logistic policy (Draft) (2019)

1) Fiscal policy on imported vehicle

In Cambodia, most of the motorized vehicles, including Motorcycles, new and used, are being imported from foreign countries. Total bulk of the imported vehicles are on the rise, constituting major revenue source from customs and excise taxes.[2] Cambodia's tax policies on the imported vehicles need to be examined in identifying the financial incentives to promote E-Mobility to ensure their affordability. The total tax imposed on vehicles to maintain their affordability and the total government revenue from vehicle import taxes were both considered in the analyses.

- There is no banning of vehicle import into Cambodia, except Right Hand Drive Vehicles (Sub Decree 209).
- In general, 50% reduction in duty and tax for the importation of new vehicle in Completely Knocked Down (CKD) which is approved by Council for Development of Cambodia (CDC) based on a case by case basis. However, currently, Ministry of Finance (MoF) and CDC are studying the feasibility of the current regulations in order to formulate a general rule for a tax incentive for the importation of new vehicle in CKD.
- Vehicles imported and used by foreign embassies and international organizations are exempted from duty and tax (Law on Customs).

[2] https://www.b2b-cambodia.com/news/cambodian-car-market-2020/

2) Vehicle tariff rate

The government can generally maximize revenue collection by adopting a more comprehensive gradation of taxes by engine size as well as fuel type. Cambodia follows the 8-digit Harmonized System Code under the World Customs Organization and its tariff classification also conforms with the Association of Southeast Asian Nations' (ASEAN) Harmonized Tariff Nomenclature. The import duties are levied on certain goods entering Cambodia and the rates vary depending on the type of goods. This action plan has reviewed existing Motorcycle tariff rate and tax composition. Currently, imported electric Motorcycles are applied the same Special Tariff rate as that of conventional Internal combustion engine (ICE) Motorcycles with engines exceeding 50cc-150cc.

Table 4. Motorcycle tariff rates (Cambodia customs tariff 2017 in force) based on cylinder[3]

Engine Size	Duty + Special Tariff + VAT
Not exceeding 50cc	15%+5%+10%
Exceeding 50cc-150cc	15%+10%+10%
Exceeding 150cc-250cc	15%+15%+10%
Exceeding 250cc-800cc	15%+20%+10%
Exceeding 800cc	15%+25%+10%
Motocross	15%+25%+10%
Electric Motorcycle	15%+10%+10%

3) Climate Change Action Plan

The Climate Change Action Plan of Cambodia (CCAP) identifies the measure that will promote both the transport sector development and effective climate change response to be implemented during the five years period (2014-2018) for the sector. The action plans categorized into two main strategic priorities: promote climate resilience in the transport infrastructure and promote low-carbon consumption for GHG reduction in the transport sector. In particular, Action 7 of the Plan ("Develop and test low carbon resilient approaches and options in urban area") includes introducing electric Motorcycles in two selected cities in encouraging more sustainable urban transport options.

[3] Source: MPWT Vehicle Tariff Rate for Motor Car & Family Vehicle

Table 5. Action Plan of Cambodia Climate Action Plan (CCCP) related to E-Mobility

Action 7: Develop and test low carbon resilient approaches and options in urban areas

Action 7	**Develop and test low carbon resilient approaches and options in urban areas**
Strategic Objective of CCCSP	Strategic Objective 4: Promote low-carbon planning and technologies to support sustainable development
Rationale	The Action contributes to the achievement of the National Green Growth Policy and National Strategic Plan on Green Growth 2013-2030 Cambodia urbanization rate is growing rapidly in recent years, particularly in major cities such as Phnom Penh, Siem Reap and Sihanouk Ville, with currently 21.5% of Cambodians living in urban areas. As a result, cities face significant environmental and social problems, which are exacerbated by the impacts of a changing climate. The action improves the urban resilience to the impacts of climate change (addressing particular issues such as urban heat and air pollution), while it contributes to the GHG emission reduction efforts in urban areas.
Category of climate change action	☐Cat 1 – Re-scale ☐Cat 2 – Modified ☑Cat 3 – Dedicated
Type of action	☐Mitigation ☐Adaptation ☑Mitigation and adaptation
Short description of the action and expected results and benefits	This action covers the implementation of low carbon resilient urban development initiatives, such as the Green Urban Development Program (with support from GGGI) and the Building Climate Resilience of Urban Systems through Ecosystem-based Adaptation (with support from UNEP/LCDF). Activities under each of these initiatives include: • Green Urban Development Program (of GGGI): - Prepare the Green City Strategic Plan for the City of Phnom Penh; - Support to the prioritization of green city investment projects, including through economic analysis and stakeholder consultation, as part of Green City Strategic planning process; and - Prepare an Investment Action Plan to mobilize finance for 'bankable' green city investment project, through the public and/or private sector, and potentially to develop a specific project proposal for multilateral funds (e.g. the Green Climate Fund). • Building Climate Resilience of Urban Systems through Ecosystem-based Adaptation (EbA): - Identify a city to pilot the proposed urban EbA interventions, in which capacity building will be provided to the institutional capacity and city management authorities to plan and implement urban EbA; - Demonstrate urban EbA interventions in pilot cities; and - Disseminate knowledge and raise public awareness on urban EbA in pilot cities • Piloting adoption of low carbon sustainable solutions: - Introduce electric motorbikes in two selected cities to encourage more sustainable urban transport options - Design and test a program for tree planting in public spaces aiming to strengthen the functionality of urban green infrastructures to

The climate change action plan is focusing on the broad aspect of climate change issues in Cambodia. It focused on enhancing adaptation and mitigation capacity of personals in the MPWT Cambodia to cope with issues arising from changing climate variable. This plan also mentions that the action plan should continue to upscale and modified existing actions and propose new dedicated actions most relevant to climate impacts on transport infrastructure and GHG mitigation in the transport sector.

4) Green logistic policy

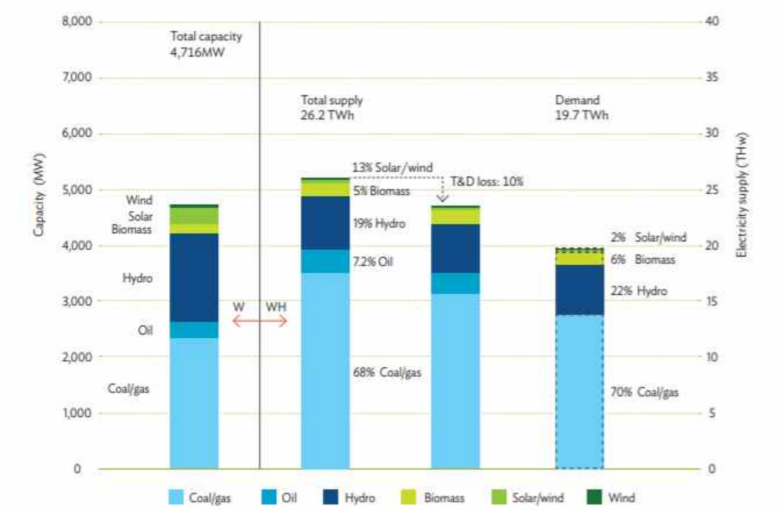
The Green logistic policy was initiated and supervised by the General Department of Logistics Cambodia. To promote the use of energy efficient vehicles and increase the load factor by good design and planning, consultation work for green logistic policy formulation has been conducted. The study recommended setting up the vehicle standards, regulation and monitoring plans on green logistics. While road rehabilitation alone would contribute to GHG emission reductions in the short term, it was also recommended to develop infrastructure supporting green transportation.

The study also mentions that the road users should pay for the maintenance/operational costs of roads encouraging additional payments to cover environmental costs and encourage modal shifts from roads to more energy-efficient modes of transport. It also strongly recommends switching to biofuels/electricity and other alternative fuels to fossil fuels.

2.3. Energy Policy and regulation

The Cambodia Basic Energy Plan on Cambodia (2019)[4] is the country's very first publication of medium-term energy policy targets with numerical values for each energy field such as oil, electricity supply, renewable energy, energy efficiency, energy security, and the energy outlook. The plan also provides polices, and roadmaps for achieving those targets. The plan is subject to review and updates every 5 years.

Cambodia imports coal and petroleum from other Association of Southeast Asian Nation (ASEAN) countries such as Indonesia and Singapore. The import amount is on the increase. The Basic Energy plan considers diversification of the energy mix which is currently dominantly based on fossil fuel energies. In the Business As Usual (BAU) scenario, the fossil fuel (coal/gas) energy is expected to be dominant (up to 68%) in 2030 with the increase of the energy demand in Cambodia due to the rapid economic and population growth. The Basic Energy Plan suggests instead increasing the share of hydropower (from 18% in BAU to 55%) and renewable energies (biomass, solar and wind, from 6.5% in BAU to 13%), while reducing fossil fuel energy (from 68% in BAU to 35%) respectively. This alternative energy mix scenario aims to minimize the potential risk from the coal price, improve energy security, and reduce the environmental impacts (air pollution, global warming).



(a) Case 1: Power Development Plan in 2030

[4] https://www.eria.org/uploads/media/CAMBODIA_BEP_Fullreport_1.pdf

Figure 1. Power Development Plan and Basic Energy Plan for Cambodia in 2030[4]

The Plan also considers the energy efficiency and aims to reduce total final energy consumptions in all sectors by 10% by the year 2030 relative to the BAU which is also indicated in the NDC. Amongst the other sectors, the transport sector will still dominate Cambodia's future total energy consumption, and which will grow rapidly but at a slower rate. In the alternative scenario suggested in the Plan, Electrification of transport vehicles would lead to reduced gasoline and diesel oil demand for the transportation sector and reduced CO2 emission from the transport sector. Thus E-Mobility policy should be aligned with energy policies tightly. The tariff rate and electricity accessibility are tightly knit with the country's overall energy policies.

Table 5. Cambodia's Key Energy Policies and regulations

Ministry (relevant stakeholder)	Associated policy
Ministry of Mines and Energy	Climate Change Action Plan (Mines and Energy Sector) (2015)
	National Energy Efficiency Policy 2018-2035 (2018)
	Policy Data_GDE 2020 (2020)

1) Climate Change Action Plan for Mines and Energy Sector

The Climate Change Action Plan (CCAP) for Mines and Energy Sectors 2016 – 2018, was developed under the overall coordination of the Ministry of Mines and Energy (MME), through active participation of its multiple departments and with the invaluable guidance from National Council for Sustainable Development (NCSD). A wide range of technical support was provided by several national and international climate change experts to the development of the CCAP for Mines and Energy Sector.

The CCAP defined concrete actions and resources needed for the operationalization of the MME's response to climate change, provided direction on a number of issues which were critical to the sectors' development, including climate-proofing of existing and future energy infrastructure, decoupling economic growth and sectors' future development from GHG emissions, and how to build the sector's capacity to meet the country's commitments on the Sustainable Energy.

MME CCAP is mainly focusing on electrification which is strongly connected to the E-mobility policy action plan. MME CCAP mentioned that in 2009, total carbon dioxide emissions for Cambodia was about four million tons. In the same year, regarding energy consumption, the highest GHG emission was registered in residential areas, followed by the transport sector. The increasing demand for energy brought about by the country's rapid urbanization (around 4% annually) and the booming construction sector in major cities of Cambodia, together with the growth in transport, were the two major contributors to GHG emissions of the energy sector. Thus, it was time to invest in measures that can increase the efficiency of energy consumption and production to reduce GHG emissions.

2) National Energy Efficiency Policy

National Energy Efficiency Policy (NEEP) (2018) has been reviewed for evaluating the alignment of the relevant energy policy and climate change action including the INDC. NEEP aims to bring about:

- Improvement of the living standard of the population,
- Enhancement of competitiveness of the Cambodian economy, through more reliable and affordable energy supply in support of the industrial policy 2015-2025,
- Reduction in the dependency on imported fuels and
- The more effective protection of the natural capital of the country.

3) Energy Policy data

Energy Policy data, raw data from MME, was reviewed for evaluating and calculating of GHG emission reduction and Energy consumption expectation. Key data sets relevant to the E-Mobility Action plan are as follows;

- Total historical electricity demand/delivered for past years (GWh/year)
- Total electricity demand forecast from 2020 to 2030 (GWh/year)
- Growth rate (%) of electricity demand for the past year
- Growth rate forecast (%) of electricity demand from 2020 to 2030
- Own use of electricity by electricity producers
- Electricity generation mix for past years (GWh/year)
- Electricity generation mix for past years (MW/year)

2.4. Sustainable Development and Gender Policy

1) Sustainable Development Strategy and Policy

Cambodian government embraced the United Nation's 2030 Agenda for Sustainable Development and in 2009 Cambodia established the National Sustainable Development Strategy 2009. Like other countries, Cambodia has also endorsed the Sustainable Development Goals (SDGs) at the UN General Assembly in 2015. Based on the strategy, the country also set up the Cambodia Sustainable Development Goals (CSDGs) Framework 2016 - 2030. In late 2018 Cambodia started its voluntary progress report (VPR) process led by the Ministry of Planning. CSDGs Framework 2016-2030 set six prioritized SDGs (Education, Decent Work and Growth, Reduced Inequalities, Climate Action, Peace and Institutions, and SDG Partnerships).

SDG 13 on Climate Action is directly relevant to E-Mobility Initiative in Cambodia: In particular CSDG 13.2. “Integrate climate change measures into national policies, strategies and planning have its sub-goal of reducing the proportion of GHG reduction through reduction activities in industries of power, production, transportation and other sectors”. CSDG Target and Indicator 13.2.1., Percentage of GHG emission through reduced activities when compared to the BAU scenario, set 3.5% reduction by the year 2017 but in reality, the country overshoot the target by

SDG achievement measures are integrated into the country’s Rectangular Strategy (currently IV 2018-2023) and the five-year National Strategic Development Plan (NSDP). The current version of the Plan, i.e. NSDP 2019-2023 reflects CSDGs in its monitoring and evaluation framework. Indicators on energy and climate change, as relevant to E-Mobility initiatives, are included in RGC Priority 4: Inclusive Development, under the sub-heading of Environmental Sustainability & Climate Change. The table below presents the list of some of the relevant indicators to the E=-Mobility initiatives in Cambodia presented in the NSDP 2019-2023:

Table 6. Core Indicators for Monitoring and Evaluation (NSDP 2019-2023)

No.	Indicators	Unit	2018	2019	2020	2021	2022	2023	References	Data Source
Impact Level: Government Policy Goals										
	Environmental sustainability & Climate Change									
101	Annual average change of the parameters of CO, NO2, SO2, TSP, PM2.5 and PM10	%	4.0	4.0	5.0	5.0	5.0	5.0	CSDG	MOE
102	Percentage of release reduction of Persistent Organic Pollutants (POPs) to the environment	%	1.0	2.0	4.0	8.0	10.0	14.0	MAIS	MOE
103	Number of registered greenhouse gas deductions projects	Projects	1	2	4	7	10	14	CSDG	MOE/GS-NCSD
104	Percentage of GDP expense of weather	%	1.2	1.4	1.5	1.5	1.5	1.6	CSDG	MOE/GS-NCSD
105	Reduced greenhouse gas emissions compared to the base year data	000 Gg CO2 equivalent	2,497	2,799	2,836	2,887	2,917	3,018	CSDG	MOE/GS-NCSD
106	The institutional level of responding to climate change (Revised targets)	%	49	53	57	60	63	65	CSDG	MOE/GS-NCSD
107	The number of ministries / institutions that integrates biodiversity issues into relevant sector plans	plans	2	3	4	5	6	7	CSDG	MOE/GS-NCSD
108	Proportion of renewable energy in total use power	Mtoe	2,750.1	2,885.5	3,031.2	3,184.5	3,346.1	3,516.3	CSDG	MME
109	Percentage of Renewable Energy Sources (Installation Power)	%	52.63	51.13	52.14	54.04	55.22	49.23	New	MME

(Source: NSDP 2019-2023)

As a cross-cutting theme, Cambodia's sustainable development approach is integrated into various green growth and climate change strategies and initiatives.

Table 7. Cambodia's Sustainable Development Strategy and Policy

Ministry (relevant stakeholder)	Associated policy
Ministry of Environment	Climate Change Action Plan (MOE) (2016)
	CDM Baseline Construction for the Phnom Penh Electricity Grid (Draft) (2011)
	National Environment Strategy and Action Plan (NESAP)_2016-2023 (2017)
	Green Growth Strategic Plan (2013
	Green Growth Policy (2013)
	Cambodia Climate Change Strategic Plan (CCCSP) (2013)
	Green City Strategic Planning Methodology (2016)
	Phnom Penh Sustainable City Plan 2018-2030 (2019)

2) Cambodia's Gender Policy

The Constitution of the Kingdom of Cambodia (1993) enshrines equal rights for women and men in all aspects of the socio-economic, cultural, and political lives of the people of Cambodia (Articles 31,34, 35 and 45.2). Cambodia signed CEDAW in 1980 and ratified, acceded, and succeeded CEDAW in 1992 (The United Nations Division for the Advancement of Women 1979). Cambodia is a signatory to the UN Convention on the Prevention of All Forms of Discrimination Against Women.

Cambodia SDGs (CSDGs) include gender equality and women's empowerment is reflected in CMDG 3 (Promote gender equality and women's empowerment), but almost across all CMDGs as a cross-cutting theme.

Gender mainstreaming in Cambodia's development activities started with NSDP 2014-2018 and promoting gender equity continues to be a part of the Cambodian government's human resource development strategy in NSDP 2019-2023, with a focus on

(1) Women's economic empowerment

(2) Legal protection for women and girls, crippled women, and vulnerable groups

(3) Women's participation in Women in in Public Sector and Politics

(4) Women's health

(5) Promoting social morality, women’s value, Khmer family including women & Education

(6) Integrating gender component into climate change, disaster management and green development.

Led by the Ministry of Women's Affairs (MoWA), through Neary Rattanak V 2019-2023, the county is planning to develop and implement the Gender Equality Policy to mainstream gender in all sectors and development programs. The Policy shall consider the poverty reduction and vulnerability of women, especially women with disabilities, indigenous women minorities.

Mainstreaming gender into the country's climate change and green development is also mentioned in NSDP 2019-2023: Cambodia will continue to implement its Climate Change Strategic Plan for Gender and Climate Change (2013-2023). The Climate Change Strategic Plan reflects the gender nexus to the GHG emission mitigation efforts as the following strategy: “Gender and mitigation strategies seek to: reduce GHG emission from households, commerce and manufacturing, and other economic activities related to transport; protect women’s health; secure and promote employment opportunities in greening and cleaning Cambodian economics.” Gender is also highly relevant to the country's energy sector development: In Cambodia, women should do most of the care work at households due to the gender division of labor. According to the Cambodian Human Development Report (2010), 83.5% of households still rely on firewood as energy sources, mainly for cooking. Modernization of the energy sector would significantly improve the welfare of Cambodian women in general.

III. TRANSPORT SECTOR GROWTH, EMISSIONS AND BAU SCENARIO

1. Overview of the Transport Sector

1.1. Introduction

Cambodia has experienced sustained economic growth for the past two decades, with an average annual growth rate of 7.7% between 1995 and 2018. Accordingly, the number of vehicles has also been growing rapidly in parallel. In 2016, more than 3.2 million vehicles were registered especially, the motorcycles were accounted for 2.7 million vehicles of the total registration. The overall vehicle registration has grown at a rate of 14% from 2015 to 2016.

In 2000, the transport sector accounted for less than 3% of national greenhouse gas (GHG) emissions, with 709 Gg of CO2eq. A 2016 inventory for the transport sector shows that GHG emissions stood at 4,752.35 Gg of CO2eq with an average annual growth of 12.8% per year.

These trends pose a serious challenge for Cambodia. The country needs to continue its economic growth while ensuring meeting the ever-increasing demand for reliable and efficient transport and infrastructure to the growing population in the country. At the same time, the country needs to steer the energy demand for the transport sector while mitigating air pollution and GHG emission, and other harmful impacts on public health.

As part of the solutions, the Cambodian government is reforming fiscal and regulatory policies for road transport vehicles, while spurring rapid transport infrastructure development.

1.2. Motorization and Land Transport Infrastructure in Cambodia

Cambodia's economy has been growing over the past decade with an annual gross domestic product growth rate of 7%. In 2016, Cambodia has transformed from a least developed country to a lower middle-income country. Economic development has also resulted in a rapid increase in land transport vehicles and motorization.

Road transport covers more than 90% for passenger and freight in Cambodia. The total road length in Cambodia is more than 61,000 kilometers (km). The number of registered vehicles has been increasing at a double-digit rate each year and was more than 4 million in 2017. The number of registered motorcycles has increased by at least 10% per year since 2005, and they accounted for about 85% of all registrations in 2017. The largest share of the land transport modality is motorcycles in Cambodia and the majority of them are of conventional ICE motorcycles.

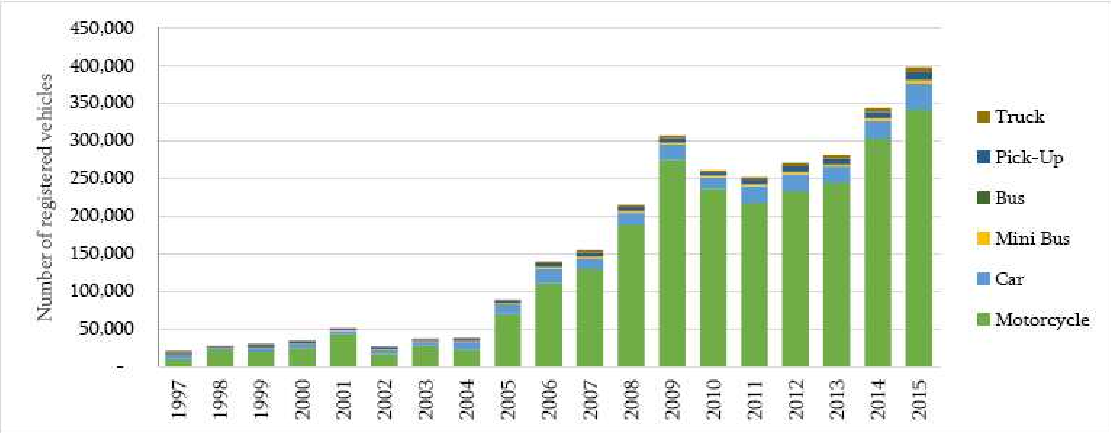


Figure 2. Registered vehicles in Cambodia, per type (1997 to 2015)

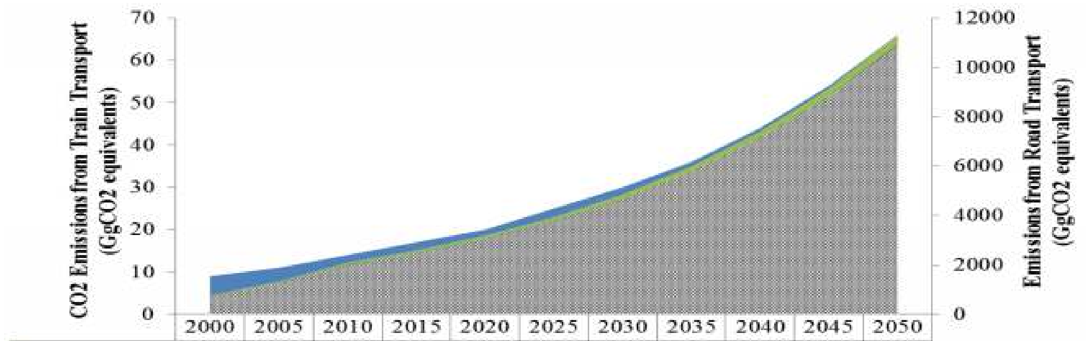
Cambodia National Strategic Development Plan (NSDP) 2019-2023 set specific targets for the road development nationwide. According to the Plan, 16,000 km of the primary and secondary road shall be developed every year between 2018 and 2023, out of which pavement rate shall be more than 50%.

The Industrial Development Policy 2015–2025 requires the improvement of the transport network, especially along the industrial corridor. The annual national budget for transport infrastructure was $123.75 million in 2014, $183.75 million in 2015, $223.04 million in 2016, $216.70 million in 2017, and $158.07 million in 2018.7 The government is preparing an integrated multi-transport and logistics master plan.

1.3. GHG and Other Pollutant Emission of Transportation Sector

Mobility of people and goods is an essential part of all social and economic activities. In Cambodia, passenger cars and trucks have become the most important modes of transport. Non-motorized transport, which in earlier times was the common form of transport has been replaced by cars in daily mobility, and by trucks for freight movement. The result of this process has been a significant increase in GHG and other pollutant emissions.

The common problems of the transport sector in big urban areas are traffic congestion and the number of vehicles on the road shows no signs of decreasing. In order to understand the CO_2 emission through the increasing number of vehicles, in 2010 the MoE estimated CO_2 emissions in the transport sector using LEAP model. It estimated a growth percentage of vehicles of 4%. The results show that emissions from the transport sector (including all types of vehicles) will increase from 785 $GgCO_2$ equivalents in 2000 to 11,376 $GgCO_2$ equivalents in 2050 (Figure 3). It revealed that motorcycles, cars, pick-up and trucks are the key sources of emission (Figure 4)



	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Train	9	11	14	17	20	25	30	36	44	54	66
Aviation	56	68	83	101	123	149	182	221	269	327	398
Road MPWT	720	1262	2020	2489	3070	3787	4675	5773	7134	8821	10912

Figure 3. Greenhouse gas emissions from transport sector (GgCO2 equivalents)[5]

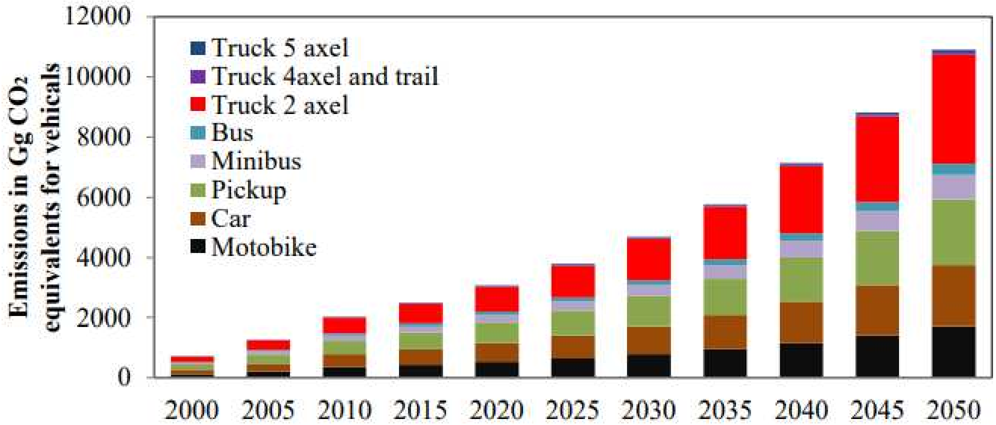


Figure 4. Greenhouse gas emission in transport sector (GgCO2 equivalents)[5]

2. Overview of Energy Sector

2.1. Introduction

The Ministry of Mines and Energy (MME) has identified challenges that arise from the continuation of existing trends in energy consumption. Therefore, MME wants to turn these challenges into opportunities by improving energy efficiency. It is globally regarded as the most cost-effective strategy to enable economic and social development while reducing the environmental impact of the energy sector.

[5] Source: MOE 2010

Cambodia National Energy Efficiency Policy is focusing on enabling economic growth and social inclusiveness, ensuring the competitiveness of businesses, and improving human health. This policy includes a national target for the reduction of energy demand and emissions. In line with the NDC, the policy has two main goals which are improving the management and maintenance of existing infrastructure by developing suitable industrial processes for energy efficiency and increasing the transfer and adoption of energy-efficient technology to reduce energy intensity.

In accordance with the policy projection, reducing the electricity consumption can save the overall power generation capacity in the range of 190 MW to 307 MW by 2035, which is equivalent to 200 to 350 million USD worth. It also mentioned that the improvement of energy efficiency will allow reaching stated electrification targets sooner and at a lower cost. As a result, the total economic savings from improving energy efficiency are expected to reach 710 million USD/year which leads to 13 billion USD by 2035

2.2. Energy Sources and Consumption

In Cambodia, there are two types of power generation licenses exists; one is Independent Power Producers (IPP) license which allows the license holder to generate and sell electricity to suppliers or industries in compliance with the Power Purchase Agreement (PPA). Another license is the consolidated license that has the authorization to generate electricity for supply to consumers through their distribution system.

The Energy mix of Cambodia is shown in below figure. The summary information about installed capacity and energy sent out by the IPP, Electricite du Cambodge (EDC) and Consolidated licenses is also described together.

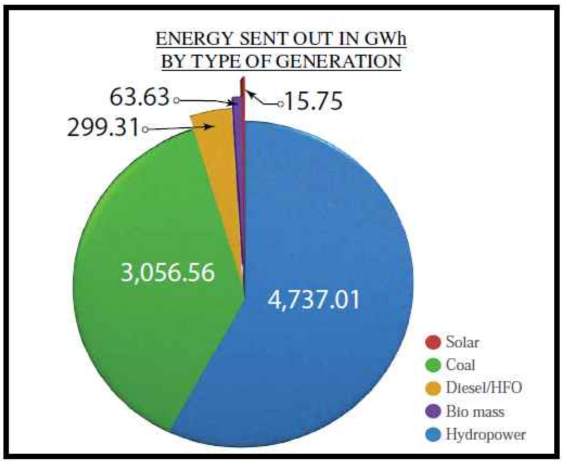


Figure 5. Energy Mix of Cambodia (2018)[6]

[6] Annual Report 2018. Ministry of Mines and Energy

The total energy generated in Cambodia during 2018 was 8,172.27 GWh which is the latest official statistical data. According to the annual report, many of the consolidated license holders decided to connect to the national grid instead of their own generation and distribution due to the expansion of the grid and sub-grid system in Cambodia. In 2018, only five licensees were operating off-grid generation which was only 0.923GWh.

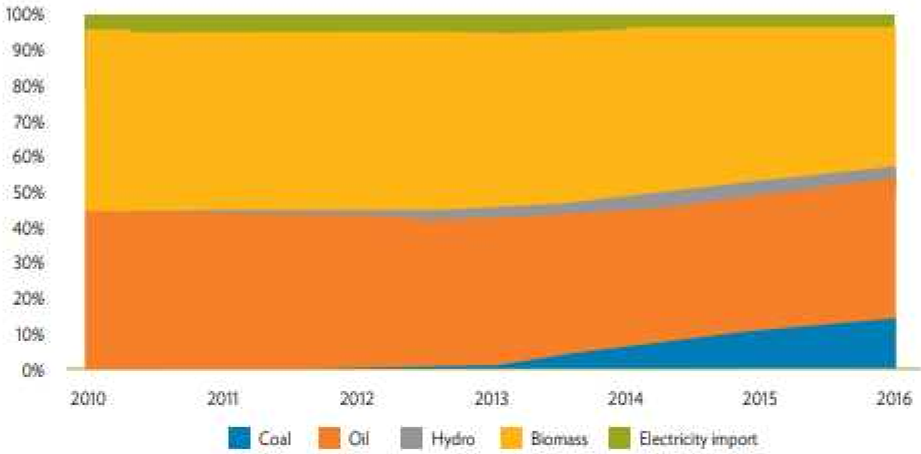


Figure 6. Primary Energy Consumption Share by Fuel (2018)[6]

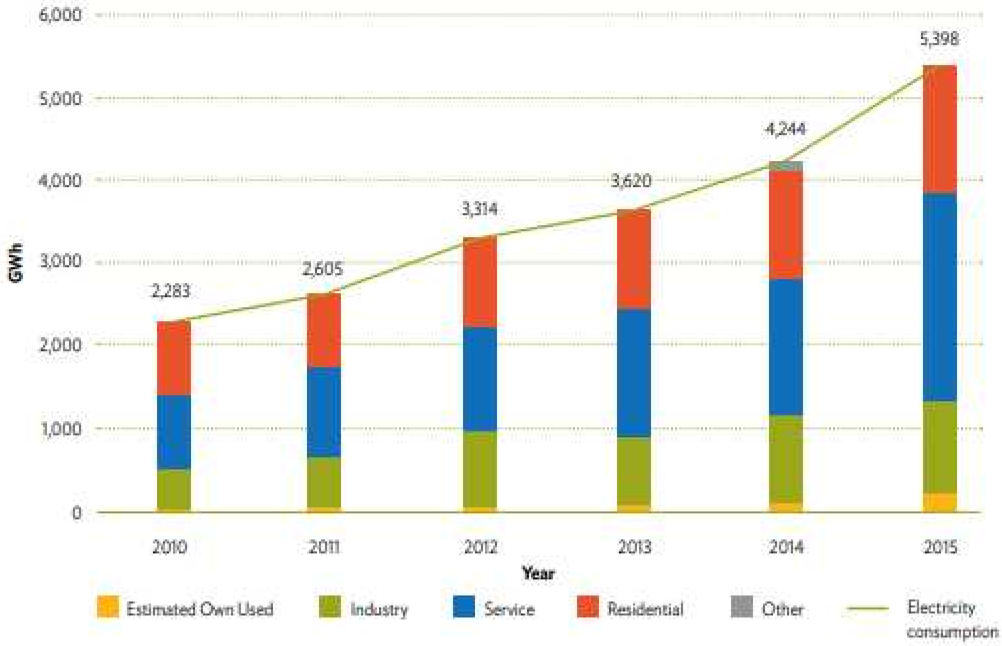


Figure 7. Historical Electricity Consumption by Residential, Commercial, Industry and other Sector[4]

The demand for electricity by the residential, commercial, and industry sectors has seen a steeper rise in consumption compared to the overall final energy consumption by all sectors. The residential sector consumes much more energy than the commercial and industrial sectors, at about 73% of the total energy consumption by these three sectors in 2015. Amongst the three sectors, the total energy demand for the commercial sector is the lowest.

In 2015, the commercial sector comprised about 3% of the total demand of the three sectors. However, the rate of increase in the projected demand by this sector is high, at an annual average growth rate of 6.1%. The industry sector consumes the second-largest share of total energy demand amongst the three sectors at about 24%, compared with 73% and 3% for the residential and commercial sectors, respectively. However, the annual growth rate is not as high as that of the commercial sector.

2.3. GHG Emission of Energy Sector

The Department of Climate Change (DCC) under the MoE is leading the preparation of third national communication for the year 2005. As part of this plan, DCC has identified experts from relevant sectors to collect and quantify GHG emissions for each sector. Each respective ministry is responsible for providing relevant data for the quantification of GHG emissions while the DCC under the MoE will consolidate collected data and prepare the national GHG inventory with the support of sectoral experts.

Cambodia´s GHG inventory 2019 Edition includes emissions from 1994 through 2016, including CO2, CH4, N2O, and HFC emissions, and includes the following sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Waste. The inventory has been developed following the 2006 IPCC Guidelines.

Table 8. Emissions by sector and gas in mass unit, year 2016 (Gg)[7]

Inventory Sector	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SOx
	Gg						
Energy	8 845.29	23.04	0.61	43.43	160.46	45.03	32.61
IPPU	1 449.46	NA	NA	NE, NA, NO	NE, NA, NO	NE, NA, NO	NE, NA, NO
Waste	524.56	79.7	0.82	NA	NA	NA	NA
Agriculture (3A + 3C)	17.42	645	7.56	NE, NA	NE, NA	NE, NA	NE, NA
Forest and Other Land Use (FOLU) (3B)	131 011.24	NA	NA	NA, NO	NA, NO	NA, NO	NA, NO
Total (without FOLU)	10 836.73	747.87	8.98	43.43	160.46	45.03	32.61
Total (With FOLU)	141 847.98	747.87	8.98	43.43	160.46	45.03	32.61

As Cambodia is mainly an importer of fuels and there is the only production of charcoal, fugitive emissions are considered not occurring in the country. Energy demand has experienced a significant increase due to the transport sector expansion and significant vehicle growth, and population migration to cities; these factors combined have led to increased transport demand and fuel consumption and higher GHG emissions in the energy sector.

[7] The Kingdom of Cambodia's GHG inventory 2019 Edition

The energy sector includes all the GHG emissions arising from combustion and fugitive releases of fuels. Based on the IPCC 2006 Guidelines, GHG emissions in the energy sector are split into three main categories: Fuel Combustion Activities, Fugitive emissions from fuels, and CO2 transport and storage. Only the emissions of fuel combustion are estimated in the current inventory.

The main contributor to the energy sector emissions is from transport with a contribution that ranges from 70.3% in 1994, to 53.1% in 2016. However, the contribution of this sector had decreased between 1994 and 2016. The second contributor to GHG emissions in the energy sector is energy industries, with a contribution that ranges from 11.1% in 1994 to 33.9% in 2016. The third emissions contributor is the other sectors, with a contribution that ranges from 11.7% in 1994 to 5.3% in 2016. Lastly, the manufacturing and construction industry contributed 6.9% of total emissions in 1994, increasing up to 7.8% in the year 2016.

3. Business as Usual (BAU) Scenario

3.1. Data and Assumptions

For the estimation of the transportation sector GHG emissions, a bottom-up approach was used. (i.e., accounting for activities of individual vehicles). The analysis was based on the data gathered from the Cambodia government ministries. The main datasets used for the Business as Usual (BAU) Scenario include vehicle registration data, vehicle fleet composition, and vehicle age distribution. However, due to the lack of data and information, and thus, assumptions that are made are as follows[8]:

- Average Vehicle speed: 25 km/h (Average travel speed in Seoul, Korea in the absence of available data)
  - Travel speed can be affected by numerous factors such as congestion level and roadway conditions. The congestion level of Cambodia may be lower than that of Korea because of the low rate of vehicle ownership. However, this effect can be canceled due to worse roadway conditions. It should be noted that the average speed should consider medium and small size cities as well as metropolitan cities that experience severe traffic congestion during rush hours.
  - Note that the differences in vehicle emission factors by vehicle speeds are only around 10% at 5 km/h intervals. (i.e., 243.63 CO2g/km for 25km/h vs. 276.20 CO2g/km for 20km/h vs. 219.87 CO2g/km for 30km/h)
- Average daily vehicle kilometers travelled (VKT) for registered vehicles in Cambodia was assumed to be 27 km, which is higher than that of European countries (known as less car-dependent countries) and lower than U.S. and South Korea (known as highly car-dependent countries). (see Figure 8). The assumption is higher than the VKT of electric

[8] There is no vehicle registration system for 3 wheelers such as "Tuk-Tuk". The analysis is based on existing official data provided by the Cambodia ministries.

motorcycles in Cambodia (23km); the VKT of passenger cars is generally known to be higher than that of motorcycles.

- For fuel based-motorcycles, average motorcycle kilometers traveled: 19 km[9]
- For electric motorcycles, average daily motorcycle kilometers traveled: 23km[9]

■ In the absence of available data, average daily vehicle kilometers travelled for transportation operation vehicles was assumed to be 100 km. For this, the adjustment factor reflecting the ratio of the VKT for Cambodia passenger cars (27 km/day) to the VKT of Korean passenger cars (35 km/day) was applied considering the Korean average daily travel distance for business vehicles, which is 130 km/day. As such, the average daily VKT for transportation operation vehicles in Cambodia was calculated as shown in the following equation, resulting in 100 km/day.

$$100 \text{ km/day} = 130 \text{ km/day} \times \left(\frac{27 \text{ km/day}}{35 \ km/day}\right)$$

■ Note that the use of Korean VKT in the analysis is assumed to be a conservative approach (not over-estimating GHG), considering the size of population and area: Korean population and area size are 51.64 million[10] and 100,209 km^2, respectively; Cambodia population and area size are 16.75 million[10] and 181,035 km^2 (as of 2020), respectively. Thus, the population density of Korea is 5.7 times higher than that of Cambodia. In general, the vehicle travelled distances in lower density areas are higher than those in high density areas. However, it cannot be easily assumed that the vehicle traveled distance is perfectly proportional to population density. The assumption that vehicle traveled distances of Korea and Cambodia are similar is a convenient guess, but it is not totally unreasonable.

■ Days in the study years: 365

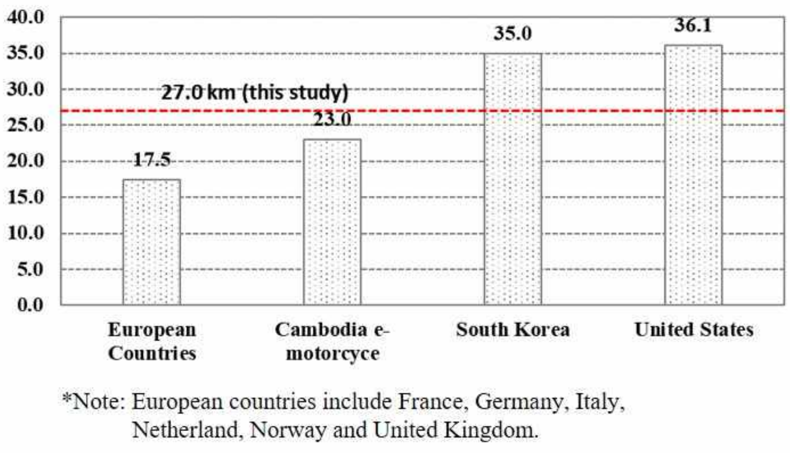


Figure 8. Average Daily Vehicle Kilometers Travelled by Countries[11]

[9] Electric Motorcycle Assessment in Phnom Pehn, MOE (2019)
[10] World Bank Data
[11] Source: International Comparison.org (2020)

3.2. Methods

1) Emission rate estimation

- First, emission factors provided by some of the foreign country agencies who have developed their own vehicle emission factors was explored. Some of the Cambodia government reports indicate that a large share of imported vehicles in Cambodia is from United States, South Korea, and Thailand[12]. Accordingly, the study specifically explored the emission factors by USEPA (U.S. Environmental Protection Agency)'s MOVES model (https://www.epa.gov/moves) as well as emission factors developed and adjusted by the Seoul Institute and Korean national institute of environmental research. Meanwhile, because of the complex nature of MOVES model and because MOVES require detailed input information, it was decided to apply Korean emission factors in estimating GHG emissions from Cambodia transportation sector considering its relatively easier model applications and data requirements. In developing the emission factors, vehicle age distribution is assumed so that the final emission rates accounts for the vehicle age distribution in Cambodia (Table 10). The assumed vehicle age distribution is then applied to the deterioration factors by Korean National Institute of Environmental Research (NIE) (Table 11). The Korean emission factors are described as follows.

$$E = \alpha V^{\beta} \text{ (when } \gamma \text{ exists in Table 9, } E = \alpha V^2 + \beta V + \gamma)$$

Where, E is emission rate in g/km. V is vehicle speed in km/h, and α, β, γ are model parameters.

Table 9. Model parameters suggested by Korean national institute of environmental research (NIE)

Classification		Code	α	β	γ
Mini-sized or motorcycle	Gasoline	1_G	900.6000	-0.5400	
Small-sized passenger car	Gasoline	2_G	1,149.8500	-0.5625	
	Diesel	2_D	1,133.1000	-0.5870	
Mid-sized passenger car	Gasoline	3_G	1,564.9300	-0.5936	
	Diesel	3_D	1,818.1000	-0.6643	
	LPG	3_L	1,539.4000	-0.5748	
Large-sized passenger car	Gasoline	4_G	0.0293	-4.6100	310.26
	Diesel	4_D	1,818.1000	-0.6643	
	LPG	4_L	1,849.8000	-0.6164	
Taxi	LPG	5_L	1,709.4000	-0.6232	
Bus	CNG	6_C	6,338.0000	-0.6300	
Bus	Diesel	6_D	4,638.6000	-0.5179	
Small-sized truck	Diesel	7_D	1,135.2000	-0.4668	
Mid-sized truck	Diesel	8_D	0.1029	-14.9370	798.9
Large-sized truck	Diesel	9_D	6,240.3000	-0.3829	
Mid-sized van	Diesel	10_D	1,828.9000	-0.4409	

[12] Source: Final Report on Vehicle Study (2019), Cambodia Ministry of Public Works and Transport

Table 10. Vehicle age distribution assumed for Cambodia[13]

Vehicle Age	Fraction	Per year
Below 5 years	20%	4%
5 years to 10 years	30%	6%
More than 10 years	50%	5%

Table 11. Deterioration factors by NIE

Classification		Deterioration factors
Mini-sized or motorcycle	Gasoline	1.0 if age < 10 years; otherwise: 10% increase per year up to 2.0
Small-sized	Gasoline	1.0 if age < 10 years; otherwise: 10% increase per year up to 2.0
	Diesel	1.0 if age < 5 years; otherwise: 5% increase per year up to 1.5
Mid-sized	Gasoline	1.0 if age < 10 years; otherwise: 10% increase per year up to 2.0
	Diesel	1.0 if age < 5 years; otherwise: 5% increase per year up to 1.5
	LPG	1.0 if age < 10 years; otherwise: 10% increase per year up to 2.0
Large-sized	Gasoline	1.0 if age < 10 years; otherwise: 10% increase per year up to 2.0
	Diesel	1.0 if age < 5 years; otherwise: 5% increase per year up to 1.5
	LPG	1.0 if age < 10 years; otherwise: 10% increase per year up to 2.0
Taxi	LPG	1.0 if age < 10 years; otherwise: 10% increase per year up to 2.0
Bus	CNG	1.0 if age < 10 years; otherwise: 10% increase per year up to 2.0
Bus	Diesel	1.0 if age < 3 years; otherwise: 5% increase per year up to 1.5
Small-sized truck	Diesel	1.0 if age < 5 years; otherwise: 5% increase per year up to 1.5
Mid-sized truck	Diesel	1.0 if age < 5 years; otherwise: 5% increase per year up to 1.5
Large-sized truck	Diesel	1.0 if age < 5 years; otherwise: 5% increase per year up to 1.5
Mid-sized van	Diesel	1.0 if age < 5 years; otherwise: 5% increase per year up to 1.5

As such, the final average emission rates for each type of vehicle and fuel are estimated as shown in Table 12.

Table 12. Average Vehicle emission rates

Classification		Code	Emission (CO2/km)
Motorcycle[14]	Gasoline	0_G	77.000
Mini-sized	Gasoline	1_G	205.148
Small-sized	Gasoline	2_G	243.625
	Diesel	2_D	217.900
Mid-sized	Gasoline	3_G	299.985
	Diesel	3_D	272.613
	LPG	3_L	313.500
Large-sized	Gasoline	4_G	276.350
	Diesel	4_D	272.613
	LPG	4_L	329.501
Taxi	LPG	5_L	379.054
Bus	CNG	6_C	1,080.618
Bus	Diesel	6_D	1,159.689
Small-sized truck	Diesel	7_D	321.436
Mid-sized truck	Diesel	8_D	623.143
Large-sized truck	Diesel	9_D	2,314.805
Mid-sized van[2]	Diesel	10_D	442.424

[13] Source: Clean Air Asia (2019), "Assessment of Regulatory and Fiscal Policies for Road Transport Vehicles in Cambodia

[14] In the absent of refined emission factor for motorcycle in Korea, the emission factor is retrieved from Meszler (2007)

2) Predicting the number of vehicle registration over time

The BAU applies the average emission rates to the number of registered vehicles in Cambodia to estimate the total GHG emissions. Here the future vehicle registration data is estimated by applying Gompertz function, which is a type of mathematical model for a time series. The Gompertz function is one of the popular models to predict growth for population, growth of tumor, etc. In this case, the Gompertz function is also believed to reasonably predict the number of vehicles in Cambodia over the next few decades. The general form of Gompertz function is as the following equation:

$$f(t) = \alpha e^{-be^{-ct}}$$

Where: a is an asymptote; b sets the displacement along the x-axis; c sets the growth rate; e is Euler's Number.

In this study, the constants α, b, c were estimated by minimizing the sum of residuals between the actual vehicle registration and the estimated vehicle registration by Gompertz function, using Excel solver. The final fitting constants were estimated to be α = 8969.5, b = 25.5, and c = 0.081. By applying the estimated Gompertz function, the future vehicle registration data were estimated as shown in Figure 9 and Table 13.

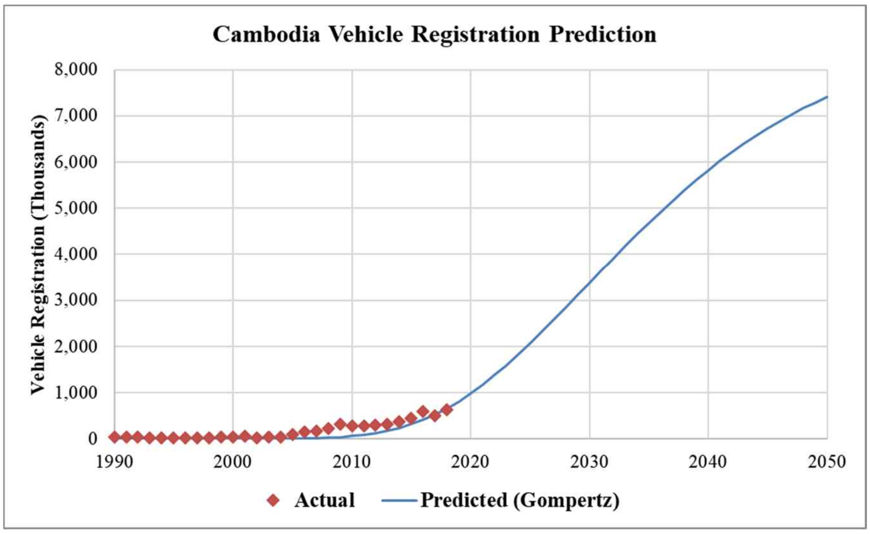


Figure 9. Predicted number of registered vehicles in Cambodia

Table 13. Predicted number of registered vehicles in Cambodia (Thousand)

Year	Population	Year	Population	Year	Population
2018	665	2029	3,107	2040	5,822
2019	816	2030	3,376	2041	6,023
2020	984	2031	3,645	2042	6,214
2021	1,170	2032	3,911	2043	6,395
2022	1,373	2033	4,174	2044	6,567

2023	1,590	2034	4,432	2045	6,729
2024	1,821	2035	4,683	2046	6,883
2025	2,064	2036	4,928	2047	7,027
2026	2,315	2037	5,165	2048	7,163
2027	2,575	2038	5,393	2049	7,290
2028	2,839	2039	5,612	2050	7,409

3.3. Total GHG emission result for BAU scenario

Combing the average vehicle emission rates, vehicle registration estimates, and some of the assumptions made in this study (e.g., vehicle speeds, vehicle kilometer traveled), the total GHG emissions were estimated for current and future years, as shown in Figure 10. The results showed the current and predicted GHG emissions under the business-as-usual condition.

Note that the estimated GHG emissions for future years in this study are much higher than the values by MOE (2010). For example, MOE (2010) estimated 10,913 Gg of GHG emissions for 2050, but the estimated amount in this study is 15,200 Gg, which is 39% higher than MOE (2010). The significant differences are likely to be produced by some assumptions such as emission rates by vehicle type and growth rate of vehicle population. However, due to the lack of information, it cannot be clearly identified what factors bring the differences.

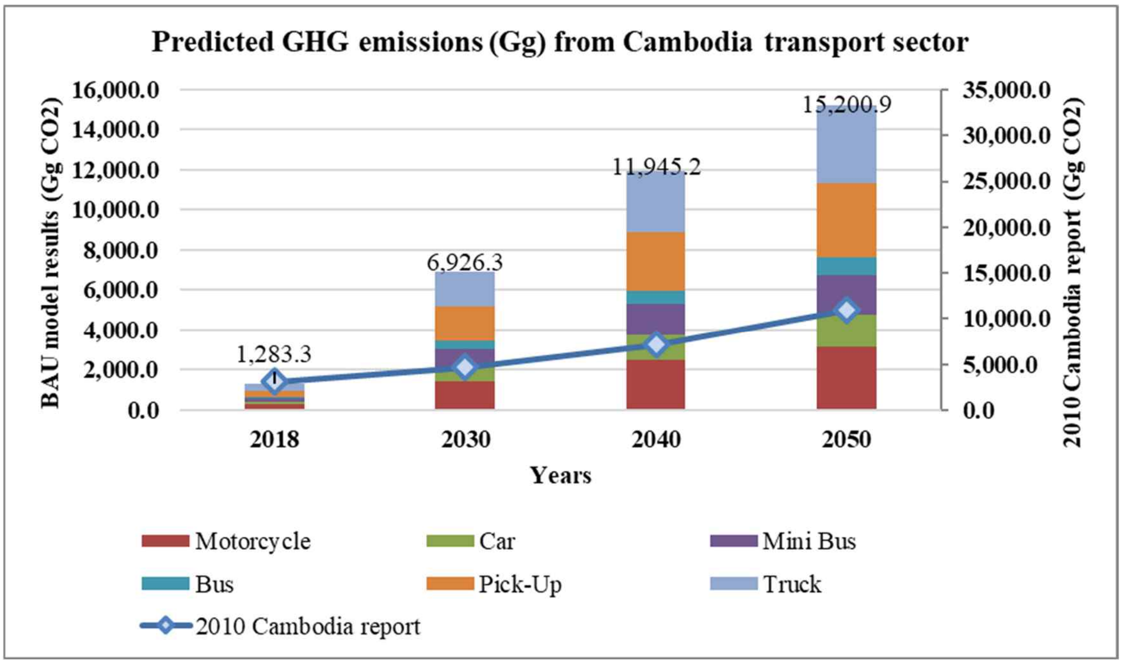


Figure 10. Cambodia transport GHG emission estimation results

3.4. Environmental and Health Impacts on BAU scenario

Due to the lack of the data on the number of electric Motorcycles in Cambodia (as there are no regulatory requirements to register electric Motorcycles in Cambodia), it is not possible to estimate what percentage of the Motorcycles are of the electric type. Based on the empirical observation, however, it is assumed that the share of the electric Motorcycles is rather negligible and that most of the Motorcycles are of a conventional type. It is also assumed that a large proportion of the electric bikes in Cambodia have lead battery (rather than lithium ion battery) and a sizable bulk is second- handed.

1) Air Pollutant Emission of the conventional Motorcycles

In addition to GHG, the conventional ICE Motorcycles emit other air pollutants such as particle matters, nitrogen oxide, and sulfur dioxide. The magnitude of the impacts on the air would differ from country to country depending on how stringent the enforcement of the vehicle emission standard (In Seoul, it is estimated that a 125cc motorcycle emits about 7 times higher NOx emissions compared to a compact car). As stated earlier, the enforcement level is low in Cambodia. There are reports indicating the correlation between the worsening air condition and rising number of the related public health costs in Cambodia.

It is reported that enforcement of the vehicle emission standards in Cambodia is weak and a number of unregistered and/or used (second-hand) Motorcycles are being driven without retirements. In combination, these factors are judged to worsen the air pollution situation in Cambodia, especially in big cities.

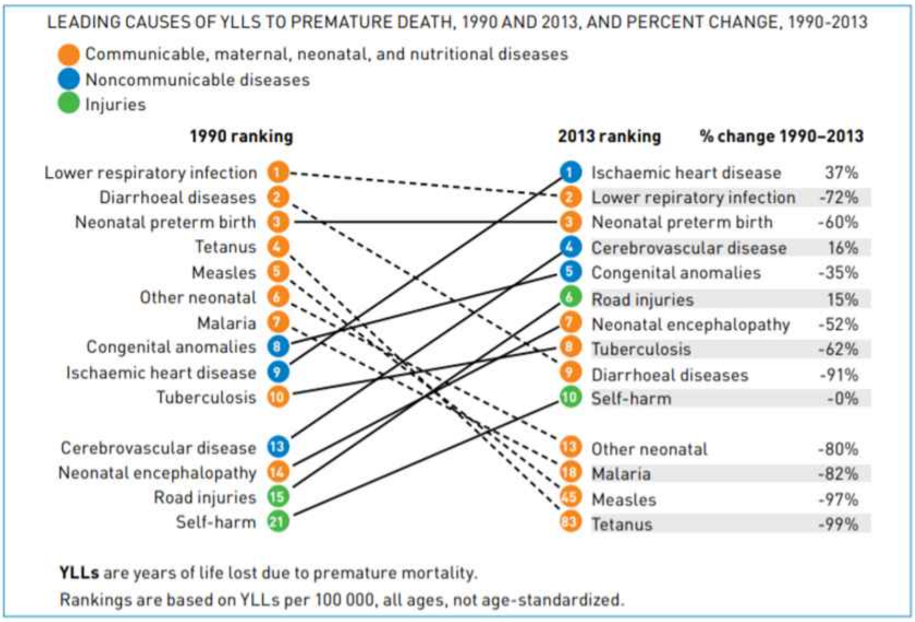
Quantification of the share of the contribution of the ICE Motorcycles to the overall air pollution and overall GHG emissions is not possible due to the lack of data.
Gender Impacts.

2) Health Impacts of conventional Motorcycles

In Cambodia, the national growth rates have been marking about 10% since the mid-1990s. Rapid population growth and a visible increase of the GHG emission and worsening air pollution has been followed accordingly.

GHG and other pollutants emitted from ICE Motorcycles and vehicles on the road generates a range of health impacts on the people. Gasoline and diesel from ICE are incompletely combusted that substance harmful to human health, such as NO2, is emitted. NO2 and air pollutants emitted from ICE Motorcycles and vehicles are combined with dust and particular matters, generating a second set of air pollutants in the air.

The rapid increase of outbreaks of ischemic heart diseases (ISD) are observed in Cambodia (esp. Acute lower respiratory disease is common for the minor below the age of 5), a primary type of diseases related to the air pollution, together with ALRU, COPD, lung cancer and strokes: Compared with the year 1990, ISD topped as the country's most frequent disease in 2013 (increased by 30%). Lower Respiratory Infection also marked the second in the rankings on the list. Fine dust (esp. PM 25) also causes respiratory diseases, asthma and ISD.



Source: Institute of Health Metrics and Evaluation. Country Profile of Cambodia. *Global Burden of Disease* (2015).

Figure 11. Epidemiologic transition in Cambodia (1990-2013)

WHO reported that in Cambodia cost related to sudden environmental changes related to rapid economic growth and lifestyle changes constitute about 26% of the total costs borne related to the diseases (WHO, Country Health Information Profile 2011). Globally, the largest share of the economic losses related to the environmental pollution is attributed to air pollution and such the tendency as such is reported to be most prominent in Asia and the Pacific region (WB, The Cost of Air Pollution, 2016)

WB (2016) found that mortality in Cambodia related to air pollution has been doubled (between 1990 (9,935 persons) and 2013 (19,595 persons), surpassing the average population growth rate of 1.5 times. As of 2013, total welfare loss due to air pollution in Cambodia was estimated to be 3,637 million dollars, i.e. about 8.19% of the country's total GDP (PPP) in the same year, higher than the global average.

IV. ALTERNATIVE SCENARIO IMPACT ANALYSIS

1. Alternative Scenarios

1.1. Alternative Scenario #1: Introducing E-motorcycles

The first alternative scenario assumes a gradual introduction of E-motorcycles in Cambodia. As one of the dominant transport modes in Cambodia, motorcycles are one of the main contributors to transport GHG emissions in the country. Because of the cheaper prices of electric motorcycles than other electric vehicles (e.g., e-car, e-bus, e-truck), it is believed that introducing E-motorcycles in Cambodia is relatively easier and so is more effective in reducing transport GHG emissions. The target market shares of e-motorcycles set in this study are shown as follows. Here, this study assumed to introduce the E-motorcycles equipped with the lithium-ion battery because lead-acid battery E-motorcycles are not environmentally friendly (e.g., lead processing creates more pollution. Plus, lead is more toxic to human health.)

- Year 2018: 0.0%
- Year 2030: 10.0%, which equals to 271,320 e-motorcycles accumulated.
- Year 2040: 30.0%, which equals to 1,403,782 e-motorcycles accumulated.
- Year 2050: 50.0%, which equals to 2,977,304 e-motorcycles accumulated.

In addition, because of the better fuel efficiency of E-motorcycles than conventional fossil fuel based motorcycles, it is assumed that the average daily trip distance of e-motorcycles is greater than that of conventional motorcycles: 23 km/day for E-motorcycle.[15] (note that 19 km/day for conventional motorcycle is applied to BAU scenario). Then, the adjustment for the increase in e-motorcycle travel distance is applied to passenger cars. In other words, the amount of increased total travel distance by e-motorcycle is subtracted from the total travel distance by passenger cars.

In the scenario analysis, the number of e-motorcycles is assumed to be shifted from conventional motorcycles as predicted by the BAU scenario. As such, the total number of motorcycles (i.e., e-motorcycles plus conventional motorcycles) in the alternative scenario #1 is the same as that in the BAU scenario. Applying the new vehicle composition scenario to emission factors, the amount of GHG emissions are predicted for the alternative scenario #1. Specifically, this study applied the emission rate of **8.6 CO_2 g/km** for e-motorcycle, which is

[15] A study conducted by JICA predicted that almost all the motorcycles in Laos will be replaced by e-bikes by 2030. However, it appears to be too optimistic as the same study identified that only 3% of households in Vientiane, Laos were willing to buy e-bikes (source: https://news.kotra.or.kr/user/globalBbs/kotranews/782/globalBbsDataView.do?setIdx=243&dataIdx=170078) This suggests that a 10% share in 2030 in Cambodia may not be unrealistic.

estimated by MOE (2019). The results are shown in Figure 12. Predicted transport GHG emissions under alternative scenario #1. In comparison with the results of BAU scenario (Figure 10), the introduction of e-motorcycle is expected to reduce Cambodia transport GHG emissions with greater rates and amounts as time goes. Here is the summary for the expected reductions.

- Reduction rate and amount in GHG emissions from alternative scenario #1, as compared to BAU scenario.
  - Year 2018: No changes
  - Year 2030: -3.7%, which equals to -256.39 CO2 Gg
  - Year 2040: -11.1%, which equals to -1,326.51 CO2 Gg
  - Year 2050: -18.5%, which equals to -2,813.41 CO2 Gg

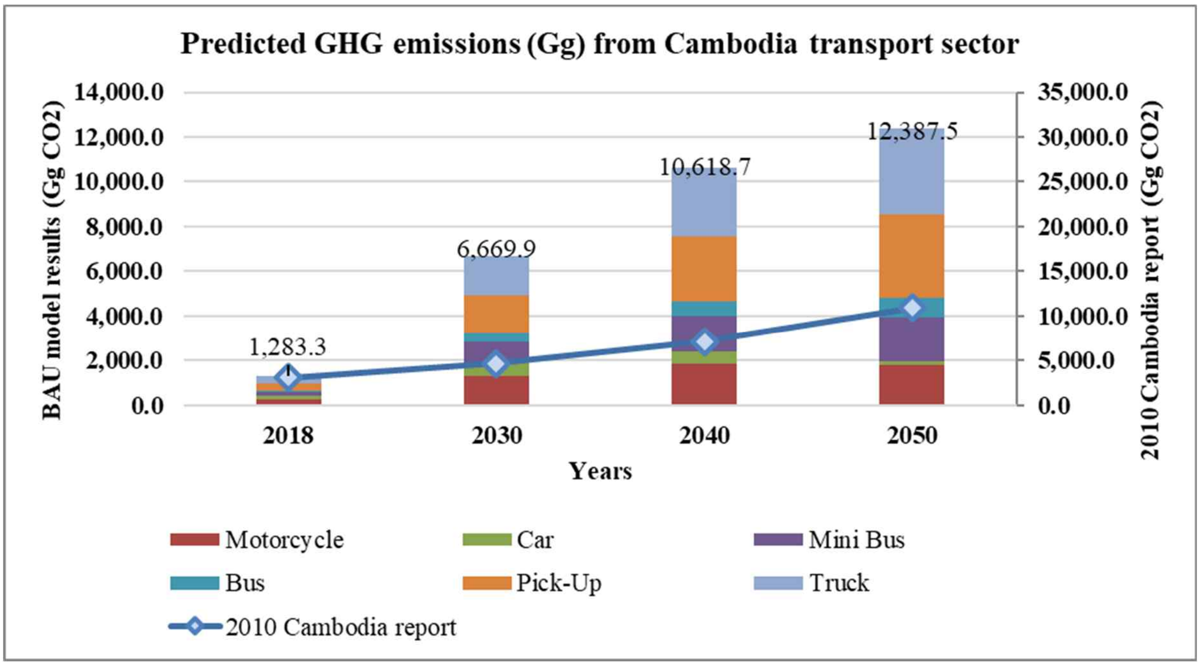


Figure 12. Predicted transport GHG emissions under alternative scenario #1

1.2. Alternative Scenario #2: Introducing electric cars and buses

Alternative Scenario #2 considered introducing electric cars and buses instead of introducing e-motorcycles stated in the alternative scenario #1. This scenario was settled, considering the significant advances in e-vehicle technologies in the projected future years. Also, the GHG emission reduction rates per vehicle are larger for e-cars and e-buses than e-motorcycles. Considering the high vehicle purchase cost of e-car and e-bus and the current and predicted market share trends of e-cars in the e-vehicle industry leading countries such as South Korea[16], the future e-car and e-bus market shares in Cambodia were assumed. For this

[16] As of 2019, the share of EVs among the registered vehicles in South Korea is only 0.38%.

assumption, the total purchase costs of e-vehicles between the two alternative scenarios were calibrated so that the total purchase costs of the two scenarios are closely to be the same. It was judged that this calibration considering a budget restriction can ensure a fair comparison for the two different scenarios. For the prices of electric cars used for the purchase cost calculations, refer to Table 15.

- E-car
  - Year 2018: 0.0%
  - Year 2030: 1.0%, which equals to 2,646 e-cars accumulated.
  - Year 2040: 3.0%, which equals to 13,690 e-cars accumulated.
  - Year 2050: 5.0%, which equals to 29,036 e-cars accumulated.
- E-minibus (around 15-20 passengers)
  - Year 2018: 0.0%
  - Year 2030: 5.0%, which equals to 3,806 e-minibus accumulated.
  - Year 2040: 10.0%, which equals to 13,129 e-minibus accumulated.
  - Year 2050: 20.0%, which equals to 33,415 e-minibus accumulated.
- E-bus (around 45 passengers)
  - Year 2018: 0.0%
  - Year 2030: 10.0%, which equals to 1,292 e-bus accumulated.
  - Year 2040: 20.0%, which equals to 4,457 e-bus accumulated.
  - Year 2050: 30.0%, which equals to 8,507 e-bus accumulated.

Similar to the alternative scenario #1 analysis, the numbers of electric vehicles are assumed to be shifted from conventional vehicles as predicted by BAU scenario. Meanwhile, the travel distance adjustment was not applied in this case. In particular, the emission factors for electric vehicles were developed separately based on the currently available electric vehicles in South Korea. In this process, the fuel efficiency of vehicles in km/kWh is applied to the emission factor for Cambodia, 0.3839 kg/kWh (national average grid emission factor in Cambodia). As a result, the emission rates are calculated as follows.

- E-car: 77.0 g/km (note that 273.32 g/km is used for gasoline cars)
- E-minibus: 157.8 g/km (note that 442.424 g/km is used for diesel minibuses)
- E-bus: 402.6 g/km (note that 1,159.689 g/km is used for diesel buses)

The scenario analysis results are shown in Figure 13. In comparison with the results of BAU scenario (Figure 10), the introduction of electric vehicles including E-car and E-buses is expected to reduce Cambodia transport GHG emissions as follows. Meanwhile, the reduction by the alternative scenario #2 is expected to produce less reduction than the alternative scenario #1 (Table 15).

- Reduction rate and amount in GHG emissions from alternative scenario #2, as compared to BAU scenario.

- Year 2018: No changes
- Year 2030: -0.9%, which equals to -60.14 CO_2 Gg
- Year 2040: -1.8%, which equals to -216.33 CO_2 Gg
- Year 2050: -3.2%, which equals to -482.28 CO_2 Gg

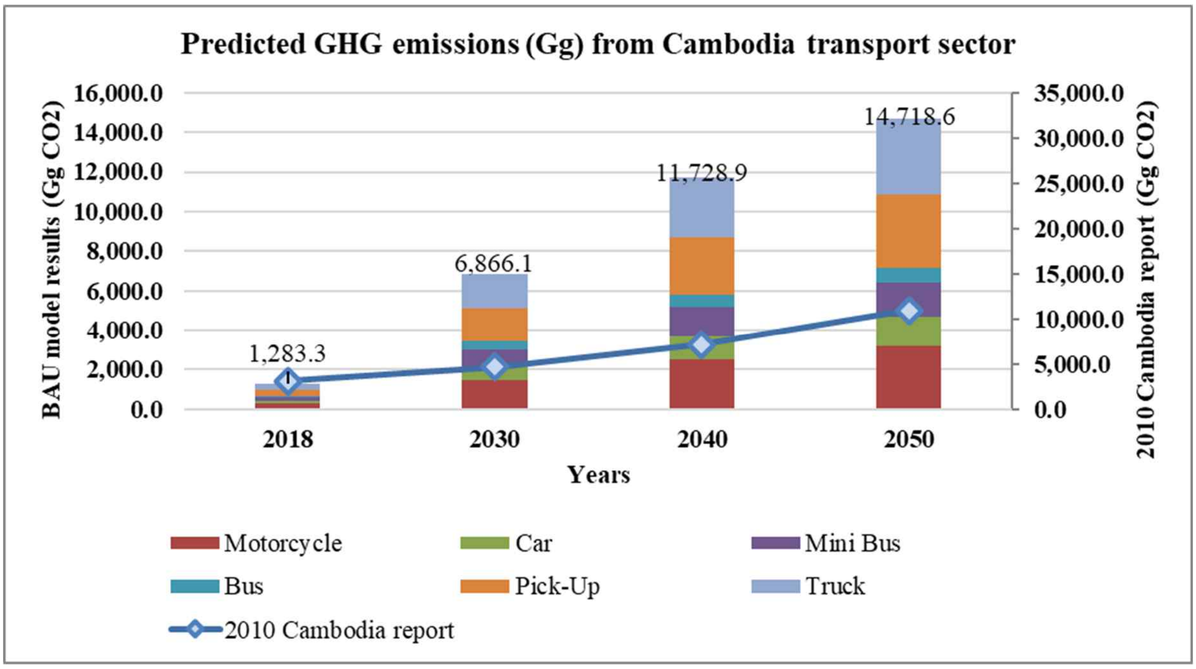


Figure 13. Predicted transport GHG emissions under alternative scenario #2

Table 14. Summary of estimated total transport GHG emission in Cambodia

Year	BAU	Alternative #1		Alternative #2	
	CO2 (Gg)	CO2 (Gg)	vs. BAU	CO2 (Gg)	vs. BAU
2018	1,283.3	1,283.3	0.0%	1,283.3	0.0%
2030	6,926.3	6,669.9	-3.7%	6,866.1	-0.9%
2040	11,945.2	10,618.7	-11.1%	11,728.9	-1.8%
2050	15,200.9	12,387.5	-18.5%	14,718.6	-3.2%

2. Alternative Scenario Impact Analysis

2.1. GHG Emission Reduction Impacts

The Alternative Scenario particularly suggested that the increase in the diffusion of E-motorcycles would be one of the most viable options that reduces the GHG from the Cambodia transportation sector. Compared to the other modes of transportation, the introduction of E-motorcycles has a greater potential that could be more effective in reducing the GHG from Cambodia transportation sector, with some of the advantageous features of E-motorcycles as addressed in the following statements.

1) High proportion of motorcycles

The share of motorcycle registration in Cambodia is much higher than other developed countries such as U.S. and South Korea (Figure 14). This may suggest that the motorcycle market and industry are more prevailing than other vehicle types in Cambodia, as compared to other countries; potentially road infrastructure may have also been adjusted for motorcycle traffic. In this regard, a larger portion of population in Cambodia is more likely to shift from motorcycles to e-motorcycles in the future. In the developed countries such as South Korea, however, the motorcycle market and industry are relatively small, and people in South Korea do not normally consider motorcycles as their daily commute/business modes of travel.

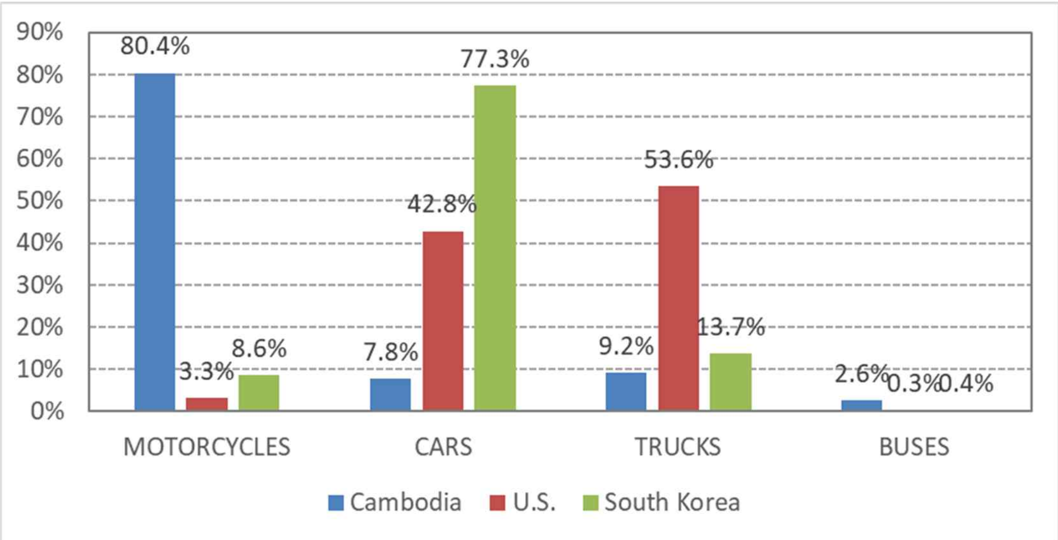


Figure 14. Comparison Results of Vehicle Registration Shares in Different Countries

2) Lower emission rate of e-motorcycles

The marginal benefit of replacing motorcycle with e-motorcycle in Cambodia is much greater than that of replacing general car with e-car. The CO2 emission from e-motorcycle (8.6g/km) is about 9 times lower than that of conventional motorcycles (77g/km). The CO2 emission rate of e-car (77g/km) is only about 3.3 times lower than that of gasoline-powered cars (256g/km). Also, to reduce the same amount of CO2 by replacing car with e-car (256g/km-77g/km=179g/km), it only requires around replacing two e-motorcycles ((77g/km-8.6g/km)×2.5 motorcycles=171g/km). Considering that the purchase price of e-motorcycles is much less than that of e-cars, the cost-effectiveness of replacing e-motorcycle is expected to be much greater than that of e-cars.

3) GHG emission for INDC Target

The Government of Cambodia submitted the Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2015, indicating the possible emission reduction of 390 GgCO2-

eq by 2030 in the transport sector. With the increase in the market share of electric motorcycles as an effective way of reducing Cambodia transport CO2 emissions as analyzed in Alternative Scenario #1, it was estimated how many electric motorcycles are needed to reduce the same CO2 emissions suggested by the INDC report. The calculation is described in the following equation, suggesting that around 488 thousand electric motorcycles are needed to reduce a total of 390 GgCO2.

$$390GgCO_2 = \{(77CO_2/km \times 19km - 8.6CO_2/km \times 23km) + 273CO_2/km \times 4km\} \times 365\ days \times \#E\_Motors$$
$$\#E\_Motors = 453{,}289$$

Where, 77 CO2/km, 8.6 CO2/km and 273 CO2/km are the emission factors for gasoline motorcycles, electric motorcycles, and cars in Cambodia, respectively. The distance 4km is applied to reflect the reduction VKT of cars by the increase in VKT of electric motorcycles (from 19 km to 23 km, daily) because of a better fuel efficiency of electric motorcycles than gasoline motorcycles, #E_Motors is the required number of electric motorcycles to reduce the total transport CO2 of 390 GgCO2 which was predicted in the Cambodia INDC report.

This reduction target is comparable to the amount of the estimated reduction in 2030, 316.6 GgCO2-eq (combining Alternatives #1 and #2). Note that the reduction target of 390 GgCO2-eq includes the impacts from various measures such as promoting mass public transport and eco-driving, improving the operation and maintenance of vehicles through motorcycles inspection, and increasing the use of hybrid cars, electric vehicles and bicycles.[17] Therefore, the smaller reduction amount in this study, compared to the target by the Government of Cambodia, seems to be reasonable.

2.2. Lifecyle Cost Analysis

As mentioned, the total purchased costs of E-vehicles between the two alternative scenarios were calibrated so that the total purchase costs between the scenarios #1 and #2 are adjusted approximately to be the same, for a fair comparison. One of the key components in the cost impact analysis is to identify the unit purchase prices of each type of electric vehicles. Here, the unit prices were determined based on the extensive review of present market values of currently available electric vehicles. Then, the target prices of the calendar year of 2030 were assumed to be down to the lower ranges of current market values. This assumption may be plausible because the purchase prices of electric vehicles are expected to decrease with the advancement in vehicle technology over time. Then, to account for the projected decrease in electric vehicle purchase costs for the following scenario years (i.e., 2040 and 2050), the prices of e-vehicles are assumed to be down to 50% of the 2030 prices as of 2050. Based on the review of available websites, the ranges of current market values are summarized and the

[17] Source: Cambodia's Intended Nationally Determined Contribution

unit purchase prices of each type of electric vehicles considered in the scenario analyses are summarized in Table 15.

- The prices of small-sedan electric vehicles range from $30,000 to $40,000.[18]
- The electric bus prices are typically much higher than other electric vehicles
  - The prices of e-buses currently available in South Korea range between $250,000 and $350,000 for a 45-seat unit.
  - The prices of 15- and 25-seat e-buses range between $70,000 and $100,000.[19]
- The prices of e-motorcycles in Cambodian markets are shown in Table 16. As this study proposes introducing lithium ion battery e-motorcycles, the price of e-motorcycle considered in the analysis was set to $1,400 based on the price ranges of lithium ion battery e-motorcycles in Cambodia. In particular, the prices of three e-motorcycle models (Voltra MATRIX, Oyika Ego, and Thada-OX) are within the range between USD 1,350 and USD 1,390.

Table 15. Assumptions on Electric Vehicle Prices (USD)

Year	E-motorcycle	E-cars	E-minibus (15-25 seats)	E-bus (45 seats)
2030	1,400	30,000	70,000	250,000
2040	1,050	22,500	52,500	187,500
2050	700	15,000	35,000	125,000

Table 16. Price ranges of e-motorcycles in Cambodian markets as of January 2020

Make	Model	Price (USD)	Battery Type
Voltra	MATRIX	1,390	Lithium Ion
	OFF-Road	899	Lithium Ion
Oyika	Oyika Ego	1,380	Lithium Ion
Thada	Thada-OX	1,350	Lithium Ion
Terra Motor	X-Man	950	Lead Acid
	D750	930	Lead Acid
	A2000	849	Unknown
Star8	ST-01	890	Unknown
	M3	1,450	Lead Acid

As such, based on the number of electric vehicles proposed for each calendar year and the unit purchase price, the total vehicle purchase costs were calculated. Then, the cost impact analysis was conducted to compare the effectiveness of the alternative scenarios as illustrated in Table 17. As a result, it shows that the alternative #1 (i.e., introducing e-motorcycles) appears to be more effective in reducing the transport GHG in Cambodia than the alternative #2 (i.e., introducing e-cars and e-buses). In other words, the purchase costs per GHG

[18] https://electrek.co/best-electric-vehicle-prices/

[19] https://www.alibaba.com/showroom/electric+bus+.html?fsb=y&IndexArea=product_en&CatId=&SearchText=electric+bus+&isGalleryList=G

reduction unit are 6.5 to 8.0 times, depending on target year, lower for alternative #1 than alternative #2. This may be mainly due to the much lower purchase costs of e-motorcycles than other electric vehicles (Table 15).

Table 17. Cost Impact Analysis on Alternative Scenarios

	Alternative #1			Alternative #2		
Year	Total CO_2 Reduction to BAU (Gg)	Total Purchase Cost (USD, $)	Cost per benefit ($/Gg)	Total CO_2 Reduction to BAU (Gg)	Total Purchase Cost (USD, $)	Cost per benefit ($/Gg)
2018	0	0	0	0	0	0
2030	256	379,848,683	1,481,555	60	668,854,676	11,122,350
2040	1,327	1,094,122,148	824,814	216	1,164,110,771	5,381,081
2050	2,813	610,141,881	216,869	482	835,512,616	1,732,418
Total	4,396	2,084,112,712	474,060	759	2,668,478,063	3,516,934

2.3. Environmental and Health Impacts

1) Less consumption of fossil fuels leading to no air pollutant and GHG emission during EV driving, results in less damages to the public health.

While biomass still plays an important role for energy sources especially in rural areas traditionally, demand for gasoline and diesel is expected to increase with the rapid motorization and industrialization which requires mass production of the petrochemical goods. All in all, switching to E-transport would substantially reduce gasoline and diesel consumption, helping the country to be more energy-independent and reducing harmful impacts on public health related to air pollution.

Unlike conventional transport vehicles based on conventional engines based on diesel and gasoline, driving electric vehicles do not emit exhaust gas polluting airs and harms human health. The GHG emission from EV is five times less than that from conventional motorized vehicles.

2) GHG Emission in battery production but less than in conventional Motorcycles in Life-cycle assessment (LCA).

Impacts on the environment of E-Mobility is largely in the process of resource extraction for manufacturing. A report indicates that as high as 2.5 times of CO2 is emitted in manufacturing an electric vehicle compared with manufacturing conventional motorized vehicles. The production of lithium-ion batteries is a carbon intensive process. Nevertheless, once produced, operation of the EVs have a smaller CO2 footprint compared to conventional vehicle counterpart. Thus, considering the entire lifecycle (from resource extraction, manufacturing to the operation of the vehicles), EVs are concluded to have less carbon footprints, contributing to GHG emission reduction compared to conventional vehicles.

3) Environmental and health impacts of lead acid battery pose significant threats. Phasing-out and safety regulation are recommended.

Until recently, lead batteries were widely used for electric vehicles and Motorcycles in Asian countries such as China and Vietnam and in Cambodia. As of 2017, 80% of the electric motorcycles in Cambodia is of lead acid types and the rest comprises of lithium-ion battery and nickel metal hydride types. Nickel metal hydride battery type is currently being phased out. Thus, selection of the batteries would be between lead batteries or lithium ion batteries. In general, it is reported that the latter is better for the environment in several aspects as follows:

(1) Lead battery is reported to more raw materials than the lithium ion batteries. It is reported that while the energy efficiency of conventional Motorcycles is 80%, while the electric Motorcycle is 100%.

(2) Lead processing is known to create more pollution and lead poisoning negatively affects human health. Lead is classified as a hazardous material that decays slowly. In China, where lead-battery type electric Motorcycle has been widely used until recently, it is reported that equivalent of 70-100% of lead content of a battery is emitted into the environment through mining, manufacturing, recycling and disposal processes (Mao, Lu et. 2006). Lead's impacts on human health is widely reported. Lead poisoning (a high level of lead concentration in blood) may lead to children's long-term development disorders, low IQ and physical growth impairments (Shen 2001).

Mistreatment of the lead during manufacturing and recycling can generate health effects on workers and people residing nearby. For example, a study (Suplido and Ong, 2000) shows that workers at battery recycling shops and children of workers in the Philippines were found to have much higher lead levels (330% higher for adult and 400% for children than the control group not exposed to the lead.) The US EPA (1997) identified lead pollution can lead to mortality, lower IQ, hypertension and stroke.

4) Noise

Traffic noise can cause irritation and annoyance, sleep disturbances, cardiovascular disease, risk of stroke, diabetes, hypertension and loss of hearing. It is also reported to result in decreased work performance. While the data on the level of overall traffic noises in Cambodia, it is well reported that big cities such as Phnom Penh and Siem Reap suffer from constant high level of noise, largely attributable to the use of Motorcycles with poorly conditioned engines etc.

As both the conventional and Electric vehicle technology are under development, it is not possible to generally conclude whether former or latter is any better in terms of noise emission level. To quote a recent research finding, “at constant low speed, EVs [...] are quieter than ICE cars. However, other studies show that on average there is no substantial difference between EVs [...] and ICE cars on the whole speed range. Results are also mixed when dealing with noise increase under acceleration."

It is not possible to conclude at this point if the newly introduced e-Motorcycles would substantially lessen the traffic noise level on the road in Cambodia. However, replacement of old conventional Motorcycles with a new electric Motorcycle is likely to lessen the noise level to a certain extent in Cambodia.

5) Environmental Impacts of Lithium Ion Battery Production is less than Lead Battery but also need to be actively managed.

Lithium ion batteries do not have toxic material such as lead but generate potential environmental impacts in the process of material extraction such as lithium and cobalt. Lithium is rather common resource but consumes a large amount of water in the extraction process (about 500,000 gallons of water being used for extracting 1 ton of lithium.) Technology to use less water in lithium extraction need to be developed.

6) Measures to further mitigate environmental and CO2 Emission impacts

The potential of reduced environmental impacts by introducing electric vehicles (including 4-, 3- or 2-wheeled motorized vehicles of all types) would differ from country to country depending on a range of factors such as: energy sources of electrification and vehicle emission standards etc. (ADB, 2016). As of 2019 about 32 % of the electricity generation in Cambodia is from coal-based energy sources such as gasoline and diesel marking the 2nd highest rate of the country's overall energy portfolio, after hydropower (33%).

The scale of EVs' GHG emission reduction effects could increase through the decarbonization of lithium extraction technology. Also, if EVs uses electricity from non-fossil-fuel based energy sources, such as solar and geothermal, the GHG emission impacts of the EVs would be even lower.

Thirdly, re-use and safe recycling of the used batteries from e-Motorcycles need to be institutionalized. It is reported that the average lifespan of an e-Motorcycle run in Cambodia is 5-10 years, but the maximum lifespan of lithium ion battery is 3 years and lead acid battery only 1 year. Thus 3~10 times of battery replacement would be required for the life span of an E-Motorcycle. While the majority of the currently run E-Motorcycles in Cambodia are plug in types, battery replacement type could be a more feasible option in remote rural areas, where electric grid penetration is rather low.

Few cases exist in developing countries where proper battery recycling process have been institutionalized. Lead poisoning and harmful effects especially on the children exposed to a high level of lead from the battery recycling facilities in developing countries are reported. Inappropriate recycling operations release considerable amounts of lead particles and fumes emitted into the air, deposited onto soil, water bodies and other surfaces, with both environment and human health negative impacts. Lead battery is also widely used in Cambodia. It is important for the Cambodian government to introduce strong incentives to phase out lead batteries from e-Motorcycles and EV production. Simultaneously, dismantling existent lead acid battery recycling facilities under operation without sufficient health and safety regulations is urgent.

Valuable metals such as cobalt and nickel can be extracted and reused from lithium ion batteries. Used EV and e-Motorcycles batteries often have residual electricity stored. These can be used for storage and charger for other purposes after terminating their useful life span on the vehicle. Re-use and recycling of the used EV batteries require regulations and technical guidelines for manufactures, recycling industries and consumers.

2.4. Socio-economic and Gender Impacts

The Scale of GHG emission reduction impacts between Alternative Scenario #1 and #2 would require more detailed technical and quantitative analysis, it is clear that Alternative scenario 1 would be preferred to Scenario 2 and maximizing the pollutants and CO2 emission reduction benefits would require fine-tuning the implementing policies and measures.

Social Impacts, especially on the poor and women and rural population in Cambodia requires further differentiation in analysis between Alternative Scenario #1 and #2 as the selection of the transport modalities have different implications on the size, scale and characteristics of the beneficiaries.

As major social impacts, this report covers the following aspects:

- Impacts on road safety
- Accessibility (& Affordability)
- Impacts on poverty reduction
- Impacts on gender equity & women's empowerment

1) Resource extraction for battery production may lead to unintended social impacts in the extraction sites and societies.

Extraction of cobalt may incur unintended social impacts: Most of the cobalt reserves known as of today are in the Democratic Republic of Congo (DRC): The overall level of environmental management and workers' rights are reported to be low.

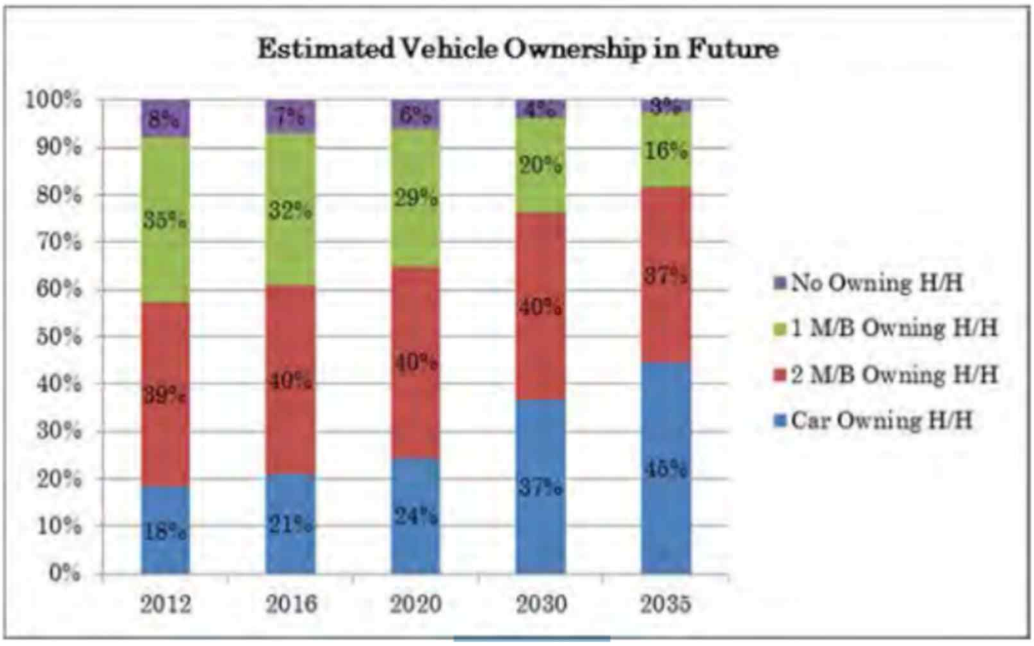
Tracking Information disclosure of the extraction sources needs to be strengthened. The United States Environmental Protection Agency (EPA) stipulates the reporting requirements of ion batteries (in Section 311 and 312) of the Emergency Planning and Community Right-to-Know Act (EPCRA). According to this, owners and operators of lithium ion batteries are required to prepare or have a Material Safety Data Sheet (MSDS) for any hazardous chemical as defined under the Occupational Safety and Health Act (OSHA) or its Hazardous Communication Standards (HCS) . In other case, battery and EV manufacturing companies voluntarily adopt its own safety protocols and measures. For instance, Samsung SDI has begun to publish Progress Reports on Responsible Cobalt Supply Chain.

2) Electric Motorcycles (Alternative Scenario #1) are more affordable / accessible to lower income group than electric vehicles. (Alternative Scenario #2) as long as the electrification of private vehicles is concerned

Private ownership of Motorcycles is more prevalent and accessible to the low(er) income population than that of 4 wheeled vehicles. Thus, electrification of Motorcycles (Alternative Scenario #1) affects a wider population with broader income level groups, including lower income segments than AS #2). In general, more equitable benefit sharing would occur in AS #1 than in AS #2. According to the Cambodia Climate Change Alliance (CCCA)[20], "Lower income groups (<USD350) including students are potential E-bike users in the future."

Given the current economic level and conditions in Cambodia, the dominance of the Motorcycles on the road is expected to continue in mid-term, especially in big cities. As shown in the Figure below, more than 53% of households in Phnom Penh are expected to have one or more Motorcycles by 2035. Thus, the electrification of Motorcycles means there would be more beneficiaries.

[20] CCCA, "E-bike presentation_final_202001431" (PPT)



Note: H/H: Household and M/B Motorbike

Figure 15. Change in Vehicle Ownership in the Future[21]

Currently, in Cambodia the average price of an e-Motorcycle is cheaper than a conventional ICE motorcycle (USD 1,000 vs. USD 2,000) and overall operational costs (lifetime cost) of an electric motorcycle are even cheaper. However, the price competitiveness of an E-motorcycle is not leading to visible shift from conventional ICE motorcycle to E-motorcycle purchase. Cambodian public perceives that E-motorcycle are inferior to conventional ICE motorcycle in quality and reliability. Studies indicates that the public distrusts the quality of the battery of the E-motorcycle, which is a major deterrent to adoption of E-motorcycle.

To ensure electric motorcycle are widely used, a set of measures may need to be introduced to incentivize the Cambodian customers to choose electric motorcycle over the conventional types such as financial incentives (e.g. import tax exemptions, subsidized electricity price etc.) and regulatory measures (e.g. strengthening quality standards of import of electric Motorcycles and strict enforcement of preventing outdated batteries and Motorcycles from re-entering to the market and roads etc.). Nonprice incentives such as giving favor (priority permits) for parking (or special parking space allocation) and voucher system for saved electricity from returned batteries etc.

3) Electrification of public buses (Alternative Scenario #2), however, may have more positive gender and poverty impacts in the long run

While electric Motorcycles are more affordable than electric 4-wheeled vehicles, there are

[21] Source: "THE PROJECT FOR COMPREHENSIVE URBAN TRANSPORT PLAN IN PHNOM PENH CAPITAL CITY (PPUTMP)" _ Executive Summary," / https://openjicareport.jica.go.jp/pdf/12245833.pdf

still segments of the population (especially the rural poor) who could not afford to purchase private transport equipment For them, resorting to public transport, such as buses or mini-buses, are often the only means for long-distance travel (other than walking). Electrification targeting private Motorcycles only may exempt these groups from benefiting from the policy. Same applies to women with the lowest income level who could not afford to purchase the electric Motorcycles. Minors, the elderly and the those with physical disabilities are another group who could not ride electric Motorcycles.

In case of introducing AS #2 policies, it is important for the Cambodian government to ensure additional public transport support system targeting these lowest income group so that they can enjoy the mobility regardless of E-motorcycles introduction.

4) Poverty reduction and gender empowerment impacts may be higher when electrifying Motorcycles (AS #1) than electric vehicles (AS #2)

Although there is no data available on the figure, many Cambodians, both men and women, use motorcycles for taxi ("Motordup" in local language) or other types of business operations in cities and rural areas. 2 or 3 wheelers are often used for grocery shops, street peddling and logistic purposes (transport of goods and materials in short-distance) and guiding services for tourists etc.

Figure 16. Motorcycles (2- and 3-wheelers) in Cambodia Used for Various Types of Economic Activities

The extent for the Cambodian women to use the motorcycles are not reported in figures. However, in observation, it is confirmed that especially young female population's use of motorcycles is not uncommon both in urban and rural areas. Motorcycles provides economic (income generation) opportunities for the Cambodian women by providing them mobility for trades and easier market access and moving children for commuting for education etc. In Cambodia there is no felt cultural stigmatization against women riding motorcycles.

Given that the noise level is lower, cleaner and customized rather for a short-distance (maximum speed of E-motorcycles run in Cambodia being 50~60 km/hour), electric Motorcycles potentially functions as an optimum vehicle for the low income citizens whose daily income generation is related to short-distance but frequent mobility as in the case of market peddlers in cities. In this regard, women could be substantially benefit from affordable and quality-wise reliable electric motorcycles.

Figure 17. Cambodian Women Riding Motorcycles

Economic benefits of using Motorcycles and 3 wheelers for various income generation and other livelihood activities would require another study. In general, adoption of E-motorcycles by business operators for the purpose of transport, carrying and delivering goods as well as sales purpose would be largely dependent upon the performance of E-motorcycles, batteries and its cost saving effects. It is indicative that a food delivery company ("Temple Meal") in Cambodia had once switched its Motorcycle fleet into electric ones but returned to conventional Motorcycles due to the short life span (6 months) of the lithium ion batteries (products imported from China). It would be important to ensure quality standards of the newly introduced e Motorcycles including the quality and life span of the batteries.

In terms of health and environmental impacts, EVs, be it 2-, 3- or 4-wheelers, would be a better option as the EVs would not emit air pollutant or CO2. This benefits would especially benefits women and children of low income who are more exposed to the transport pollutants (as they tend to reside and carry out economic activities nearby road sides.)

5) Promotion of electric Motorcycles in rural areas may generate more socio-economic benefits but proper rural electrification and infrastructure development is a pre-condition

Remote rural areas in Cambodia is still beyond the reach of central electricity grid network and paved road infrastructure, nor public transport facilities. Residents in these areas are often the lowest income population in the country. Such conditions provide barriers to effectively introduce E-motorcycles and at the same time pose the importance of introducing them there.

Absence or lack of electricity grid connectivity is identified the primary barrier for rural population to adopt e Motorcycles. Thus, rural electrification in Cambodia and ensuring sufficient electricity supply to the rural population is a pre-condition for effective diffusion of E-Motorcycles in rural areas in Cambodia. Immediate introduction of e Motorcycles or 4 wheeled vehicles may need to be introduced in big cities first where proper electricity and infrastructure are equipped and the need for air pollution and CO2 emission reduction is higher.

Rural electrification would contribute to gender equality as income poverty is skewed to women and especially to rural women in Cambodia. The access to (esp. grid-connected) electricity is lower among female-headed households (comprising 34% of the total households in Cambodia) than the overall average. Thus rural electrification would not only significantly benefits rural women in general (as women are the ones who spend long time and efforts to secure for traditional energy sources in the absence of modern energy such as electricity in Cambodia), but also ensure better access to electricity by female-headed households in rural areas, often in the most dire poverty condition. Uplifting their income level through E-Motorcycles is expected to improve their living standards and quality of life.

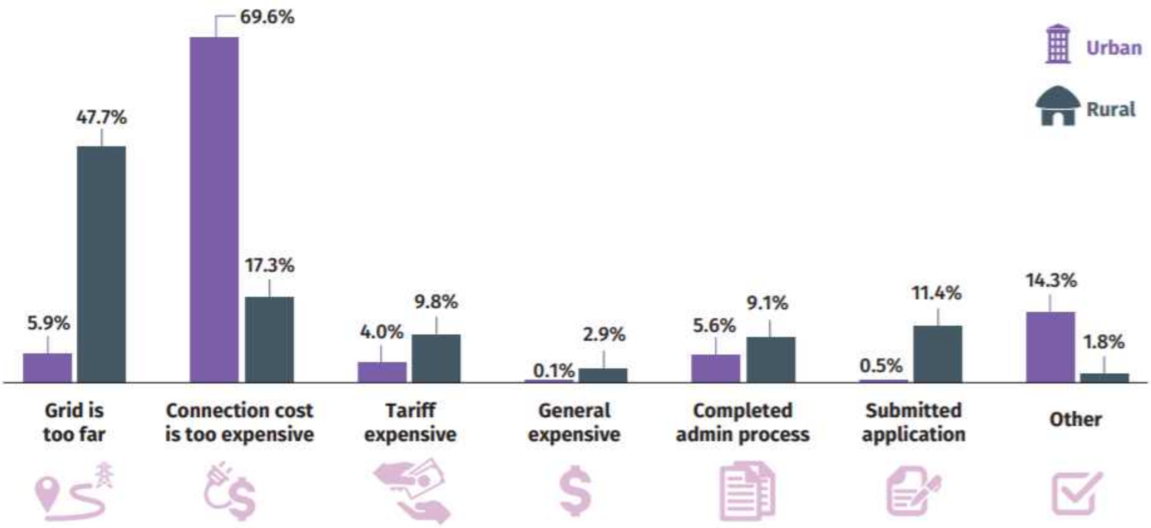


Figure 18. The main barrier to grid electricity access for urban household is ability to pay for connection fee, while distance from the grid infrastructure is the main barrier for rural households.[22]

6) With or without electrification, current Motorcycle taxi business sector in Cambodia need modernization, i.e. formalization and stronger regulations for safer, better services.

Other than walking or riding animal-carts or bicycles, Motorcycles could be the only resort for the residents in the remote rural areas in Cambodia to travel a relatively long distance. In case of medical emergency, such as sudden childbirths or outbreak of illness or accidents, rural villagers resorting to Motorcycle taxis often leads to highly risky situations, asides from the discomfort and inconvenience of the vehicle itself. As Motorcycle taxi operation in rural areas are often run by informal (unregistered and unregulated) business enterprise (individual

[22] Source: World Bank Energy Access Diagnostic Report Cambodia

or in syndicate types).

While fees are subject to negotiation, passengers virtually have no bargaining power as there is no other means to transport other than the informally run Motorcycle taxi operators. In addition, female passengers report safety concerns as most of motor taxi drivers of (relatively young) males without proper orientation and training on customer safety or safety let along proper supervision and penalty system of violence, formal or informal.

Given the importance and essential function the Motorcycle taxi business is playing as a major transport modality in Cambodia, overall quality and safety of the service would need to be improved through a set of policies enforcement of the government. This include, among others, licensing and registration of the businesses and enforcement of safety and pricing regulations, among others.

In conclusion, while it would not be possible to quantify the exact share of contribution of ICE engine vehicles to the total economic and welfare costs associated with the transport sector, it is still valid to conclude that switching from gasoline and diesel-based ICE Motorcycles to electric ones would immediately reduce the overall GHG emission and air pollutants such as NO2 and particular matters.

3. Comparative Impact Analysis of the Three Scenarios: Summary

In assessing the optimum Scenario, two-step approach with different set of selection criteria was applied.

- **STEP 1**: Consideration of Primary Criteria (GHG Emission Reduction, Environmental and Health Impacts) of Each Scenario

This is the criteria demanding for primary consideration as a selection of engine type and (hard) technology determines to a significant difference across options. In summary, active electrification of transport vehicles, either of Motorcycles (AS #1) and 4 wheeled cars and buses (AS #2), are found to be more beneficial than BAU scenarios (resorting to conventional transport vehicles) in terms of GHG emission reduction, air pollutant emissions, mitigating health damages, extent of which would be determined by the scale of the electrification. Given that Motorcycles are dominant share of the country’s land transport, AS #1 is expected to generate bigger GHG emission reduction, air quality improvement and health benefits.

However, electrification of transport vehicles is not exempt from generating other types of environmental impacts. Safety and environmental regulation and management need to be strictly applied in the process of extraction, manufacturing and recycling of the batteries. Lead acid batteries need to be phased out while dismantling unregularized recycling facilities. Stringent stronger safety and quality standards need to be introduced for battery production, replacement and management. Used EV batteries could be recycled for other purposes with its residual electricity before discarding them.

- **STEP 2**: Consideration of Secondary Criteria (Poverty reduction, economic and other social co-benefits including gender and vulnerable group consideration)

Impacts on poverty reduction, economic and other social c-benefit generation would be not only determined by (hard) technology choice and scale of investment but also by the policy designing and introduction of various supporting policies and measures. They are set as a second-tier selection criteria for selection optimum policy options for E-Mobility diffusion in Cambodia.

The preliminary analysis, as presented above, concludes that amongst AS #1 and AS #2 (selected from STEP 1), overall socially positive co-benefits, in terms of poverty reduction and economic benefit sharing, as well as empowering women's mobility and business entrepreneurship would be higher in AS #1 than AS #2.

In this analysis, rural population in Cambodia demands special consideration. Cambodia's urban-rural divide is still prominent in terms of economic performance, poverty level and overall living standards. There are pockets are remote rural areas still beyond the reach of grid electrification and without appropriate road infrastructure. Grid connectivity and connection fees as well as the tariff for the e Motorcycles disproportionately burden the rural Cambodians with less purchasing power. Appropriate infrastructure development is a precondition to introduce E-Mobility in Cambodia to ensure better access to electricity and affordable pricing schemes. A separate incentive packages may need to be considered for rural E-Mobility initiative in Cambodia.

In conclusion, while it would not be possible to quantify the exact extent of contribution of conventional ICE engine vehicles to the total economic costs and welfare losses associated with the transport sector, it is still valid to conclude that switching from gasoline and diesel-based conventional transport vehicles ICE Motorcycles to electric ones would immediately reduce the overall GHG emission and air pollutants such as NO2 and particular matters. Comparing electrification of Motorcycles (AS #1) with that of 4 wheeled cars and buses (AS #2), it is concluded that the former scenario is likely to bring about more immediate and extensive environmental, economic and social co-benefits. .

The table below maps out the results of the assessments of three scenarios (BAU, AS #1 & AS #2) in more details.

Table 18. Result of the assessment of three scenarios

Criteria / Scenario		Business-as-Usual (BAU) Scenario	Alternative Scenario (AS#1)	Alternative Scenario (AS#2)	Analysis & Further Consideration
[STEP 1 SELECTION] **Primary Criteria**	**GHG Emission**	(0: Baseline)	(++)	(+)	Overall GHG Emission reduction effect is bigger in AS #1
	Cost Effectiveness	(0: Baseline)	(++)	(+)	Cost effectiveness for GHG Emission reduction is higher in AS #1
	Environmental Impact 1: Air Pollution	(- -) GHG Emission	(++)	(-)	Air pollution is highest in BAU and lowest in AS #1
	Other Environmental Impact	(- -) Gasoline and diesel leakages lead to soil and water contamination	(- -) Lead acid battery results in soil and water pollution. Production of Lithium ion battery consumes large amount of water.		All three options have environmental impacts. BAU incur more environmental damage during operation(driving), while AS #1 and AS #2 in resource extraction and manufacturing stage. The latter (AS #1 and AS #2) is easier to control and manage (as the source and agent is concentrated.) Extraction of materials and manufacturing of batteries need to be managed through environmental management and safety regulations.
	Health Impacts	(- -) Gasoline/diesel combustion leading to excessive air pollutant	(++) During driving Air pollutants are not emitted. Thus overall health impacts associated with air pollution and traffic exhaust gases would be reduced in the long term.		One of the biggest benefits of E-mobility is cleaner environment and reduced health damages associated with the air pollution. The extent of improvement of air quality would be determined the bulk of air pollutant emission saved by introducing E-Mobility in AS#1 and AS#2.

Criteria / Scenario		Business-as-Usual (BAU) Scenario	Alternative Scenario (AS#1)	Alternative Scenario (AS#2)	Analysis & Further Consideration
[STEP 2 SELECTION] **Secondary Criteria**	**Social Impact 1: Poverty Reduction & Economic co-benefits**	x [DESELECTED FROM STEP 1 SELECTION]	(++)	(+)	E Motorcycles are more affordable transport modality to broader segment of population (including lower income groups) than 4 wheeled vehicles when considering private ownership. Beneficiary base is broader in AS#1. E Motorcycles are vital asset for many low income households in Cambodia facilitating various income generation activities.
	Social Impact 2: Gender and Vulnerable Group Consideration	X [DESELECTED FROM STEP 1 SELECTION]	(++)	(+)	Due to lower purchasing power, Cambodian women in general has less car ownership. Motorcycles are more accessible transport means to women. By enhancing women's mobility and ensuring less exposure to toxic chemical, E Motorcycles provide safer and cleaner option and improve women's welfare. Limited purchasing power and poor road condition in rural areas, favors electric Motorcycles (AS #1). However, additional incentives are required to effective implement AS #1 in rural areas due to the shortage of electricity, shortage in grid connectivity as well as limited affordability of tariff and overall purchase and operation costs.

V. BARRIERS TO ELECTRIC MOBILITY IN CAMBODIA

In promoting the E-Mobility in Cambodia, six types of barriers are identified as below:

- Data and information gap
- Policy and planning gap
- Institutional gap
- Technical capacity gap
- Financial gap
- Market and infrastructure gap

1. Data and Information Gap

1.1. Database on E-Mobility for Evidence-based Policy making and Planning

The current vehicle registration system in Cambodia does not differentiate E-Mobility as a separate category. The country lacks a reliable database on the current stock of electric vehicles, their level of impacts on air quality and emission. Limited access to reliable data hampers policy analysis and thus decision-making on E-mobility options and planning.

In addition, enforcement of the vehicle registrations also needs to be strengthened so that unregistered or unlicensed vehicles are not being operated on the roads without restriction. Failure to phase out vehicles which are not compliant with the country's vehicle emission standards would weaken the impacts of the country's GHG emission reduction efforts.

1.2. Lack of Information Leading to Low Level of Public Awareness of E-Mobility

Electric Motorcycles are not favoured by the Cambodian public ones as the public is not clearly aware of the advantages of switching to e Motorcycles. Although the purchasing price is cheaper than conventional Motorcycles, electric Motorcycles are perceived to be expensive due to high connection fees. Inconvenience related to frequent charging and ensuring grid connectivity is another barrier. As stated earlier, the total cost of e electric Motorcycle ownership is even cheaper considering that lower operation costs (as the electricity is cheaper than the gasoline or diesel) during driving. However, economic merit of e Motorcycles along the entire lifecycle of the vehicle have not been clearly informed to the customer groups that the public is often oblivious of these economic benefits. Studies also show that the public is not actively aware of considering CO2 emission reduction and other environmental (and public health) co-benefits of choosing e Motorcycles either.

Not only consumers but also, policy makers and vehicle manufacturers are not fully aware of the environmental and economic benefits related to cleaner fuels and vehicles. In many middle and low-income countries introducing low-emission transport is still perceived as an expensive policy measure which is not adapted to location conditions. On the contrary long-term benefits of using low-emission vehicles from reduced energy use, CO2 and air pollutant emissions are often out shadowed.

2. Policy and planning Gap

Policy measures to incentivize the introduction of E-Mobility is often weak, fragmented or non-existent, whose effects are usually compromised by the contractor policies. No or counterproductive policy measures are in place. Many low and middle-income countries have no dedicated fiscal or regulatory policies (such as tax relief or subsidies) in place to incentivize the uptake of cleaner fuels and vehicles. On the opposite, many countries still subsidize petroleum fuels or have disadvantageous fiscal policies in place, which complicate for example the import of electric vehicles. Cambodia also needs to develop a concrete action plan in order to achieve the low carbon transport goals and meet the NDC targets in the Transport sector. This plan should go hand-in-hand with a complimentary plan to develop E-Mobility infrastructure, such as battery charging and clean and safe recycling facilities as well as electricity grid connection.

3. Institutional Gap

Introduction and diffusion of E-Mobility in Cambodia need to be coupled with effective enforcement of related policies, such as environmental management and safety regulation on battery production, recycling and dismantling; regulation on the associated business operators. In addition, consultative and participatory policy making process would need to be institutionalized in order to formulate feasible and viable policy options with maximum effectiveness. A multi-party consultation mechanism needs to be established, involving all relevant stakeholders for E-Mobility diffusion in Cambodia, (including government and public, business, and academic as well as the transport occupational associations etc.)

4. Technical Capacity Gap

Decision makers in government need to strengthen the capacity to develop national electric mobility policy and programs. The development of policies to foster the uptake of low-emission mobility most often includes stakeholders from various ministries and requires thorough analysis and understanding of the national transport sector. There is a whole suite of options to incentive low-emission vehicles and a tailored set of interventions needs to be developed based on the national preconditions. Overall institutional governance for E-Mobility needs to be strengthened.

Decision makers need technical support during all stages of low-emission transport policy development. Qualified human resource would also need to be nurtured in the country. As a large share of the transport vehicles is being imported from abroad, the number of trained engineers and technician among the local population is limited in Cambodia, which hampers required innovation and locally sprouted entrepreneurship.

5. Financial Gap

Large scale investment in electric mobility is hindered by the chicken and egg situation between market uptake of electric vehicles and charging infrastructure development. All sources of financing electric mobility projects need to be untapped. This includes looking at fiscal policies to support investments in transportation and promote uptake of more sustainable transport technologies. This also includes the set-up of new business models which involves cross border actions between all stakeholders to spread the needed investment as well as the economic risk.

The market for the E-Mobility diffusion in Cambodia is not fully developed yet: Charging stations are few and repair and spare part markets are also scanty. The number of sellers are also limited, and investment is weak due to weak consumer demand. To break through this dilemmatic situation, strong political leadership and policy support is necessary. More rigorous quality standards and regulations on the E-Mobility manufactures and dealers would also ensure transparency of the market, which in turn will boost consumers' confidence in E-Mobility market in Cambodia.

6. Market and Infrastructure Gap

Suppliers in the E-Mobility market in Cambodia is still few and their presence is scanty. Private investment and business start-up are lacklustre and largely led by retailing services of imported foreign electric vehicles.

Associated infrastructure such as electricity supply (e.g. grid connection) and paved roads need to be developed in remote rural areas simultaneously as planned and reflected in the country's National Strategic Development Plan 2019-2023.

VI. ACTIONS FOR ELECTRIC MOBILITY

1. Identification of Action Areas & Enabling Conditions

Based on the barrier (gap) analysis presented above, a set of action areas are suggested in the table below for the implementation of E-Mobility. Each action area is categorized as "Primary Action", "Secondary Action" or "Enabling Conditions":

- **Primary Action Area**: The core component of the E-Mobility Policy Action Plan, largely to be carried out by the Cambodian government for kick-starting the E-Mobility diffusion effect. A stage of overall framework setting.
- **Secondary Action Area**: Complementary but still essential component of the E-Mobility Policy Action Plan, to be carried out by the Cambodian government and partly supported or collaborated by other entities (such as international development or climate financing institutions. Longer-term (or sequential) action items.
- **Enabling Conditions**: Area of action that is not within the scope of E-Mobility Policy Action Plan but essentially required for effective E-Mobility diffusion and achievements of NDC targets and other objectives and co-benefits of E-Mobility.

Table 19. Set of Action areas for implementation of E-Mobility

Barriers / Gap	Details	Action Areas	Action Type (Primary / Secondary / Enabling Condition)
Data & Info Gap	1. Insufficient data & information collection	(1) Introduce EVs and electric Motorcycle registration system (2) Establish DB on the current EV and Motorcycle stocks (e.g. technical specification, engine types, user group analysis, pricing etc. & conduct trend analysis) (3) Set up air quality monitoring DB over-time during the E-Mobility Action Plan implementation	Primary Action
	2. Insufficient access to information	(1) Conduct public information and campaign for awareness raising on E-Mobility	Primary Action

Barriers / Gap	Details	Action Areas	Action Type (Primary / Secondary / Enabling Condition)
Policy & Planning Gap	3. Insufficient Policy to Incentivize low carbon transport & E-Mobility	(1) Set up specific NDC target for E-Mobility (by different modalities: E-Motorcycles, E-Car and buses etc. (2) Prioritize key incentives, set up supporting policies and allocate budgets (3) Financial incentives to end users (electricity and/or Motorcycle subsidies/import tax (tariff vs. duty) exemptions or favored rates) etc. (4) Non-financial incentives to end users (special lane and/or parking allocation, battery return cash-back/credit system etc.)	
	4. Lack of insufficient Plan on E-Mobility Infrastructure development	(1) Setup plans with concrete time-bound targets to develop # units of battery charging stations, repair and other related shops and infrastructure (2) Setup incentives to support for the start-ups on and private investment in E-Mobility business	Primary Action
Institutional Gap	5. Lack of collective (consultative) decision-making mechanism for policy adoption	(1) Establish multi-party consultation mechanism involving all relevant stakeholders for E-Mobility diffusion in Cambodia, (including government and public, business, and academic as well as the transport occupational associations etc.)	Primary Action
	6. Lack of environmental management and safety regulations on battery production, recycling and dismantling	(1) Phase out lead acid battery type of E Motorcycles with a clear sunset policy & dismantle lead acid battery manufacturing and recycling facilities (2) Introduce tracking and reporting system on resource extraction for battery production of imported and domestically manufactured EVs and E-Motorcycles	Secondary Action
	7. Insufficient management and regulations on transport business operators (including	(1) Formalization and modernization of public transport sector operations, including mandatory registration and business licensing regulations,	Enabling Condition

Barriers / Gap	Details	Action Areas	Action Type (Primary / Secondary / Enabling Condition)
	Motorcycle taxis), leading to unsafe and irregular services	mandatory safety and occupational training on drivers and associated employees, standardization on fares etc. (2) Quality control of the licensed e Motorcycles and EV & enforce strict vehicle emission standards	
Technical Capacity Gap	8. Insufficient local experts and engineers on E-Mobility R&D, innovation, and business operations	(1) Identify technical capacity gap and required level of human resources in Cambodia for government and business sector (2) Provide training on engineers and nurture local E-Mobility experts (e.g. scholarship for overseas education etc.)	Secondary Action
Financial Gap	9. Insufficient public and private investment on E-Mobility Market	(1) Improve banking for EV-related business & enterprises etc.	Secondary Action
	10. Existence of contradictory financial incentives	(1) Gradually phase out fossil-fuel subsides and any incentives on conventional Motorcycle purchase	Enabling condition
Market & Infrastructure Gap	11. Insufficient suppliers	(1) Incentivize new entrants on the electric mobility Market (2) Foster supply of electric two-wheelers	Secondary Action
	12. Insufficient, unstable, or unaffordable electricity	(1) Improve reliability of electricity supply, including voltage fluctuation	Enabling condition
	13. Lack or poorly conditioned road esp. remote rural areas	(1) Ensure achieving the country's rural road infrastructure development target as planned.	Enabling condition

2. Additional Consideration for Cambodia's E-Mobility Implementation

This report set the three scenarios of the future transport sector development in Cambodia, largely by the selection of the transport modality, i.e. whether 1) to conserve the current dominant status of conventional (gasoline/diesel consuming international combustion engine-based) vehicles (BAU scenario), or 2) switch to electric Motorcycles (AS #1), or to 3) electric cars and buses (AS #2). In selecting optimum policy options for Cambodia's E-Mobility, policy decision-makers may also need to further consider the following factors:

2.1. Public and Private Vehicles

Depending on the scale of public vs. private vehicles currently run on the road, the GHG emission and public health impacts would differ. Social co-benefits may also be differentiated: In general, private electric Motorcycle electrification may instantly benefit the individual business and enterprises who are private vehicle owners. Electrification of public transports would benefit the passengers who are not vehicle owners.

In case the diffusion to the private market is not easy, piloting electrification of a number of fleets, such as food delivery and logistic service operators (with a group of Motorcycles or four-wheeled trucks) may be a more viable option. For the latter option, however, the overall performance level of the E-vehicles (esp. lifespan of the batteries) need to be improved.

2.2. Urban vs. Rural Focus

While some remote rural areas may have more dependency on Motorcycle types of transport (in the absence of other motorised transport modes), the economic feasibility of diffusing E-Mobility in rural areas in Cambodia is weak due to lack of grid connectivity and insufficient economy of scale. As a result, GHG emission reduction effect would be less. Given that cities suffer more on air pollution and associated health problems, environmental, GHG emission reduction and health benefit would be higher in urban areas. In addition, with relatively higher electricity penetration rates and better road and other infrastructure, urban areas are more ready for introducing E-Mobility. From the business point of view, private investors and business operators would be more prone to be located in urban areas with dense population for sales purposes.

However, economic feasibility should not be a sole ground for exempting rural population from benefiting the E-Mobility in Cambodia. It is recommended that the E-Mobility Action Plan prioritize urban areas at the initial phase with pilot application to a couple of major cities, such as Phnom Penh and Siem Reap, and spread to less urban areas over time. During this interval, Cambodia would need to complete its targeted goal of 100% rural electrification and road infrastructure development. Given the significant difference in their purchasing power, differentiated prices or special financial incentives may need to be introduced targeting the rural population for E-Mobility diffusion in rural areas in Cambodia.

2.3. Pricing & Subsidies

Based on current Cambodia people economic standard and income, it will be critical to optimize the range of prices of each E-Mobility including E-motorcycle and EV. Governmental subsidy policy is required to allow consumers to receive positive investment benefits through the purchase of e-mobility, at the same time changing their purchasing behaviour from conventional vehicles to electric transportation. Over time the government would also consider phasing out its subsidy policy gradually, allowing emerging energy technologies to return to the market mechanism. Some of the developed countries who successfully implemented E-Mobility has adopted Governmental subsidy policies and some policies are as follows;

- United States established the E-motorcycle Federal Tax Credit, also known as the 2-wheeled plug-in tax credit in the tax extenders bill approved by Congress and signed into law by President Trump late on Friday, December 20, 2019. It covers 10% of the purchase price on a new Zero motorcycle up to a maximum of $2,500. The federal tax credit is available in all 50 US states and applies to new e-motorcycles purchased in 2018 and 2019 (retroactive) as well as all of 2020. As an added bonus, an additional tax credit was approved which covers electric motorcycle chargers (e.g., Zero Quick Charger) with a 30% tax credit up to $1,000.
  - Credits are based on the final bill of the sale price for the motorcycle (including configuration accessories and additional batteries purchased on the same invoice, less taxes, fees and registration). If the product was discounted, the tax credit applies to the discounted price.
  - To ensure eligibility for the 30% federal tax credit specifically on charging equipment and accessories, these should be purchased on a separate invoice, which may serve as tax documentation.
- In addition, many other countries established tax credit policies to subsidy e-motorcycles purchases (https://www.zeromotorcycles.com/en-gb/incentives/)
  - United Kingdom: £1,500 government grant.
  - Austria: Austrian residents are eligible for € 1,200 combined E-Mobility discounts. Ends 12/31/2020.
  - Belgium: Eligible for 15% tax credit, up to € 3,010 depending on model and consumer.
  - Flanders, Belgium: Zero motorcycles purchased before December 31, 2019 are eligible for a € 1,500 cash subsidy.
  - France: € 900 government grant.
  - Paris, France: Companies with up to 50 employees purchasing up to five Zero motorcycles are eligible for assistance of € 1,500 for 7.2 kWh models and € 3,000 for a 14.4 kWh models.

2.4. Infrastructure Development

In Cambodia, electric motorcycles can be mainly used for short-distance commuting, and electric motorcycles have a daily travel distance of around 20 km (MOE, 2019). Besides, most electric motorcycles can travel up to 100 km on each full charge, so one full charge can accommodate the basic transportation needs even in the next day. Portable batteries can be charged without being bound to a specific location. Hence, Cambodia government needs to endeavour to build battery charging facilities which can cover a wider range of different models to meet the needs of consumers. If the charging is performed during off-peak hours, the electricity cost can be reduced, which can be called smart pricing or metering.

Charging infrastructure is one of the most important aspects of e-vehicle. Many countries have made efforts to expand charging facilities. For example, according to the U.S Department of Energy, there are currently 1,185 public Level 1 charging stations and 14,193 Level 2 charging stations across the country (Figure 19).

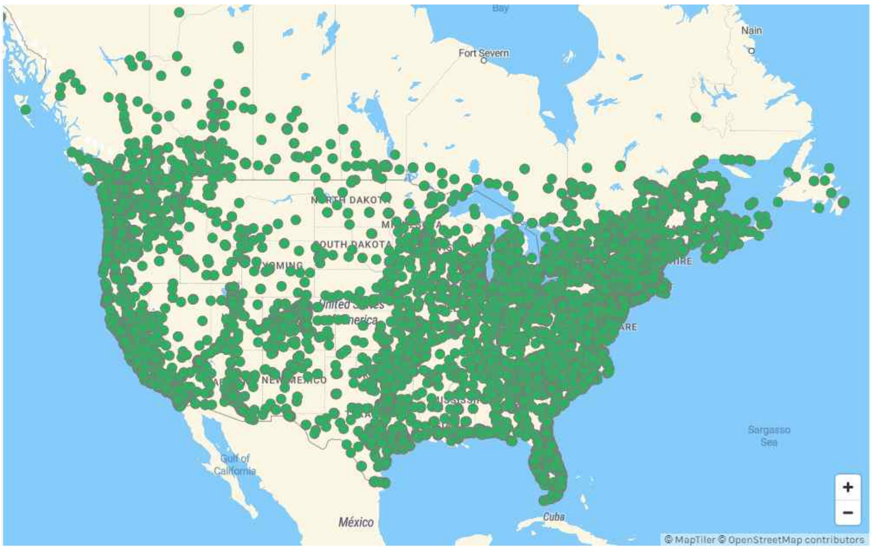


Figure 19. Electric Vehicle Charging Station Locations in United States

The time required for charging an electric vehicle (EV) is a constraint as it takes a lot of time. Furthermore, it requires several charging points in order to intercept range anxiety. Suitable space, for accommodating these charging stations required, is also challenging. Moreover, the availability of direct current (DC) fast chargers and challenges associated with the installation is the major concern for the EV stakeholders. In this regard, the EV battery swapping market has recently gained attention in this field. The global EV battery swapping market share is currently at its nascent phase but is projected to grow at a significant rate during the forecast period (2020–2030) (PSIPL, 2020). Here, swapping technology plays a vital role by eliminating such issues. Swapping technology drastically decreases the waiting time through its under 3-minute exchange of batteries, which is notably convenient compared to 1.5-2 hours at a minimum for charging solution. The significant increase in the projected number of e-motorcycles, e-buses, and e-cars in Cambodia as suggested in the previous chapter suggests that battery swapping technology should be placed to effectively support charging the huge number of EVs in Cambodia.

Some motorcycle companies' battery swap electric motorcycles are gaining market share such as Korean Company Veryword. Veryword with the support from Korea Energy Agency has provided 2 solar charged battery swapping station and 6 electric motorcycles in Phnom

Pehn and Siem reap.23 The batteries of some of the e-motorcycles can be detached from the motorcycle body, and as such it can be easily replaceable with fully charged extra batteries. Charging time for the most models is less than 5 hours. It suggests that such battery swap technology based Electric Motorcycle will be leading the E-Mobility market. Figure 20 shows the Veryword' battery swap electric scooter.

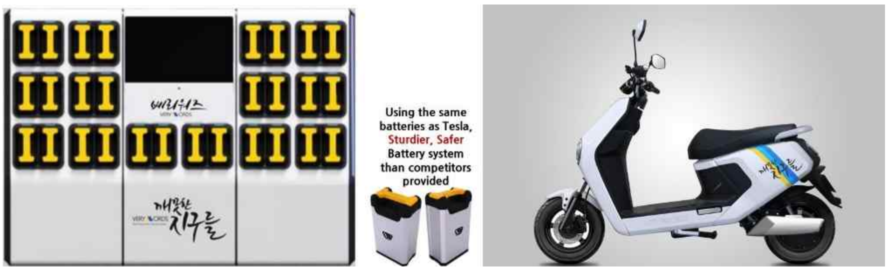


Figure 20. Veryword's Charging Station and E-Motorcycle

Along with the charging stations, repair shops for E-motorcycle should be installed. Currently E-motorcycles companies in Cambodia provide maintenance services to their customers but all companies have only one maintenance service station in Phnom Pehn. When the E-motorcycle breaks down, the customer needs to go to the specific brand maintenance service station. Compared to conventional motorcycle the inconvenience of maintenance service is too high.

3. Proposal for future Projects

Based on the current situation in Cambodia and enabling conditions and action areas for implementation of E-Mobility, some future projects that needs to be implemented will be recommended.

3.1. Micro-Financing Program for E-Mobility

Concept of E-mobility is new to the Cambodian vehicle market and consumers. The conventional method of transportation utilizing fossil fuel (i.e., diesel and gasoline) is familiar to the Cambodian people. In order to promote E-Mobility including E-motorcycle, financial incentives need to be provided to the Cambodian people.

A Micro-Financing Program for E-Mobility should be in place to encourage the Cambodian people to purchase/replace the conventional type of vehicle to E-motorcycle. With utilizing funds from green international funds, the consumer will be able to purchase E-Motorcycle at a more affordable price with low-interest rate through a financial program. Also, this project

[23] https://en.khmerpostasia.com/2020/04/27/korea-energy-agency-promoting-solar-bikes-in-cambodia-2/

should include a Technical Assistance program to raise awareness of climate change and the impact of E-Mobility to government officials responsible for the implementation of E-Mobility and also the people of Cambodia.

3.2. EV Implementation Project

In Cambodia, a Project for the implementation of EV is yet to be done. One of the successful projects for EV implementation in Korea was EV Project in Jeju island. With benchmarking the Jeju island EV Project in Korea a pilot scale project can be implemented.

As of March 2020, there are 118 electric buses in operation in Jeju Province, consisting of Seogwipo-city (located in the southern part of Jeju) and Jeju-city (located in the northern part of Jeju). Electric buses are mostly used as public transportation means and account for 13.8% of the total of 852 regular-route buses. Of the electric buses, 59 are used as intra-city buses for operation in Seogwipo-city, 35 as intra-city buses for operation in Jeju-city, and 20 are used as village buses on Udo Island. The remaining four buses are Seogwipo-city tour buses.

1) How electric buses introduced and operated in Jeju

The major details of electric bus operation in Jeju Province are as follows. First, the electric buses in operation in Seogwipo-city were introduced in 2015 and pursued in connection with the national pilot program for battery-lease buses. The battery lease program is a business model where an electric bus company purchases the vehicles, bearing the price of the vehicle body only and excluding the battery, which is leased from a battery lease company that is paid for battery management and recharging. The national pilot program was concluded after being carried out for 1 year and 6 months for Jeju Province from 2015.

In the battery lease program, electric buses that replace their batteries mid-route were proposed and battery replacement stations were installed at four bus stops. When an electric bus stops at the stop, the battery located in the roof of the bus is taken out and replaced with a new battery that is fully charged. Since the pilot program concluded, all electric buses introduced in Jeju Province are plug-in based.

Second, the electric buses that are operated as intra-city buses are owned by a private bus company, as the company purchased them with partial support of national and local government subsidies. Currently, the national subsidy for electric buses is paid differentially based on the performance level of the buses. As of 2020, the national subsidy for large-sized buses is 63.42 to 100 million won and that for middle-sized buses is 36.21 to 60 million won. If other national and local government subsidies are received, the electric bus purchase cost for the private bus company becomes similar to the diesel bus purchase cost.

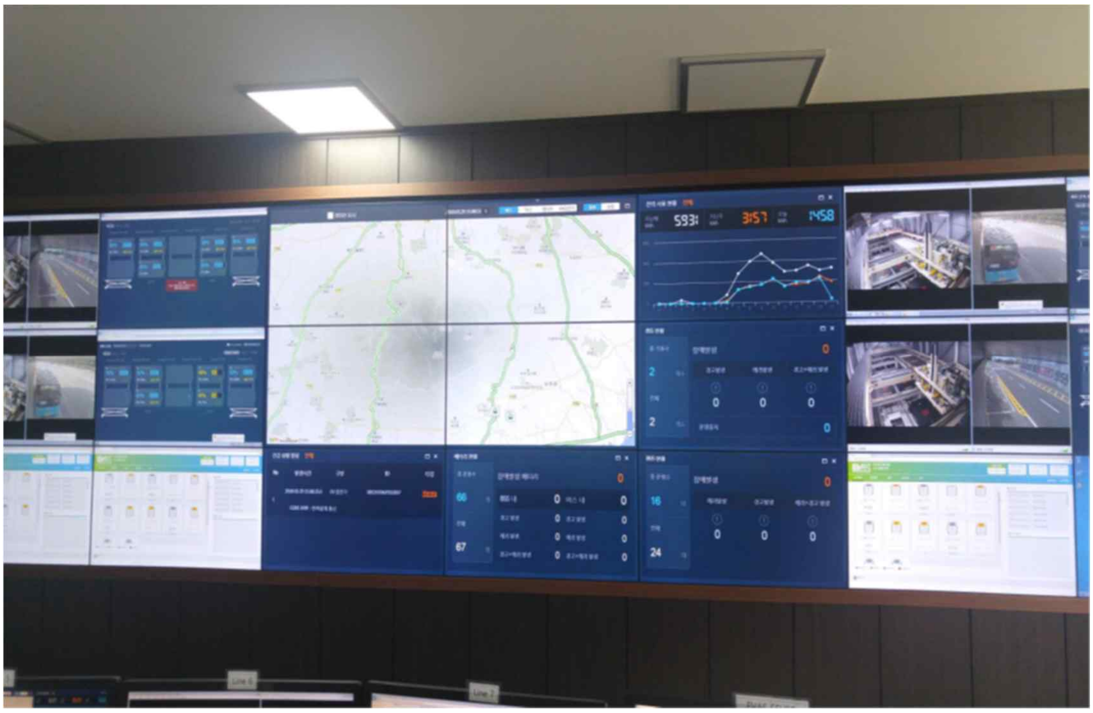


Figure 21. Electric bus operation center in Jeju

Third, the village buses operated on Udo Island are middle-sized electric buses. Udo Island is an annexed island of Jeju Province and is visited by 2 million or more visitors per year. Due to rental car users, diverse traffic issues including traffic congestion and accidents took place on Udo Island. As a result, the policy of prohibiting the entrance of rental cars has been executed since 2017. Consequently, middle-sized electric buses have been introduced and are in operation as an environmentally friendly transportation means considering the road situation on Udo Island.

2) How electric buses going forward in Jeju

The number of electric buses in use in Jeju is expected to increase further for the following reasons. First, Jeju Special Self-Governing Province is strongly pursuing its "Carbon-Free Island Jeju by 2030" policy (hereinafter "CFI 2030"), which is an environmentally friendly energy policy to replace internal combustion engine vehicles operated in Jeju Province with electric vehicles and is systematically pursuing CFI 2030 through its official "Mid-/Long-Term Comprehensive Plan on Electric Vehicles." In March 2020, the 3rd Mid-/Long-Term Comprehensive Plan on Electric Vehicles was announced, and Jeju Special Self-Governing Province is planning to introduce electric buses in link with private bus companies based on the electric bus supply target and execution plan by year.

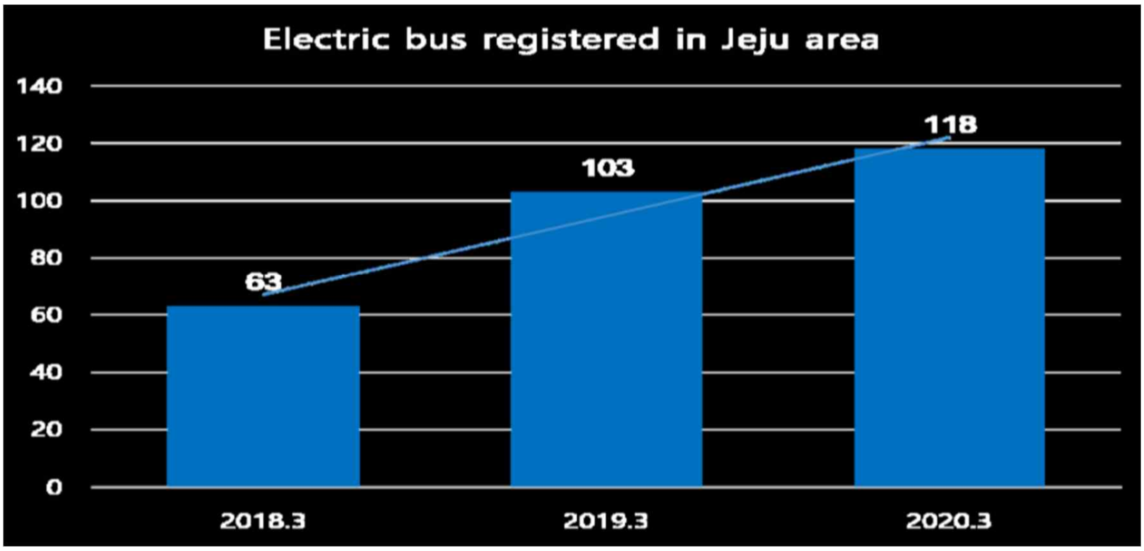


Figure 22. Registered electric buses in Jeju

Second, Jeju Province is pursuing the introduction of electric buses in link with policies for the convenience of vulnerable transportation users and public transportation policies. Currently, electric buses are designed and introduced in the market as low-floor buses. As the official "Plan to Promote the Mobility of Vulnerable Transportation Users" presents the introduction target and execution plans by year for the introduction of low-floor buses to promote the convenience of vulnerable transportation users, the introduction of electric buses and the scale of their operation are bound to only increase in Jeju Province.

Figure 23. Low-floor buses for traffic-impaired people operating in Jeju

In Jeju Province, a quasi-public system of mass transportation (the local government takes responsibility for covering any deficits and route coordination on bus operation while private bus companies take responsibility for the management of bus operations and drivers and the maintenance of buses) is in place. When the introduction of electric buses expands, it is expected that the financial support expense by the local government to cover any deficits in bus operation can be reduced as fuel costs and maintenance costs decrease.

Third, while electric buses have been introduced mostly for regular-route buses so far, they are also expected to be widely utilized as chartered buses going forward. This is because related vehicle prices are expected to decline as the models of electric buses continue to expand and also, in terms of fuel cost, because electric buses are assessed to consume less fuel than diesel bus. There are 1,930 diesel buses owned by 53 chartered bus companies as of the end of 2019, and these are expected to be replaced with electric buses in a phased manner.

3.3. E-Mobility initiative for Commercial Vehicles

The fastest way to initiate the implementation of E-Mobility is replacing conventional commercial vehicles. Cambodia currently has a lot of potential in tourism with various natural and cultural resources including Angkor Wat. With the development of eco-tourism utilizing E-Mobility along with Solar Charged battery charging station, it can assist in the expansion of implementation of E-Mobility and also provide charging infrastructure to the rural area.

Also in Cambodia, conventional ICE three-wheelers ("Tuk-Tuk") and motorbikes are the main modalities for taxis and delivery services. Both modalities used in the transport industries operate 5 times more than regular operation. It is recommended to partner with delivery companies such as Grab to implement E-Mobility in the delivery business sector.

3.4. Recycling E-Mobility Battery

With the implementation and expansion of E-Mobility in Cambodia, the number of waste batteries are expected to increase. In case of waste batteries, it can be either recycled, remanufactured, or reused. Reusing the waster battery is the most effective approach for environmental and social impact. A pilot project for utilizing reused battery as Energy Storage system (ESS) or Uninterrupted Power Supply (UPS) to support the charging station for E-Mobility is recommended.

VII. CONCLUSION

By identifying the barriers and gaps restricting the adoption of E-Mobility in Cambodia, this Plan was able to present a set of actions areas to be utilized in the implementation of E-Mobility in Cambodia. These action areas and additional consideration stated in Chapter 6 were identified through stakeholder consultation and various technical, financial, social and environmental analysis. It is designed to support the implementation and achievement of the transport target outlined in Cambodia's Nationally Determined Contribution.

The Government of Cambodia is in the initial stages in promoting E-Mobility and developing policies to implement E-Mobility. The Primary Action Area, Secondary Action Area and Enabling Conditions recommended in this Plan should be considered to successfully implement E-Mobility to reduce GHG emission and successfully transition to a low-emission pathway.

The implementer of this CTCN TA project Envelops will support the implementation of the low-emission mobility policies and believe that soon Cambodia will achieve the work for electric mobility.

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