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Cambodia:

RECOMMENDATIONS TO THE NATIONAL ROADMAP FOR ELECTRIC MOBILITY TRANSITION

WORLD BANK GROUP

PPIAF
Enabling Infrastructure Investment

Cambodia: Recommendations to the National Roadmap for Electric Mobility Transition

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Acronyms/Abbreviations

AC	Alternating Current
ASEAN	Association of Southeast Asian Nations
BAU	Business-as-usual (scenario)
BEV	Battery Electric Vehicle
CCS	Combined Charging System
CDC	Council for the Development of Cambodia
CHAdeMO	CHArge de MOve
CoM	Council of Ministers
COP26	UN Climate Change Conference of the Parties in Glasgow
CPO	Charge Point Operator
DC	Direct Current
EAC	Electricity Authority of Cambodia
EDC	Electricité du Cambodge
EM	Electric Motorcycle
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
EVCS	Electric Vehicles Charging Station
FCEV	Fuel Cell Electric Vehicle
FOLU	Forestry and Other Land Use
GB/T	Guobiao (Chinese charging standards)
GDCE	General Department of Customs and Excise
GDLT	General Department of Land Transport
GGGI	Global Green Growth Institute
GHG	Greenhouse Gas
GWh	Gigawatt hour
ICE	Internal Combustion Engine
ICEM	Internal Combustion Engine Motorcycle
IEC	International Electrotechnical Commission
IPPU	Industrial Processes and Product Use
ISC	Institute of Standards of Cambodia
ISO	International Organization for Standardization
km	Kilometer
ktoe	Kilo tonne of oil equivalent
kVA	Kilo Volt Amperes
kW	Kilo Watt
LGe	Liters of Gasoline equivalent
LGV	Light Goods Vehicle
LPG	Liquid Petroleum Gas
LTS4CN	Long-Term Strategy for Carbon Neutrality
MEF	Ministry of Economy and Finance
MISTI	Ministry of Industry, Science, Technology and Innovation
MLMUPC	Ministry of Land Management, Urban Planning and Construction
MLVT	Ministry of Labor and Vocational Training
MME	Ministry of Mines and Energy
MOC	Ministry of Commerce
MOE	Ministry of Environment
MOEYS	Ministry of Education, Youth and Sport
MPWT	Ministry of Public Works and Transport
NCSD	National Council for Sustainable Development
NDC	Nationally Determined Contribution
NEEP	National Energy Efficiency Policy
PDP	Power Development Masterplan
PHEV	Plug-in Hybrid Electric Vehicle
PPP	Public-Private Partnership
RGC	Royal Government of Cambodia
SEA	Southeast Asia
tCO_2e	Tons of Carbon Dioxide equivalent
TCO	Total Cost of Ownership
VAT	Value Added Tax
VCP	Vehicles, Charging and People (framework)
VKM	Vehicle Keeper Marking (Register)
VKT	Vehicle Kilometers Traveled
2W	Two-wheeler
3W	Three-wheeler
4W	Four-wheeler

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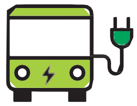
Definition of Key Concepts



E-mobility

Also known as electric mobility, E-mobility refers to the use of electric power to propel vehicles such as cars, buses, trains, motorcycles, boats, and bikes instead of an internal combustion engine (ICE).

E-mobility encompasses battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell electric vehicles (FCEVs), and other forms of electric transportation such as electrically assisted vehicles.

Throughout this report, E-mobility will refer to road transport vehicles: two-wheeled motorcycles (2W), three-wheeled tuk-tuks (3Ws), four-wheeled cars and vans (4Ws), and heavy-duty buses and trucks.

Zero-emission vehicles

Zero-emission vehicles produce no tailpipe emissions of greenhouse gases (GHGs) or other pollutants during operation. However, as the emissions associated with zero-emission vehicles depend on the grid emission factor, it is important to consider the source of the electricity used to power them. The grid emission factor reflects the average amount of GHG emissions associated with electricity generation in a particular region or electricity grid.

Zero-emission vehicles are typically powered by electric motors that use energy from batteries, fuel cells, or other renewable energy sources rather than internal combustion engines that burn gasoline or diesel.

Zero-emission vehicles include BEVs, hydrogen FCEVs, and PHEVs that can operate in all-electric mode for some distance before switching to a gasoline engine.

Net-zero

The term net-zero, popularized following COP26, refers to a state where the emissions of GHGs are balanced out by absorbing an equivalent amount from the atmosphere, resulting in net-zero emissions.

Achieving net-zero emissions is critical to limit the effects of climate change and involves reducing emissions through decarbonization and increasing the capacity of carbon sinks to absorb GHGs.

In transportation, achieving net-zero emissions requires transitioning to zero-emission vehicles powered by renewable energy sources such as solar or hydro, which can help reduce the amount of GHGs produced through transportation.

Greenhouse gases

GHGs cover all the gases trapped in the atmosphere creating a greenhouse effect to maintain a temperature compatible with life on earth.

Due to human activity, particularly by burning fossil fuels, these gases produced in higher quantities are released into the atmosphere and are responsible for global warming and climate change. These gases are mostly made up of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.

Executive Summary

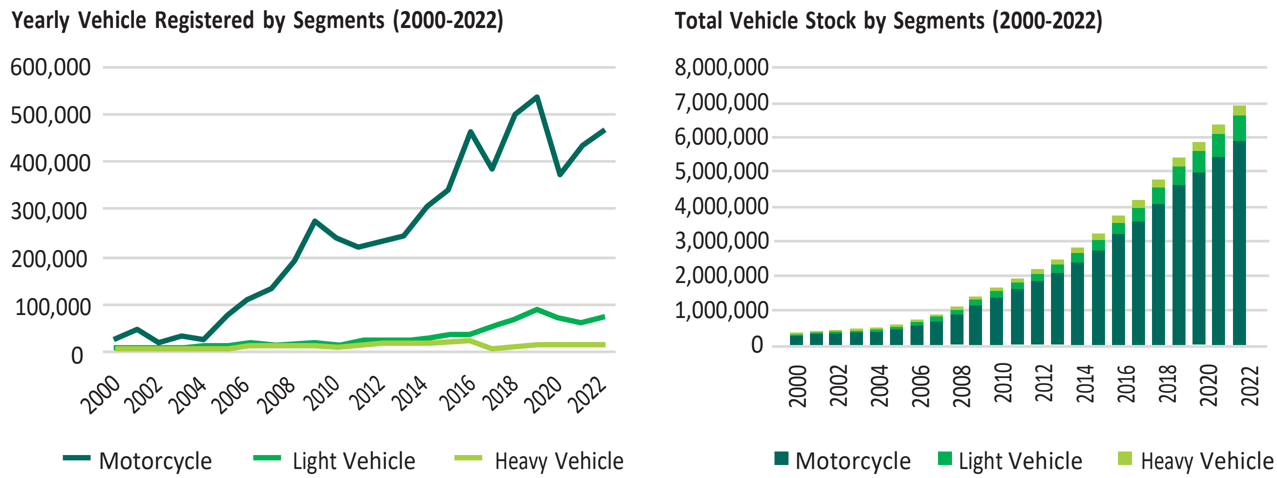
In December 2021, the Royal Government of Cambodia (RGC) published Cambodia's Long-Term Strategy for Carbon Neutrality (LTS4CN), which outlines the country's vision in achieving a carbon-neutral economy by 2050. As part of the long-term strategies to achieve net-zero emissions, the RGC set targets for decarbonizing the transportation sector through a combination of measures, including electrifying 70 percent of motorcycles, and 40 percent of cars and urban buses by 2050. It also aims to have 30 percent of mode share by public transport in cities by 2050.

The Electric Mobility (E-Mobility) Transition encompasses multiple sectors, from the transportation sector to the power sector, environment sector, and the broader trade and importation sector as well as the industrial development of Cambodia. In order to steer the complex process of the E-Mobility Transition, the RGC has established an Inter-Ministerial Technical Working Group led by the Ministry of Public Works and Transport (MPWT), in close collaboration with the Ministry of Mines and Energy (MME), the Ministry of Economy and Finance (MEF) and 9 other national entities and 25 representatives from city and provincial administrations.

In response to the request from MPWT and MME, the World Bank commissioned this study to evaluate the policy and market landscape for E-mobility in Cambodia, aiming to assist the development of Cambodia's national roadmap for the E-Mobility Transition toward achieving the EV penetration targets set by LTS4CN.

Cambodia's transportation sector is dominated by road transport. Road vehicles are the primary means for passenger and freight mobility across the country. Driven by rapid economic growth and steady urbanization progress, the motorization rate in Cambodia has been growing aggressively — firstly in the two-wheeler (2Ws) segment since 2004 and more recently in the passenger car segment (4Ws) since 2016. The 2Ws by far are the dominant vehicle segment in Cambodia. As of 2022, there were about 351 units of 2Ws per 1,000 population, compared with 44 units of 4Ws per 1,000 population. The total of 5.8 million motorcycles accounts for more than 85 percent of Cambodia's total vehicle stock in use, followed about 0.75 million light-duty vehicles (10 percent) and 0.28 million heavy duty vehicles (5 percent). Nearly all road vehicles in Cambodia today are internal combustion engine (ICE) vehicles, with exception for about 700 EVs registered.

ES Figure 1: Cambodia's Historic Vehicle Growth Yearly and in Total Stock (in units of vehicles)



Source: MPWT, 2023.

5.8 million motorcycles account for more than 85 percent of Cambodia's total vehicle stock in use. However, when measured by GHG emissions, 2Ws are only responsible for about 27 percent of road transport emissions.

Trucks are the largest emitting vehicle segment, contributing to 42 percent emissions.

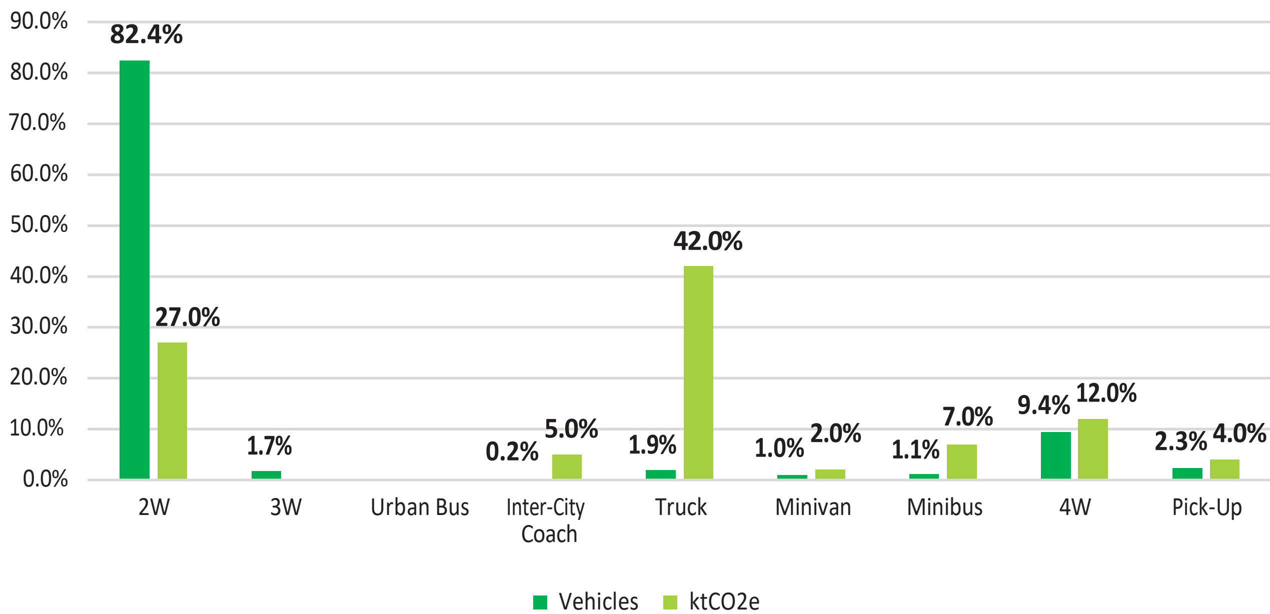
However, when measured by GHG emissions, 2Ws are only responsible for about 27 percent of road transport emissions. Trucks are the largest emitting vehicle segment, contributing to 42 percent emissions. Passenger cars, including pick-ups, account for about 16 percent of emissions. The urban bus segment has a neglectable role both in terms of vehicle stock and emissions given that the only urban bus service available in Cambodia today is in Phnom Penh with about 180 buses operating on 13 routes (source: Phnom Phen Bus).

As Cambodia continues its economic growth and the disposable household-income level raises, the motorization rate is set to increase through 2050. Benchmarking similar economies in the region whose economic growth rate and transportation structure are comparable to Cambodia, it is estimated that Cambodia will reach a motorization level of 574 with 2W units per 1,000 population and 57 passenger vehicle units per 1,000 population by 2030. By 2050, this level rises to 655 of 2-W units per 1,000 population and 138 passenger vehicle units per 1,000 population. This leads to a total active vehicle stock of more than 8.1 million in 2030 and 14.2 million in 2050, assuming 65 percent of registered vehicles are in active use. Correspondingly, the total annual vehicle kilometers traveled (VKT) is forecasted to grow significantly from 39.7 billion kilometers (km) in 2022 to 71.6 billion km in 2030.

Photo: Chhor Sokunthea / World Bank

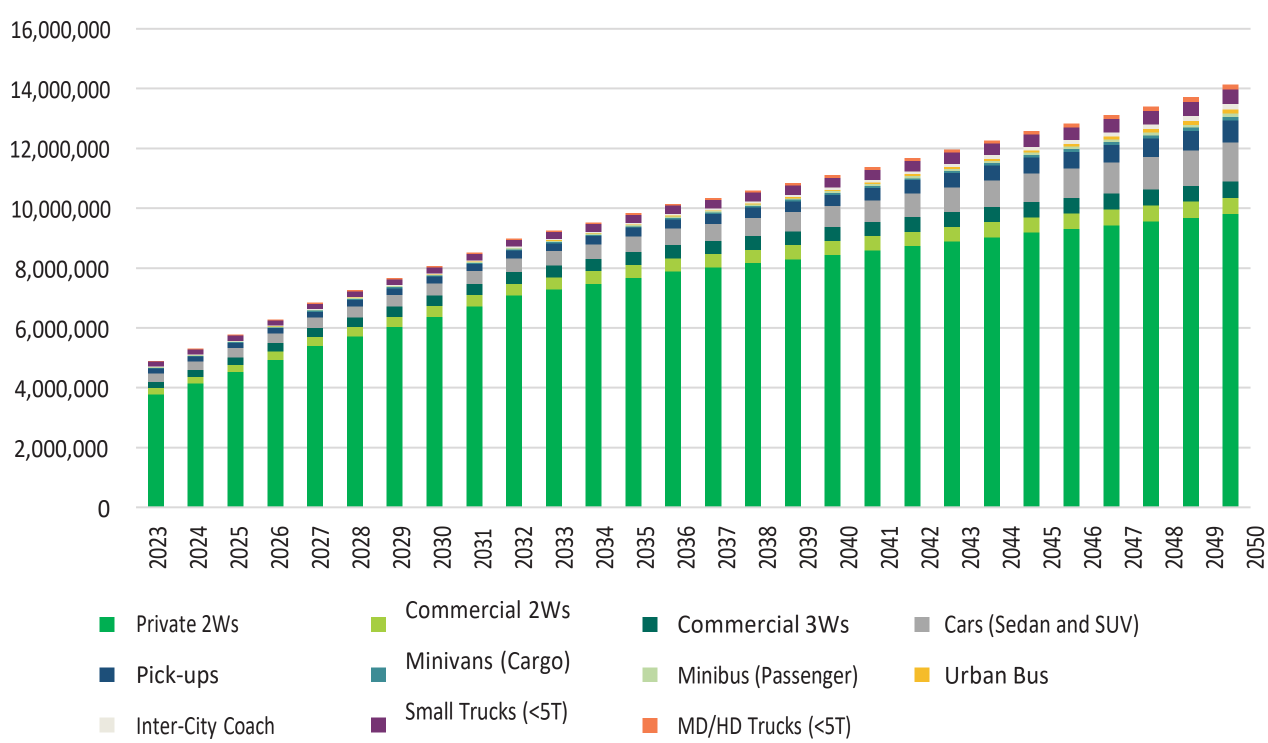
As Cambodia continues its economic growth and the disposable household-income level raises, the motorization rate is set to increase through 2050.

ES Figure 2: Estimated Vehicle Stock and Emissions by Road Transport Segments in Cambodia - 2022



Source: MPWT, 2022; UNESCAP, 2023; ADB, 2019.

ES Figure 3: Projected Total Vehicle Stock in Active Use (2023-2050, in units of vehicles)

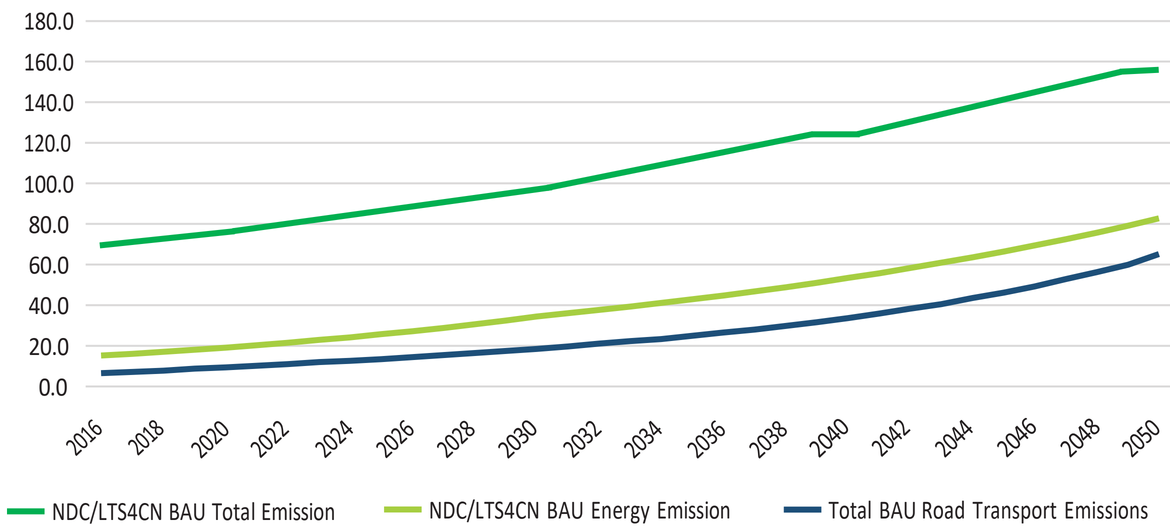


Source: WB Calculation

Under the business-as-usual (BAU) scenario, which models the hypothetical scenario where the overall powertrain structure of Cambodia's road vehicles remains dominated by gasoline and diesel as in 2022, the total tank-to-wheel GHG emissions from the road transport will increase from about 10.9 million tons of carbon dioxide equivalent (tCO_2e) in 2022 to 18.4 million tCO_2e by 2030 and 65.1 million tCO_2e by 2050. To put it into perspective, 18.4 million tCO_2e by 2030 accounts for 54 percent of total energy sector emissions under the nationally determined contribution (NDC) BAU scenario. By 2040, total road transport emission will reach 53.3 million tCO_2e, equivalent to 63 percent of total energy sector emissions.

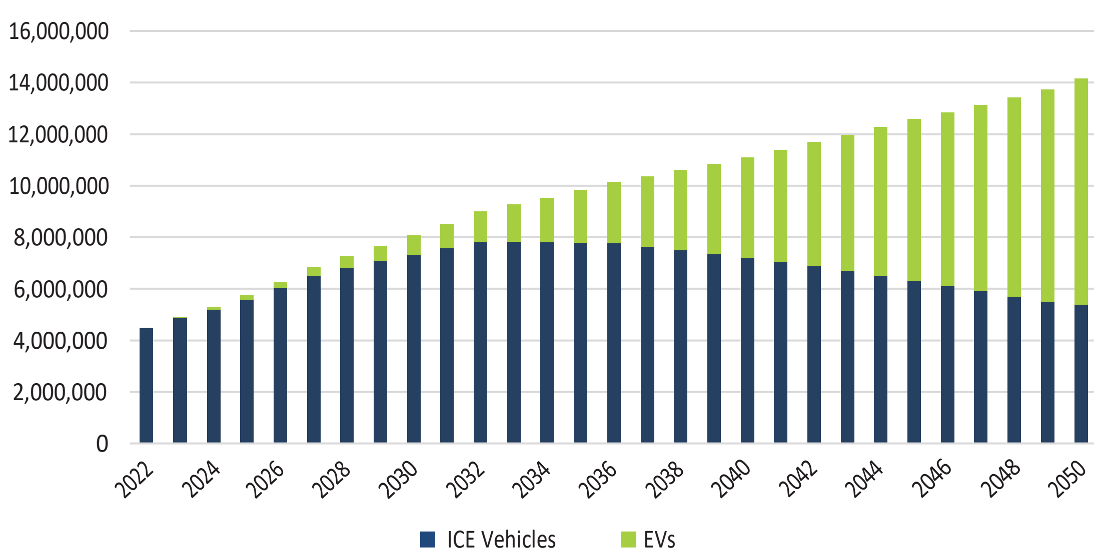
The E-Mobility Transition would require a profound penetration of EVs into Cambodia's expected motorization increase and shifting the transport demand from ICE vehicles to EVs. Achieving the LTS4CN targets for EV penetration – 70 percent among motorcycles, and 40 percent among cars and urban buses by 2050 – would require the total EV stock to reach around 751,000 by 2030 and 8.8 million by 2050. This EV penetration would lead to about 7.3 million ICE vehicles remaining in active use by 2030, which will decline to about 5.4 million by 2050.

ES Figure 4: GHG Emissions Compared with NDC/LTS4CN BAU (in million tCO_2e)



Source: Cambodia LTS4CN, 2021, WB Calculation

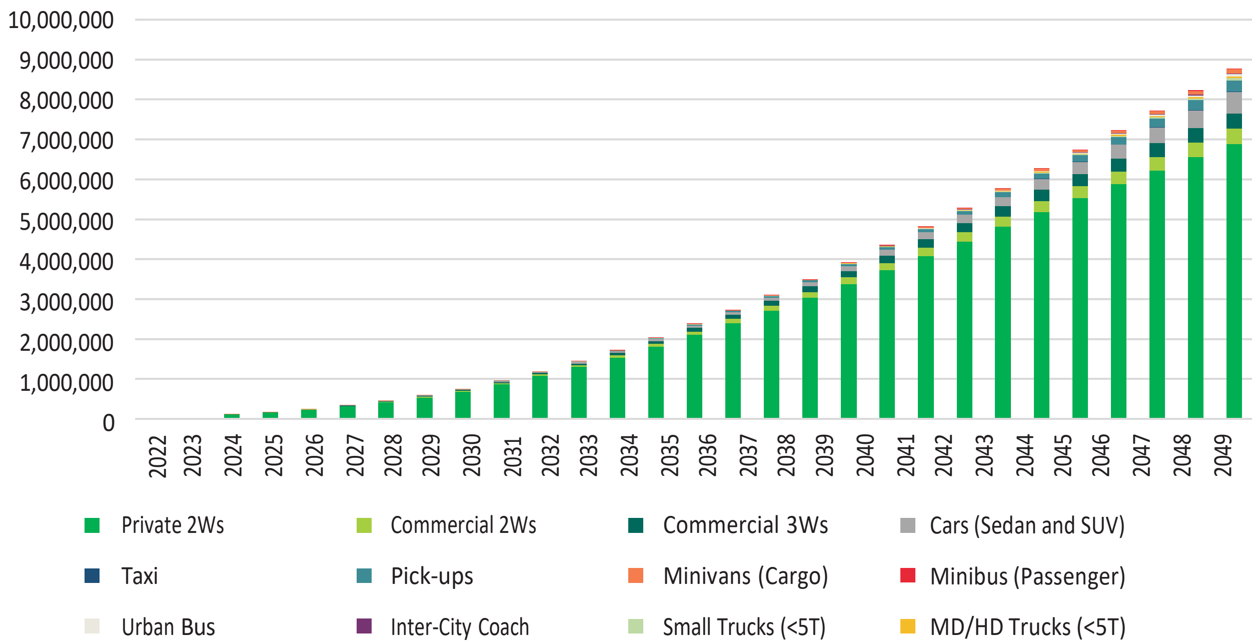
ES Figure 5: EV Penetration in Active Vehicle Stock under SPS (in units of vehicles)



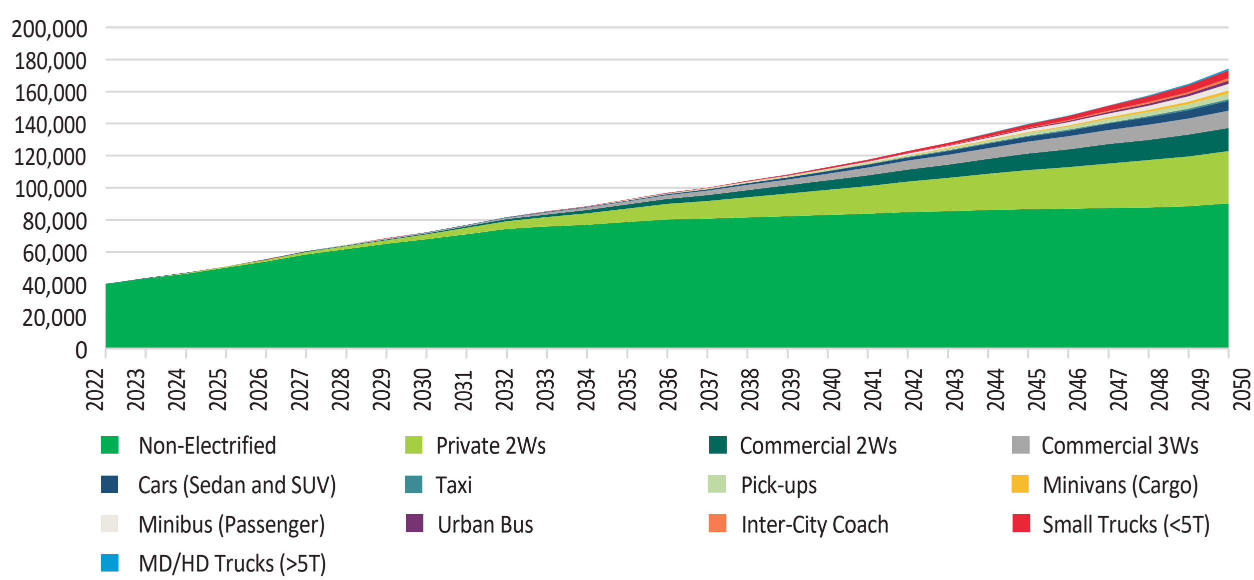
The E-Mobility Transition in Cambodia is expected to be driven by the 2W segment owing to the total size of the 2Ws stock and competitive costs of electric 2Ws (E-2Ws). To achieve the LTS4CN target, E-2Ws stock, including both private and commercial vehicles, would need to reach 730,000 units by 2030 and 7.7 million units by 2050, while electric car stock, including sedans, SUVs, pick-ups, minibuses, and minivans, would need to reach about 21,000 units by 2030 and 930,000 units by 2050.

While the majority of EV uptake is projected to be concentrated in the 2Ws segment, E-2Ws would only carry half of the electrified transport activities by 2050. Other vehicle segments, particularly commercial vehicles operating in long distance and/or frequent services such as minibus and small trucks would constitute the remaining half of the electrified transport activities even if the projected EV penetration in these segments are moderate.

ES Figure 6: EV Penetration by Vehicle Segments under SPS (in units of vehicles)



ES Figure 7: Electrified VKT by Segment vs. Non-Electrified VKT under SPS (in million kms)

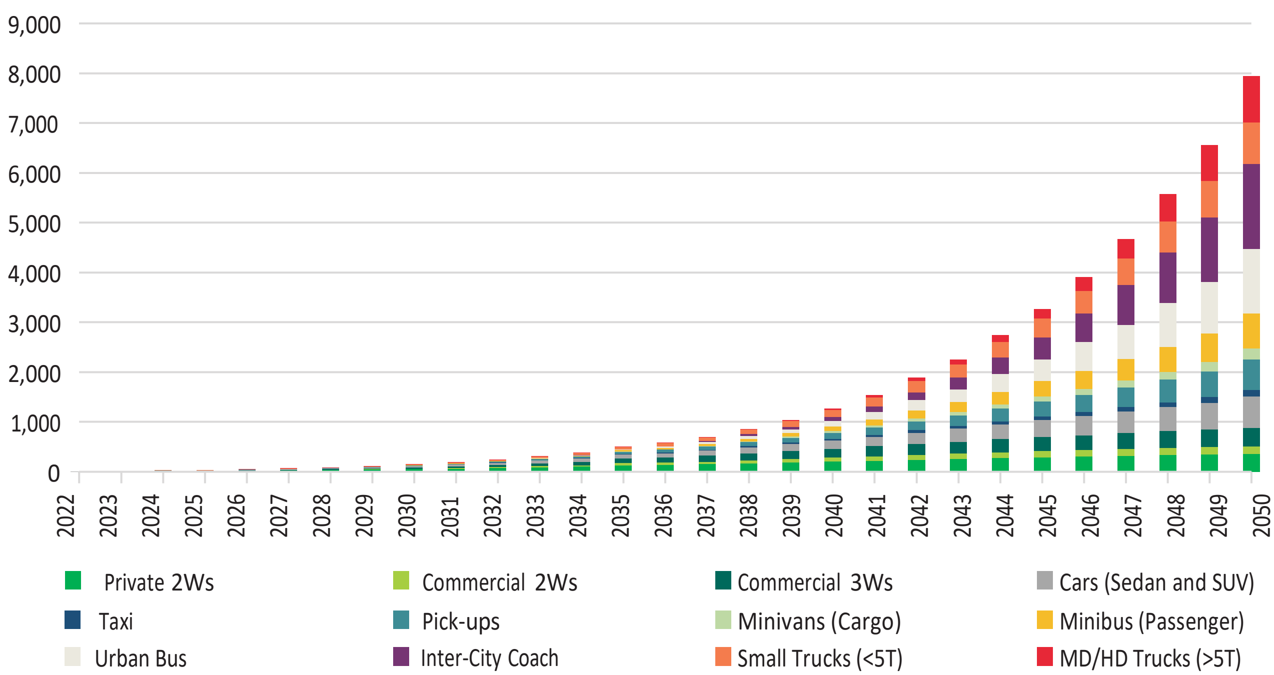


With the projected EV penetration level in ES Figure 9, the total power demand for EV charging would be about 135 gigawatt hours (GWh) by 2030 and 1,235 GWh by 2040. This represents about 0.45 percent and 2.6 percent of the projected power demand, respectively, for 2030 (30,080 GWh) and 2040 (54,597 GWh) under Cambodia's Power Development Masterplan (PDP). Over the timeframe of 2023-2040, the projected EV charging demand could be accommodated by the planned generation capacity under PDP.

After 2040, the power demand from EV charging would rise exponentially for Cambodia. By 2050, the total charging demand would reach nearly 7,803 GWh. This increase of charging demand is driven by the increased EV penetration in large commercial vehicles segments, particularly medium- to heavy duty trucks, inter-urban coaches, and urban buses. The medium- to heavy duty trucks with about 11 percent EV penetration and inter-urban coaches with about 12 percent EV penetration would generate respectively over 1,700 GWh and 930 GWh charging demand by 2050. Urban buses, which have a much smaller vehicle stock size, would demand 1,300 GWh for charging once EV penetration reaches 40 percent as targeted by LTS4CN. Small trucks with 20 percent of EV penetration in 2050 would generate the fourth highest power demand for charging at around 820 GWh. Motorcycles and light-duty vehicles together would require 3,200 GWh to charge.

After 2040, the power demand from EV charging would rise exponentially for Cambodia. By 2050, the total charging demand would reach nearly 7,803 GWh.

ES Figure 8: EV Charging Demand by Vehicle Segments under SPS (in GWh)

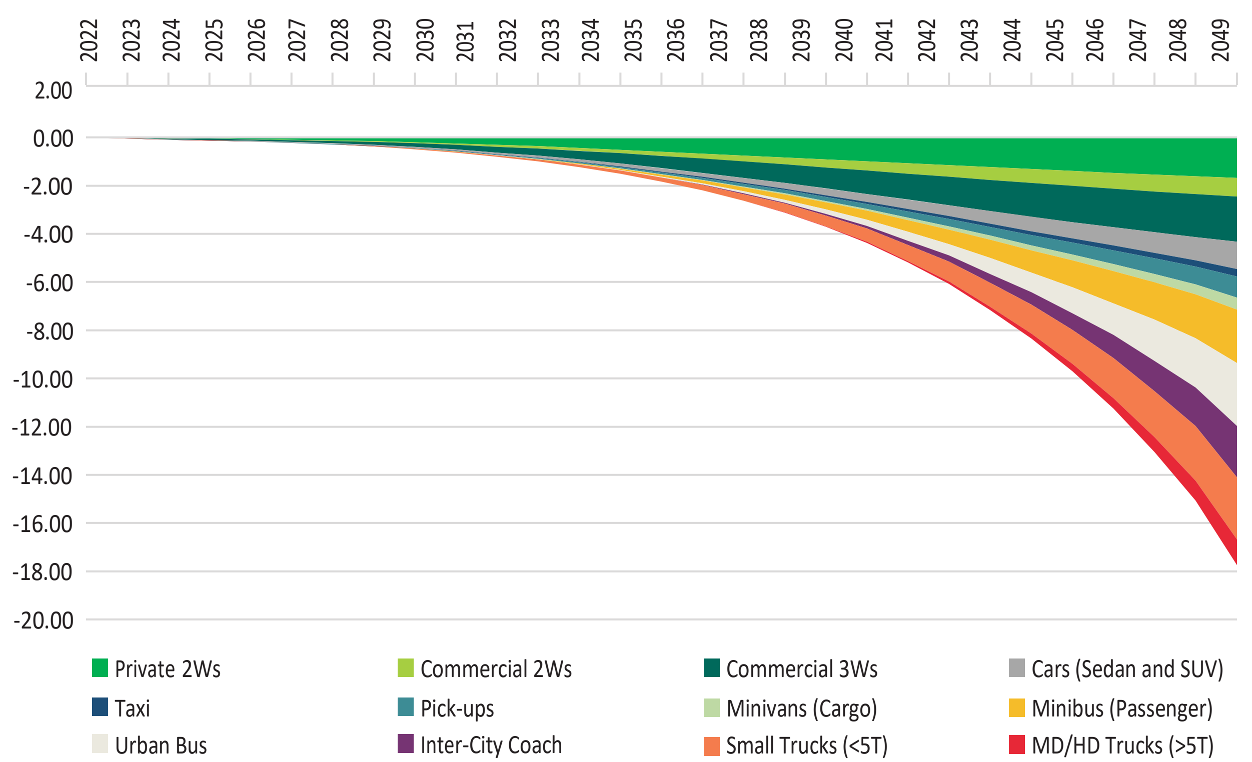


Even if the stated EV uptake targets under LTS4CN are achieved, a substantial portion of Cambodia's road vehicle activities would remain powered by fossil fuels, particularly across hard-to-electrify segments such as medium- to heavy-duty trucks and inter-urban coaches. By 2050, the non-electrified trucks, coaches, and buses would require more than 12,806 million liters of diesel to power their trips. This is more than 87 percent of the total fossil fuel demand by 2050 from the road transportation. This indicates a strong need to decarbonize these segments through modal shift strategy by moving passenger and freight demand from coaches/trucks to railways/waterways in order to achieve net-zero emissions for the sector.

Based on the projected national power mix and grid emission factor under PDP, the well-to-wheel GHG emissions from EV usage is calculated for up to 2050. The total emissions from the road transport under the state policy scenario (SPS) will reach 18 million tCO_2e by 2030, and 82.7 million tCO_2e by 2050. Compared to the BAU scenario, this represents a reduction of GHG emissions by 0.49 million tCO_2e by 2030, and 17.75 million tCO_2e by 2050. The cumulative GHG emission reduction between 2023-2050 is about 118.37 million tCO_2e.

Achieving the E-Mobility Transition uptake targets set by the LTS4CN would require RGC to make several key decisions that will have material implications to the prospect and costs for this transition. The most critical decisions are related to (a) policies on vehicle importation and usage, (b) excise tax for motor vehicles and fossil fuels, and (c) power sector planning.

ES Figure 9: GHG Emission Reduction Compared with BAU (in million tCO_2e)



The total emissions from the road transport under the state policy scenario (SPS) will reach 18 million tCO2e by 2030, and 82.7 million tCO2e by 2050.

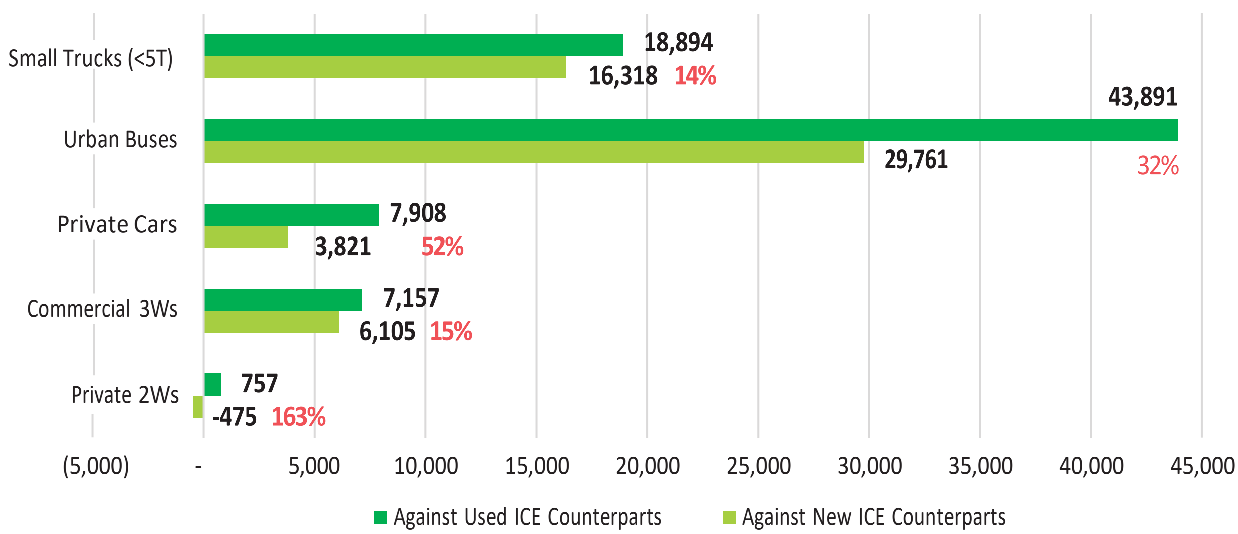
Policies on Vehicle Importation and Usage

Cambodia's vehicle market is dominated by imported second-hand ICE vehicles, particularly in the passenger car and truck segments. If such structure remains unchanged, large-scale EV penetration in Cambodia would be either massively fiscal-intensive to achieve or prohibited. As global EV production volume continues to increase, EVs are reaching cost parity against new ICE vehicles. Once such parity is reached, the need for government subsidies to incentivize EV uptake becomes minimum. However, with second-hand ICE vehicles selling at a price 20-50 percent cheaper than new ICE vehicles of the same model, the cost parity between EVs and new ICE vehicles becomes irrelevant.

Based on the transition readiness assessment for Cambodia, the total cost ownership (TCO) cost premium of EVs compared with second-hand ICE vehicles is 52 percent higher than compared with new ICE vehicles for passenger cars, 32 percent higher for buses, and 14 percent higher than trucks. In order for consumers to switch from purchasing these cheap second-hand ICE vehicles to new EVs, the RGC would need to use its fiscal resources to subsidize the additional cost premium.

Another key policy decision is regarding vehicle-age limit. Currently, there is no mandatory vehicle-age limit for usage in Cambodia while MPWT is in process of introducing a vehicle-age limit. As long as vehicles pass the mandatory annual safety inspections managed by MPWT, they could be used for as long as possible in theory. This significantly prolongs the transition of the total vehicle stock towards EVs. Policies need to mandate existing ICE vehicles to retire once reaching their economic lifetime or a certain vehicle-age limit. This will free up demand for purchasing new vehicles where EVs are becoming cost competitive.

ES Figure 10: TCO Cost Premium of EVs Compared with ICE Vehicles (in US$)



Excise Tax Policy for Motor Vehicles and Fossil Fuels

To minimize the risk of reduced tax revenue for Cambodia, the vehicle excise tax rate needs to be gradually linked to vehicle emissions or fuel efficiency rather than other parameters currently used such as engine size and gross vehicle weight.

Reforms in the excise tax policy are critical to mitigate the potential transition risk for tax revenue loss. Motor vehicles and fossil fuels are the first and third largest source of excise tax revenues for Cambodia, respectively accounting for 62 percent and 10 percent of the country excise revenue. Among motor vehicles, cars contribute the largest share across vehicle segments, followed by trucks. Motorcycles, although account for more than 70 percent of Cambodia's vehicle importation volume, contribute only a fraction of vehicle excise tax revenue. For fuels, gasoline and diesel collectively contribute to nearly 90 percent of total excise tax revenue from fossil fuels.

Compared with the excise tax rate of 35-40 percent applied to ICE passenger cars and trucks, EVs enjoy a lower rate at 10 percent in the current system. Under the E-Mobility Transition, motor vehicle imports will shift from ICE vehicles to EVs, which will lead to a reduction of tax revenue for Cambodia. To minimize this risk, the vehicle excise tax rate needs to be linked to vehicle emissions rather than other parameters currently used such as engine size and gross vehicle weight. Specifically, RGC could consider setting excise tax rate based on specific vehicle fuel efficiency standards for new ICE vehicles, and vehicle-age for second-hand ICE vehicles. The lower the fuel efficiency standard is for new ICE vehicles, the higher the excise rate. The older the vehicle-age is for second-hand ICE vehicles, the higher the excise rate. The overall excise rate for new ICE vehicles should be lower than second-hand ICE vehicles, while both are substantially higher than for EVs.

In the meanwhile, the current excise tax policy for fossil fuel could be reformed to cushion the tax revenue reduction following the decline of demand for fossil fuel import as a result of E-Mobility Transition. It can be done by equalizing specific taxes on gasoline (currently at 10 percent) and diesel increasing taxes on diesel from the current rate of at 3 percent to 10 percent. Additionally, RGC could introduce a price of carbon for all fossil fuels based on their carbon contents. Such price of carbon could be raised overtime as demand for gasoline and diesel decline with EV penetration. It would both incentivize the E-Mobility Transition while acting as a buffer for fossil fuel tax revenue reduction.

From an expenditure perspective, E-Mobility Transition will reduce Cambodia's dependency on fuel importation as well as exposure to global fossil fuel price volatility. Cambodian importers will save significantly as well as the government from a reduced need for a 'silent subsidy' to gasoline and diesel to cushion the price volatility. Economy-wide estimates indicate a yearly saving of US$8 billion from fuel importation and usage by 2050 under the SPS EV uptake.

Power Sector Planning for Charging

The total energy demand from EV is projected to be around 0.45 percent of projected power demand under Power Development Masterplan (PDP) by 2030. However, a further increase in electrification among the passenger car and heavy-duty vehicle segments after 2030 will significantly impact the energy demand as it is estimated to reach over 2.6 percent of the energy demand projected by PDP by 2040. Between now and 2030 while the EV penetration in those two vehicle segments remain relatively low, RGC would need to revise the power-generation planning taking into account the EV charging demand after 2030.

The current PDP focuses only at developing high-voltage networks and not low-voltage networks that are directly impacted by home charging. In the short-term, Cambodia's E-Mobility Transition will be driven by the private E-2Ws segment, which primarily operate on home charging with low-voltage alternating current (AC). While the aggregated power demand at grid level from E-2W charging is small by 2030, the large volume of E-2Ws stock may cast challenges at local network level and demand for upgrade for substations and transformers.

The RGC would need to mainstream, including E-2Ws charging in household power demand forecast along with other electric appliances such as air conditioners.

Based on the projected EV penetration level, it is estimated that about 690,000 E-2Ws and 19,700 EVs would require home charge by 2030. Ensuring the roll out of stringent residential charging safety protocols and policies would be critical in preparation for this transition. In addition, all chargers should be equipped with smart charging devices to promote off-peak charging in order to minimize impact to load curves.

Public charging network and battery-swapping stations will be required to enable opportunity charging during the day. By 2030, it is estimated that the demand for public battery-swapping infrastructure for E-2Ws and commercial E-3Ws will be concentrated in Phnom Penh, Kampot, and Prey Vang. The total costs for developing swapping networks are estimated to be round US$5 million by 2030, based on an average cost of US$10,000 per unit. In terms of public charging network for E-cars, Cambodia is forecasted to require between 750 rapid chargers and 1,800 fast chargers[1] rolled out throughout the 25 provinces in order to fulfill the projected E-car penetration. It is estimated that the cost of the required public infrastructure for four-wheelers (4Ws) will be in the region of US$50 million by 2030, based on an average cost of US$50,000 per rapid charge point and US$7,500 per fast charger.

Recommended Action Plan

The E-Mobility Transition encompasses all key interventions, recommendations, and policies for each E-mobility dimension, which include EV supply, demand, and charging infrastructure. The following tables summarize these actions, with ministerial lead and timelines for each phase: short-term (2024-2026), medium-term (2027-2040), long-term (up to 2050)

The objective of this action plan is to provide a path to accelerate the transition toward the electrification of road transport in Cambodia, leveraging its potential for economic, social, and environmental benefits. The recommended actions aim to establish a solid foundation for E-mobility and promote its adoption throughout the country.

ES Table 1: Increase EV Supply

E-Mobility dimension	Policy – Intervention – Recommendation	Lead *Support*	Timeline
Data	Create a data platform to monitor trends and manage the transition	MPWT	Short-term
Increase EV Supply	Introduce incentives and de-risked financing for E-2Ws	MEF *GDT*	Short-term
	Implement a scrappage scheme for 3Ws	MEF *MPWT*	Short-term
	Release governmental EV targets to reach by 2030 and 2050	RGC	Short-term
	Establish a well-structured domestic supply chain, including battery end-of-life disposal and recycling, focusing on small components	MPWT	Medium-term
	Encourage foreign direct investment by offering streamlined administrative processes and a favorable fiscal environment	MEF *GDT*	Medium-term
	Provide educational and professional development initiatives focusing on EV technology to train future engineers, mechanics as well as project managers and policy makers	MOEYS *MLVT*	Medium-term
	Start manufacturing small 2Ws	MISTI	Long term
	Build the retrofitting opportunity, particularly for buses and heavy-duty vehicles	MISTI *MPWT*	Long term

1 These numbers go up to respectively 7,000 and 15,000, respectively, by 2050.

ES Table 2: Drive Up EV Demand

E-Mobility dimension	Policy – Intervention – Recommendation	Lead *Support*	Timeline
Drive up EV Demand	Monitor incentives to ensure they are effective in delivering expected outcomes	MEF *GDT*	Overall
	Release guidance on how to use the sub-distribution license to make CPOs confident to enter the market	EAC	Short-term
	Ensure affordability of prices through tariff setting as part of the updated license	EAC	Short-term
	Introduce disincentives for new ICE 2Ws purchases	MEF *GDT*	Short-term
	Start a major public information campaign to debunk EV myths and promote its benefits	Public/ Private	Short-term
	Establish a representative industry group to consult with the government and take part in communication campaign for an optimal outreach	MPWT *MME*	Short-term
	Explore the feasibility to convert Government fleets to electric vehicles	MME *MPWT*	Short-term
	Collaborate with original equipment manufacturers and financiers to provide financing solutions and insurance schemes to make EVs affordable and protect batteries. (See Section 5.1, Market Intervention 2).	MEF	Short-term
	Promote consumer awareness of the financing options available for electric vehicles, with the automotive and leasing finance industry	MPWT *GDT*	Short-term
	Increase awareness for EV importers and car dealers of tax reductions and fiscal incentives	CDC	Short-term
	Work with the National Bank of Cambodia and other stakeholders to develop guidelines for the automotive and leasing finance industry on offering loans and leases for electric vehicles	MEF	Medium-term
	Encourage leasing companies to explore innovative new financing models, particularly in the 4Ws market, where all-in leasing arrangements can be used to cover the cost vehicle maintenance and battery insurance	MEF	Medium-term
	Introduced additional legislation that covers extended producer responsibility and can incentivize more sustainable choices. This can include using second-hand batteries as part of the storage solution	MEF	Medium-term

ES Table 3: Charging and Power Supply

E-Mobility dimension	Policy – Intervention – Recommendation	Lead *Support*	Timeline
Charging and Power Supply	Provide charging infrastructure at express way rest stops.	MME	Short-term
	Publish *Technical Standards of The Kingdom Of Cambodia For Electrical Wiring and Safety for Buildings and Households* (MME 2015) with an added section on EV charging for property developers to ensure all new housing developments answer safety norms.	MME	Short-term
	Provide a clear route for CPOs to provide battery-swapping stations and EDC to strengthen their access to the grid and ensure grid capacity at planned locations.	MME *EDC*	Short-term
	Ensure the three main connection standards (CCS, CHAdeMO, GB/T) are included in ISC standards and available on the market	ISC *MISTI*	Short-term

E-Mobility dimension	Policy – Intervention – Recommendation	Lead *Support*	Timeline
Charging and Power Supply	Set standards for interoperability and simple payment for all suppliers.	ISC *MISTI*	Short-term
	Update standards repository with relevant IEC and ISO standards and continuously keep track of the evolution of standards in the industry	ISC *MISTI*	Short-term
	Create a long-term EV charging deployment plan	MME *MPWT*	Short-term
	Engage with key private sector players in this market to deliver power to required locations and review if they can resell energy legally under the Law of Electricity and support their wider development	MME *EDC*	Short-term
	Undertake electrical housing assessment to ensure people can safely charge at home	MME	Short-Medium term
	Include best design and EV charging accessibility best practices in procurement for public-private partnerships	MME	Short-Medium term
	Issue guidance on sub-distribution license applicable to EV charging and determining tariff for EV charging	EAC	Short-Medium term
	Identify/ developing sites for battery-swapping stations in key cities as part of the long-term national EV charging development plan	MME *EDC*	Medium-term
	Ensure that there are regulations in place for EV batteries to be disposed of safely alongside other hazardous waste containing lithium	MOE	Medium-term
	Introduce EV charging at several strategic sites identified	MME *EDC*	Medium-term
	Ensure good design and inclusivity of the new charging station	MME *EDC*	Medium-term
	Undertake PPPs and/or work with petroleum stations to convert some of their infrastructure into EV charging	MME *EDC*	Medium-term
	Assess the community charging opportunity	MME *EDC*	Long-term
	Create partnerships with recycling partners in the region as the market develops.	MOE	Long-term
	Introduce a smart metering plan to allow for smart charging	MME *EDC*	Long-term
	Use renewables, such as solar photovoltaic canopies in charging hubs with battery storage, to decrease costs	MME *EDC*	Long-term

CHAPTER 1.

Framing the Electric Mobility Transition in Cambodia

1.1 Targets and Current Policy Environment

The Royal Government of Cambodia (RGC) has fostered an enabling policy environment for electric mobility (E-mobility) by setting targets both across transport and energy in contribution to wider mid-century net-zero emission goals. These governmental documents are supported by creation of a dedicated steering technical working group and a set of wider E-mobility studies from various organizations, each tackling a particular aspect of the transition.

Governmental Policies Review

The following governmental policy documents represent the five foundations of this E-mobility roadmap:

1. Updated Nationally Determined Contribution (NDC)
2. Long-Term Strategy for Carbon Neutrality (LTS4CN)
3. Power Development Masterplan (PDP) 2022-2040
4. National Energy Efficiency Policy (NEEP) 2022-2030
5. Automotive and Electronics Sectors Development Roadmap

Updated Nationally Determined Contribution

The first foundation is the 2020 update of Cambodia's Nationally Determined Contribution under the Paris Agreement. Using 2016 as the baseline year, Cambodia's greenhouse gas (GHG) emissions is expected to increase from 125.2 million tons carbon dioxide equivalent (tCO_2e) in 2016 to 155 million tCO_2e by 2030 under the business-as-usual (BAU) scenario. Forestry and land use is the largest emitting sector in Cambodia, accounting for 49 percent of total GHG emissions by 2030 under the BAU scenario, followed by energy sector at 22 percent, and agriculture sector at 17 percent. Transport is a part of the energy sector.

The NDC sets the emission reduction target of 64.5 million tCO_2e by 2030 compared to the BAU scenario, which would require an emission reduction from the energy sector by 40 percent from BAU, or 13.7 million tCO_2e.

Long-Term Strategy for Carbon Neutrality

The second foundation is Cambodia's Long-Term Strategy for Carbon Neutrality, published in December 2021, which builds on the country's existing goal for a carbon-neutral economy in 2050. The LTS4CN complements the NDC by extending the decarbonization pathway planning from 2030 to 2050. The LTS4CN targets to stabilize the country's total GHG emissions at around 156 million tCO_2e after 2030 and eventually reach net-zero by 2050. Forest and land use sector will play a critical role as carbon sink to offset positive GHG emissions from other sectors.

For energy sectors, which includes power and transport, the ambition is to reduce the emissions from 82.7 million tCO_2e under the BAU scenario in 2050 to 28.2 million tCO_2e. Key numeric targets by 2050 announced under LTS4CN include (a) increasing renewable energy to make up 35 percent of the energy generation mix, including 12 percent from solar; (b) electrifying 70 percent of motorcycles and 40 percent of cars and urban buses; (c) increasing mode share of public transport to 30 percent in urban areas; and (d) switching 80 percent of interregional coach buses and trucks to compressed natural gas (CNG).

Other non-numeric mitigation actions include (a) new coal generation capacity beyond already committed projects, (b) investing in power grid modernization, (c) increasing fuel efficiency for internal combustion engine vehicles, and (d) developing railway for freight and passengers.

Figure 1: Summary of Cambodia's NDC BAU Emissions and Emission Reduction by 2030 ($MtCO_2e$)

Sector	BAU 2016 emissions	BAU 2030 emissions	NDC 2030 Scenario	NDC 2030 reduction	NDC 2030 emission reduction %
FOLU	76.3	76.3	38.2	-38.1	-50.0%
Energy	15.1	34.4	20.7	-13.7	-40.0%
Agriculture	21.2	27.1	20.9	-6.2	-23.0%
Industry (IPPU)	9.9	13.9	8.0	-5.9	-42.0%
Waste	2.7	3.3	2.7	-0.6	-18.0%
TOTAL	**125.2**	**155.0**	**90.5**	**-64.5**	**-42.0%**

Source: Cambodia's NDC, 2020.

Figure 2: Summary of Cambodia's LTS4CN Business-As-Usual Emissions and Emission Reduction by 2050

Sector	BAU scenario, emissions	Emissions reduction in LTS4CN scenario, MtCO2e	Emissions balance in LTS4CN scenario, MtCO2e
Agriculture	34.9	-15.6	19.3
Energy	82.7	-54.3	28.2
FOLU	21.2	-71.4	-50.2
IPPU	10.7	-9.1	1.6
Waste	6.5	-5.3	1.2
TOTAL	**156.0**	**155.6**	**0.3**

Source: Cambodia's Long-Term Strategy for Carbon Neutrality.

Power Development Masterplan 2022-2040

The third foundation is the Power Development Master Plan 2022-2040 (PDP), published by MME in September 2022. Cambodia ranks as one of the fastest-electrifying countries globally (MME 2022). Between 2012 and 2021, Cambodia's peak power demand increased from 508 megawatts (MW) to 2,026 MW; by 2022, the village electrification rate was at 98.27 percent (a 34 percent increase from 2010).[2]

The PDP forecasting outlines three growth scenarios: low, medium, and high demand. Visions for future demand serve three main PDP objectives:

1. Fulfilling the future demand for power adequacy with the supply of reliable and affordable electricity across all sectors in Cambodia.
2. Strengthening energy security by reducing dependency on energy imports and maximizing the development of domestic energy resources.
3. Increasing the share of clean energy, including renewable and variable renewable energy, and energy efficiency without compromising the reliability and affordability of supply.

The PDP projects an energy demand of 30,080 GWh by 2030 and 54,597 GWh by 2040,[3] with an increase in the share of renewables, particularly solar energy, expected to reach 29.8 percent of the total energy mix by 2040. By 2030, Cambodia aims to have at least 70% renewable in the electricity mix.

Therefore, ensuring the best efficiency in terms of GHG reduction for road transport in Cambodia will require as much renewable energy generated toward EV charging as possible. Strong development of renewable resources and the ecosystem for its deployment will be crucial to ensure the best outcome of E-mobility — decreasing overall road transport GHG emissions.

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National Energy Efficiency Policy 2022 – 2030

The fourth foundation is the National Energy Efficiency Policy (RGC 2022a), which expressly addresses the electrification of transport, modal shift, and introduction of fuel economy standards. This policy is aligned with the vision to improve energy efficiency in Cambodia, contributing to a competitive and sustainable economy.

It fulfills six objectives: (a) establishing policy and regulatory frameworks, (b) defining roles and responsibilities for each ministry, (c) setting measurable targets for energy efficiency adoption by 2030, (d) outlining measures to remove barriers to adoption, (e) establishing monitoring and evaluation metrics, and (f) prioritizing human capital development.

The policy sets a national target of reducing total energy consumption by at least 19 percent by 2030, with specific targets for major energy-consuming sectors — a 5 percent reduction in the transport sector.

For more energy efficiency in the transport sector, 3 strategies are proposed:

1. Implement regulations for introducing fuel efficiency norms for vehicles in road transport with the objective of minimizing vehicular pollution and reducing demand for imported petroleum products;
2. Training programs for the staff of concerned line ministries on sustainable transport;
3. Promote clean technologies such as electric vehicles in specific vehicle segments through awareness campaigns.

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2 There remain only 245 villages outside of the distribution network's coverage, representing 1.73 percent of existing villages. The focus for these villages is understanding the feasibility of last-mile electrification options.

3 The PDP projected energy demand has considered of improved energy efficiency.

Automotive and Electronics Sectors Development Roadmap

Finally, the fifth foundation is the Automotive and Electronics Sectors Development Roadmap (RGC, 2022b). This roadmap has been created post-COVID-19 as a strategy to reinvigorate Cambodian industrial activity and attractiveness for investment. Cambodia has identified the automotive and electronics sectors as priority sectors for the country's economic recovery and long-term growth.

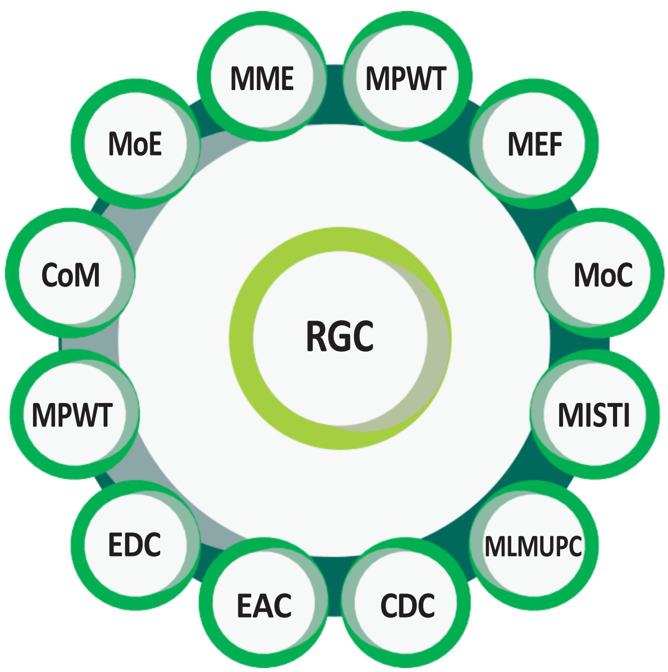
In the near-term, the focus is on growing the manufacturing of simpler, more labor-intensive automotive components for export, while increasing share for locally assembled 2Ws. In the mid-term, the goal is to move up the value chain toward manufacturing more complex automotive components and higher value-added electronics assembly and design.

The long-term vision is to become an automotive component manufacturing and integrated electronics production hub across the whole value chain. To achieve this, the government has developed a comprehensive cross-ministerial action plan comprising 20 initiatives across five areas. Placing close partnership with the private sector identified at its center, the plan has the potential to increase exports in these sectors by around US$2.1 billion and create roughly 26,000 new jobs over the next five years.

Inter-Ministerial Technical Working Group Mandated by the RGC

With the five main policy documents as a basis, an E-Mobility Inter-ministerial Technical Working Group has been created by RGC and led by the Ministry of Public Works and Transport (MPWT). This technical working group has been charged with driving E-mobility development going forward with the preparation of regulations, policy, and strategy for EV development in Cambodia.

Figure 3: Inter-Ministerial Working Group for E-Mobility Development



Representatives from 25 City/Provincial Administrations

Recent Studies and Technical Assistance on E-Mobility

The RGC is committed to developing a comprehensive, evidence-based policy environment for the E-Mobility Transition in Cambodia. Several recent studies have been carried out with support from development partners. Four strategic documents have been or will soon be published to advise on implementing E-mobility in Cambodia:

1. UNDP Cambodia EV Roadmap provides projection scenarios for EV-charging infrastructure and highlights the importance of private-sector partnerships (PPP) (UNDP 2022).
2. Global Green Growth Institute report analyzes electric motorcycles role in Cambodia's E-mobility future and identifies leading limitations in the Cambodian market (GGGI 2021).
3. Green Technology Center-Korea Climate Technology Deployment Roadmap aims to overcome barriers and gaps to E-mobility deployment by focusing on environmental impact and battery disposal (GTC-K, 2019).
4. UNESCAP is collaborating with MPWT to develop the national policy framework for EV development in Cambodia and to outline the key barriers across the EV value chain.

1.2 E-Mobility Transition Globally and in Southeast Asia

The global E-Mobility Transition Plan has been primarily driven by China, Europe, and the United States. These three leading markets are dominated by transition in the light-duty electric 4Ws segment, or electric cars. According to IEA Global EV Outlook (2023), the global sales of electric cars exceed 10 million in 2022, with China contributing 60 percent; Europe, 15 percent; and the United States, 8 percent. South and Southeast Asian countries, including Vietnam, are emerging EV markets from a small base. In 2022, India, Thailand, and Indonesia collectively reached 80,000 electric car sales, which tripled in comparison to 2021.

Compared with the car segment, the E-Mobility Transition in South and Southeast Asian is instead driven by the 2W or 3W segments given the predominance share of these segments in this region. In South-East Asia, the EV market is still in its early stages, with varying levels of adoption across the region. Cambodia's neighboring countries such as Vietnam, Thailand and Indonesia have taken active steps with government commitment reflected by ambitious targets, incentives and investments in charging infrastructure to accelerate their EV uptake.

Table 1: Global EV Technology Landscape by Segments

	Electric 2Ws/3 Ws	Electric Cars	Electric Bus	Electric Coach/Trucks
Main Technology	Battery EVs	Battery EVs	Battery EVs	Battery/Fuel Cell EVs
Maturity	High	High	Medium	Low
Global EV Stock	45 million	26 million	579,000	72,100
Leading Markets	China, Vietnam, India	China, Europe, US	China, Europe	China, Europe, US
Avg. Battery Size	2Ws: 0.5-1.5 kWh 3Ws: 7 kWh	60-165 kWh	334 kWh	424 kWh
Charging at	2Ws: Home, Public 3Ws: Public, Depot	Home Public	Public Depot	Public Depot
Charging Speed	Slow	Slow and Rapid	Slow and Rapid	Slow and Rapid

Source: IEA Global EV Outlook, 2023.

Table 2: EV Market in Cambodia compared to Southeast Asian Countries

Countries	GDP/capita in 2021 (in USD)	EV Penetration Targets	
		EV	EVSE
Cambodia	1,625.2	Under development	Under development
Vietnam	3,756.5	-	-
Philippines	3,460.5	2030: 21% of total stock 2040: 50% of total stock	2026: 5,000 EVSE
Malaysia	11,109.3	2030: 15% of new vehicles	2025: 9,000 AC & 1,000 DC
Thailand	7,066.2	2030: 40% new sales, 30% of production. Car: 50% new sales, 30% of production	2025: 4,400 AC destination charging 2030: 12,000 AC destination charging
Singapore	72,794.0	2040: 100% of total stock of BEVs, PHEVs, and FCEV	2030: 60,000 EVSE (20,000 private & 40,000 public)

Sources: World Bank, 2023; UNESCAP, 2023.

Figure 4: E-2Ws Sales by Region 2016-2022

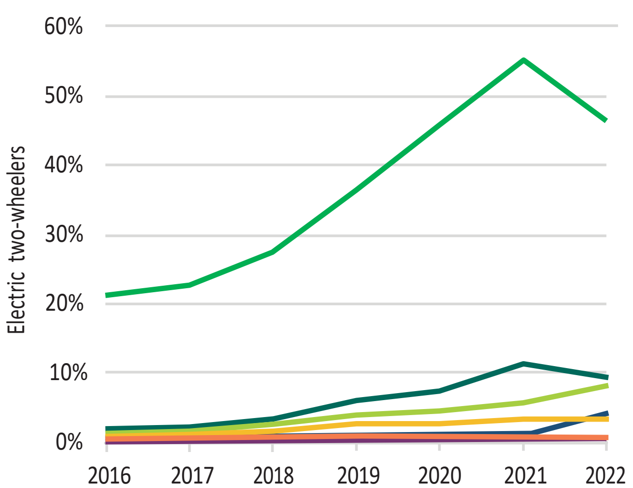
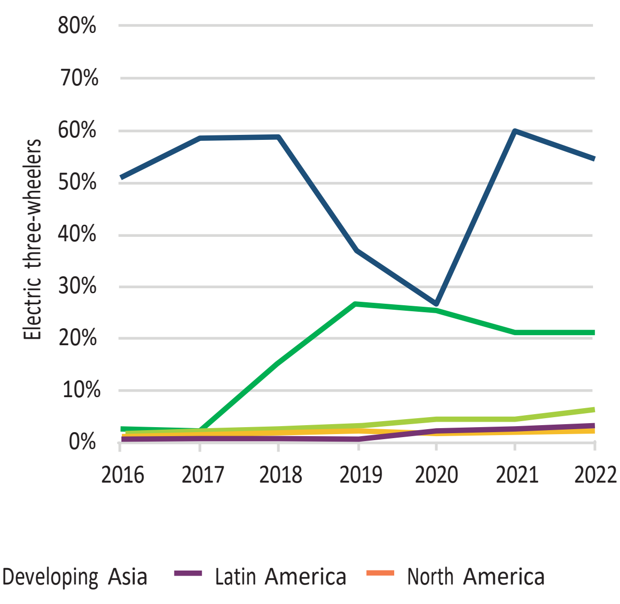


Figure 5: E-3Ws Sales by Region 2016-2022



Source: IEA Global EV Outlook, 2023.

The heavy-duty vehicle segments, which include buses, coaches and trucks, are less mature compared with light-duty commercial vehicles. For buses operating on fixed routes, battery EV technology has stood out as a mature option for bus operators. In 2022, nearly 66,000 E-buses were sold worldwide, with more than 80 percent sold in China (IEA 2023). Electric trucks and coaches that operate in the long haul remain to account for a small market share while the battery EVs and fuel-cell EVs compete on costs and performance. In 2022, about 60,000 heavy-duty trucks were sold worldwide with 85 percent in China. More than 90 percent of E-trucks sold are small trucks between 3.5-4.5 tons in gross vehicle weight.

Different technology maturity and global EV stock across vehicle segments indicate different economies of scale and cost level. For segments such as 2Ws and3Ws and cars, the mature technology and large-scale existing EV markets have been accompanied by a reduction in battery prices, which is the main cost factor for EVs. The battery cost can contribute as high as 40-45 percent of a total medium battery EVs cost. However, in the last decade, battery prices have fallen faster than expected. Battery prices, which were above US$1,100 per kW-hour in 2010, have fallen 88 percent in real terms to US$151/kWh in 2022. Prices are expected to fall further as Lithium extraction capacity comes online.

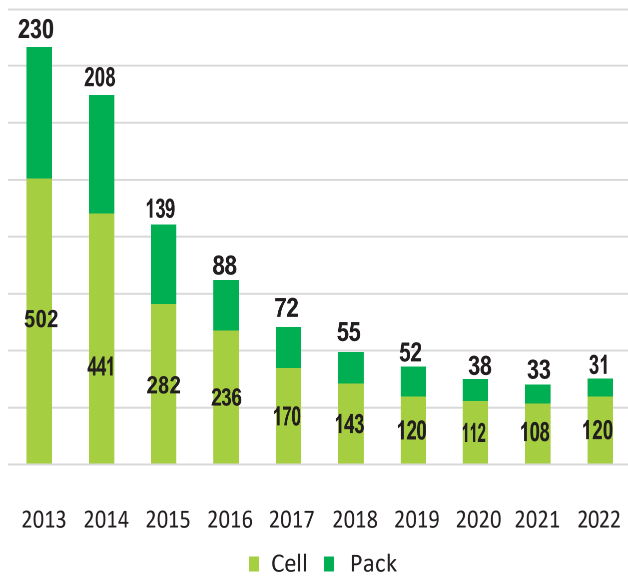
Box 1. Global Trend of the Technology Maturity for Electric Small Trucks under 4.5 tons

The small E-truck market is currently experiencing rapid technological advancements, propelling its growth prospects within the global electric vehicle industry. The Chinese market has focused on the development of electric trucks in the light-duty segment, with most e-trucks sold in 2022 (90%) falling under 4.5 tons, primarily box trucks (IEA 2023) with an average battery capacity of 143 kWh (ICCT 2023).

The truck battery market is currently dominated by two types of lithium-ion batteries. Over 95% of zero-emission heavy-duty vehicles in 2021 used lithium iron phosphate (LFP) batteries, known for their cost-effectiveness, durability, and safety. The remaining portion of the market is composed of batteries utilizing lithium nickel manganese cobalt oxide (NMC) or lithium manganese oxide (LMO) at the cathode. NMC batteries offer higher specific energy and energy density but are typically more expensive. LFP batteries are favored in heavy-duty vehicles because of their need for frequent recharging and higher durability requirements (ICCT 2023).

Ongoing advancements in battery technology and market dynamics will continue to shape the landscape and preferences in the truck battery market. The competitiveness of small e-trucks in commercial applications has significantly improved, positioning them as viable alternatives to traditional internal combustion engine trucks. This advancement aligns with supportive governmental regulations, collaborative initiatives among industry stakeholders, and the availability of larger battery sizes.

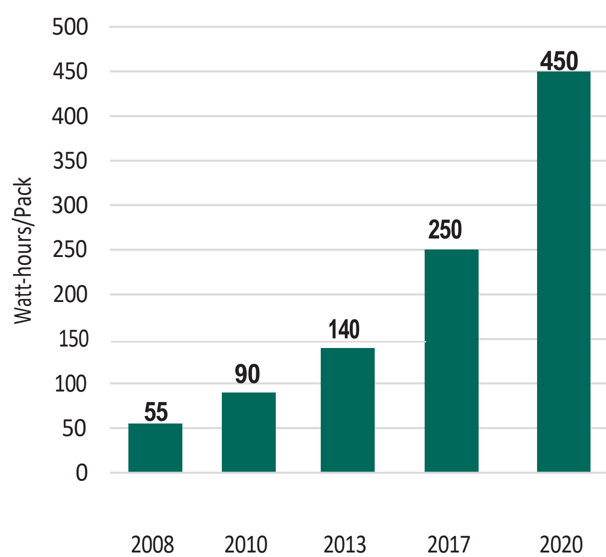
Figure 6: Global Battery Costs between 2013-2022 (in US$)



Note: All values in real 2022 US dollars. Weighted average survey value includes 178 data points from passenger cars, buses, commercial vehicles, and stationary storage.

Source: Bloomberg NEF, 2022.

Figure 7: Energy Density of Lithium-ion Battery Packs



Source: UK Department of Business, Energy, and Industrial Strategy, 2022.

The evolving battery technology significantly contributed to the EV performance improvement and hence market attractiveness. In particular, the energy density of Lithium-ion battery packs has increased 9 times between 2008 and 2020, making it an optimal option for EVs particular in 4W segments. In the 2W and 3W segments, Li-ion batteries are increasingly used by original equipment manufacturer in replace of low-performance and heavy lead acid batteries, contributing to a longer charging range for E-2Ws and E-3Ws.

1.3 Current Profile of Cambodia's Transport and Power Sectors

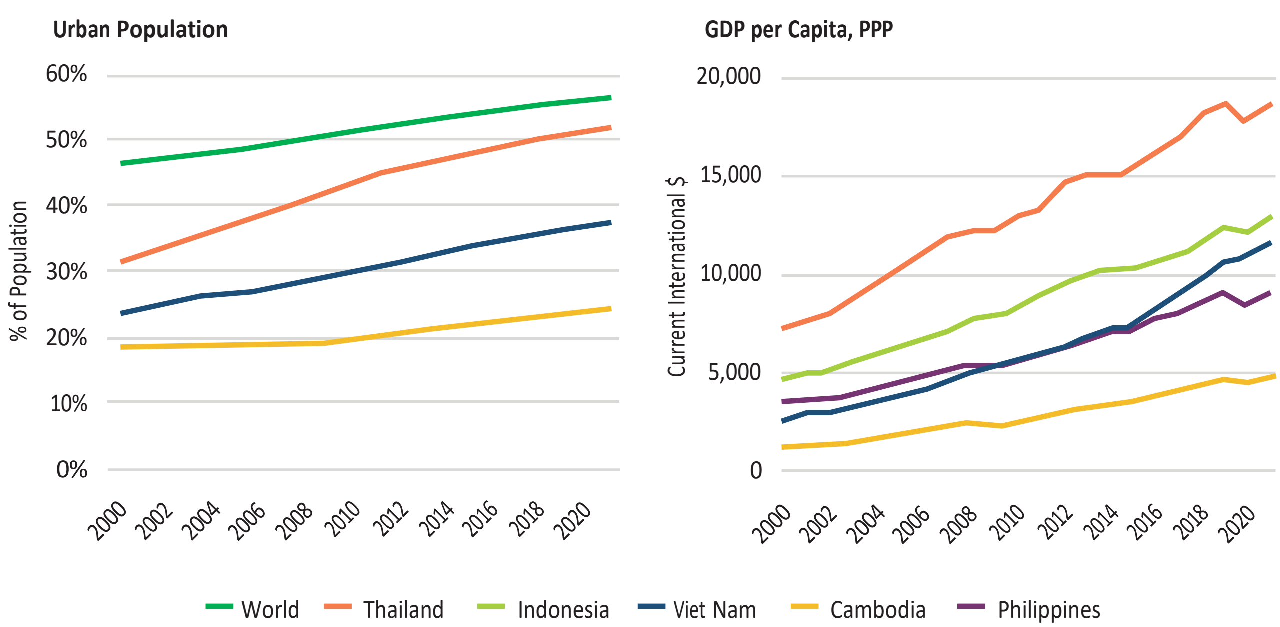
Transport Sector

Cambodia's transport sector is dominated by road transport. As of 2022, there are over 65,000 kilometers of roads in Cambodia, 74 percent of which are rural roads (ADB 2019). Road vehicles are the primary means for road transportation in Cambodia and the motorization rate has been rapidly growing driven by GDP growth and urbanization. Between 2000 and 2021, Cambodia's GDP per capita has grown by 444 percent, reaching about US$4,784 in 2021 (World Bank 2023). Over the same period of time, the Cambodian urban population increased by 82 percent, reaching about 25 percent of the total population.

Since the 1990s, the overall stock of motorized road vehicles in Cambodia has been growing at a rate of 10 percent to 15 percent each year. According to the vehicle registration data from MPWT, there were over 6.2 million motorized vehicles in the country in 2022, of which over 85 percent are motorcycles. As of 2022, there are about 351 units of 2Ws per 1,000 population, compared with 44 units of cars per 1,000 population. Each vehicle segment has seen significant recent growth with the average annual growth in motorization rate in the five past years rising at 9 percent and 11 percent respectively. This exceeds the economic growth of GDP per capita average of 5 percent over the same period.

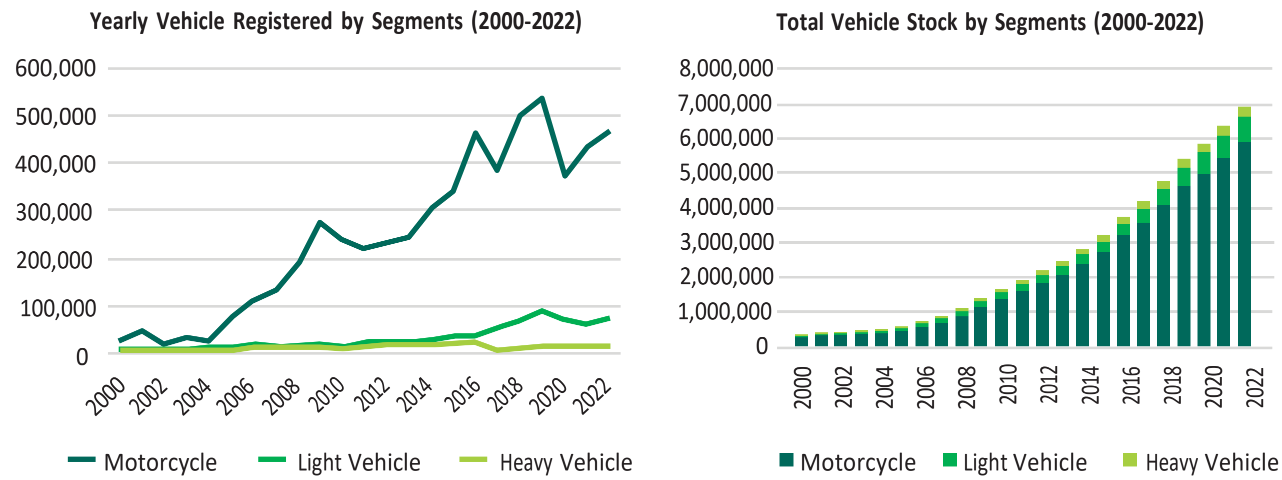
There is a strong correlation between the per capita GDP of Cambodians and the motorization growth. Vehicle ownership in Cambodia took off after 2005 when the per capita GDP reached about US$2,500. Motorcycles quickly established its dominance owing to the affordability corresponding to the household income level and has been growing exponentially over the last 15 years. In comparison, vehicle ownerships for passenger cars and heavy-duty vehicles remain low in Cambodia. At present, the mode share of urban public road transport in Cambodia is very small and development has been limited to Phnom Penh. The Phnom Penh Bus operates regular bus services with claims less than 8 percent of the mode share in the city.

Figure 8: Comparison of the Urban Population and Historical Motorization Growth across ASEAN



Data source: World Bank, 2023.

Figure 9: Cambodia's Historic Vehicle Growth Yearly and in Total Stock



Source: MPWT, 2023.

Figure 10: Historical Motorization Rate 1995-2021

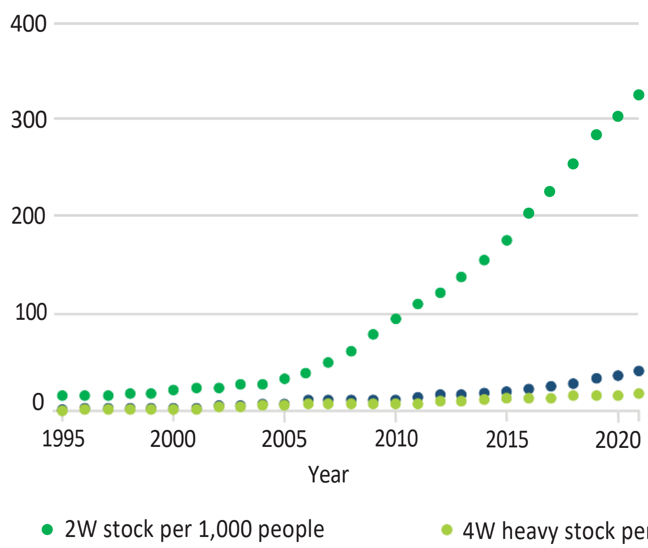
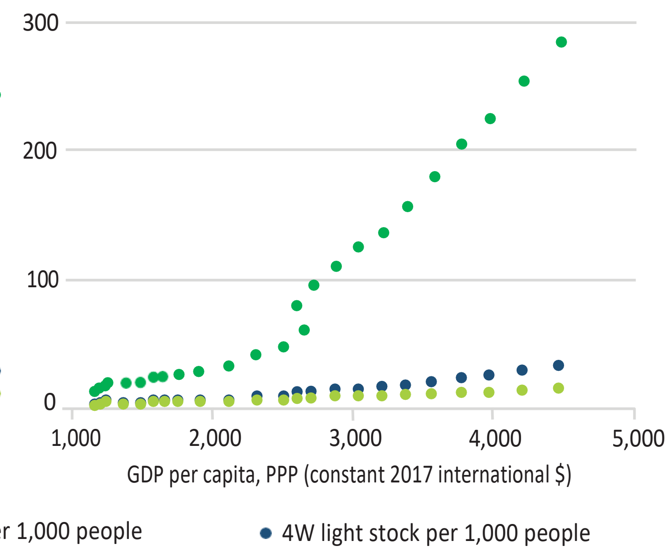


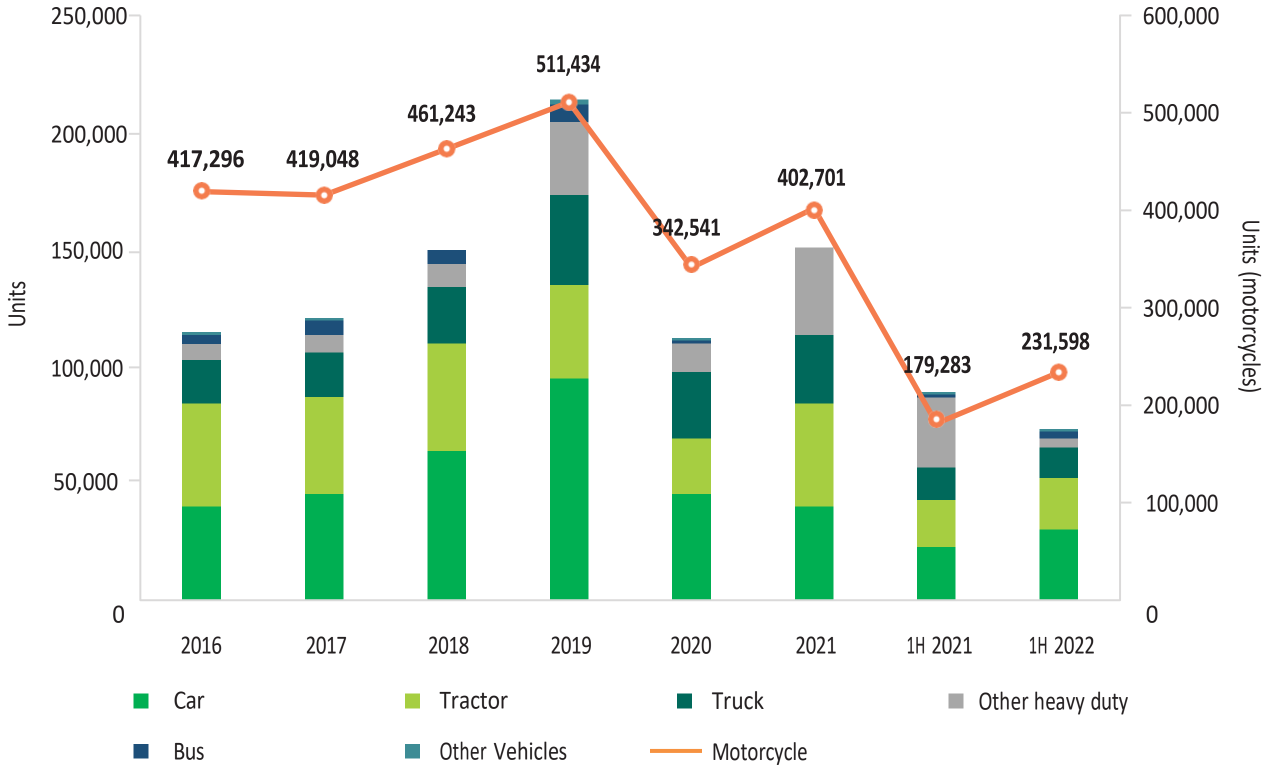
Figure 11: Historical Motorization Rate in Relation to Per Capita GDP



Source: MPWT, 2022.

In terms of vehicle supply, Cambodia has not established a domestic vehicle manufacturing and assembly industry at scale. Most vehicles used in Cambodia are imported. Motorcycles, cars, tractors and trucks make up the majority of imports and the other categories are relatively insignificant in volumes. Motorcycle is the by far the largest vehicle segment in importation (Figure 12). All categories experience growth in volumes between 2016 and 2019. Cars and motorcycles increased by 23 percent and 149 percent, respectively, while in the commercial vehicle sector buses and trucks increased by 75 percent and 115 percent, respectively. Volumes fell dramatically in 2020 and 2021 due to the COVID-19 pandemic. For example, the number of cars declined by 60 percent between 2019 and 2021, and trucks by 26 percent. Volumes are rebounding in 2022.

Figure 12: Imports Volumes of Vehicles in Cambodia, 2016-2022



Note: Motorcycles are shown on a separate axis since import volumes are dramatically higher than other categories.

Source: General Department of Customs and Excise of Cambodia (GDCE), 2022.

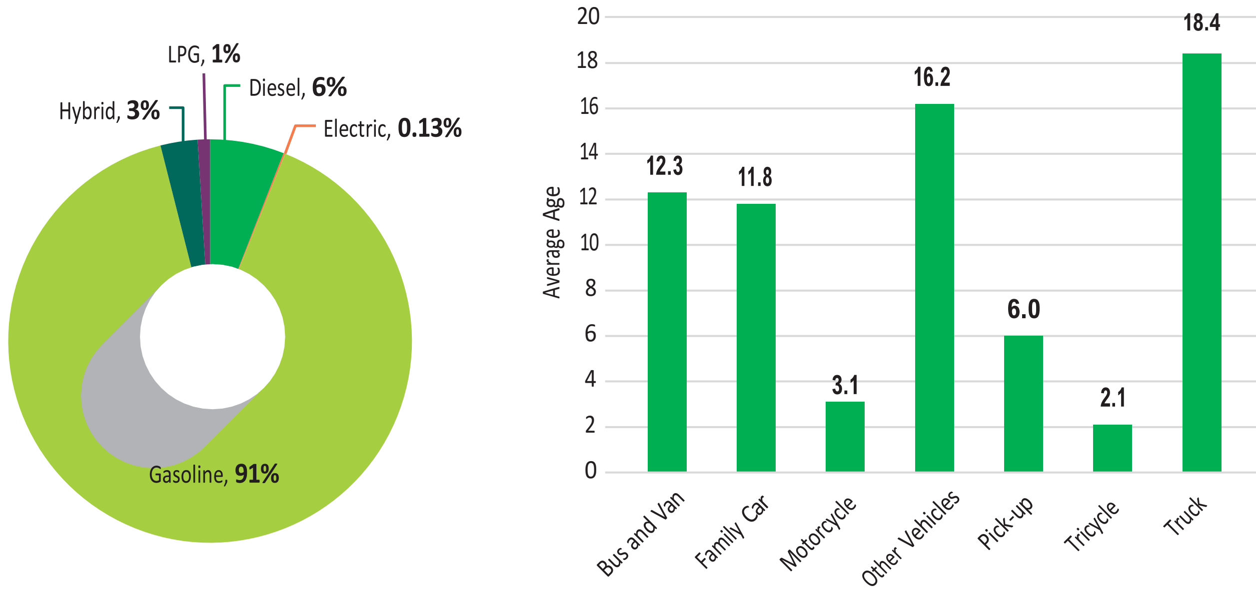
The average age of imported vehicles arriving in Cambodia in 2021 is around 12 years. However, trucks are significantly older when they are imported to Cambodia at around 18 years.

Most cars, trucks, buses and other large vehicles imported to Cambodia are second-hand vehicles from overseas, primarily from Thailand, United States, United Arab Emirates, Germany, and China (OEC 2020). Based on engagement with the industry, the average age of imported vehicles arriving in Cambodia in 2021 is around 12 years. However, trucks are significantly older when they are imported to Cambodia at around 18 years.[4] The high importation tariff applied to large vehicles (30-55 percent excise rate and up to 55 percent tariff) makes cheap second-hand vehicles attractive to Cambodia consumers. In comparison, about 82 percent motorcycles imported are new vehicles in 2021. As the household income level raises, newer vehicles are becoming more popular. This study's market assessment shows that the used car market was estimated at 77 percent in 2019 and decreased to 54 percent of the total vehicle market in 2022.

Based on market research, all 2W motorcycles in Cambodia are powered by gasoline at present. About 64 percent of 3Ws, or tuk-tuks, uses liquid petroleum gas (LPG) and the remaining 33 percent uses gasoline. Diesel and electric 3Ws are also operating in Cambodia but with a neglectable share. For the light-duty 4W segments, private cars mostly use gasoline (58 percent) or hybrid (37 percent) while diesel cars accounts for less than 5 percent of stock. Most taxis in Cambodia uses LPG. For other larger vehicles such as mini-vans, minibuses, and pick-ups, diesel is the main fuel source accounting for about 70-85 percent and gasoline makes up for the remaining share. For the heavy-duty segments, all trucks in Cambodia are running on diesel while about 87 percent of bus uses diesel with the rest operating on gasoline.

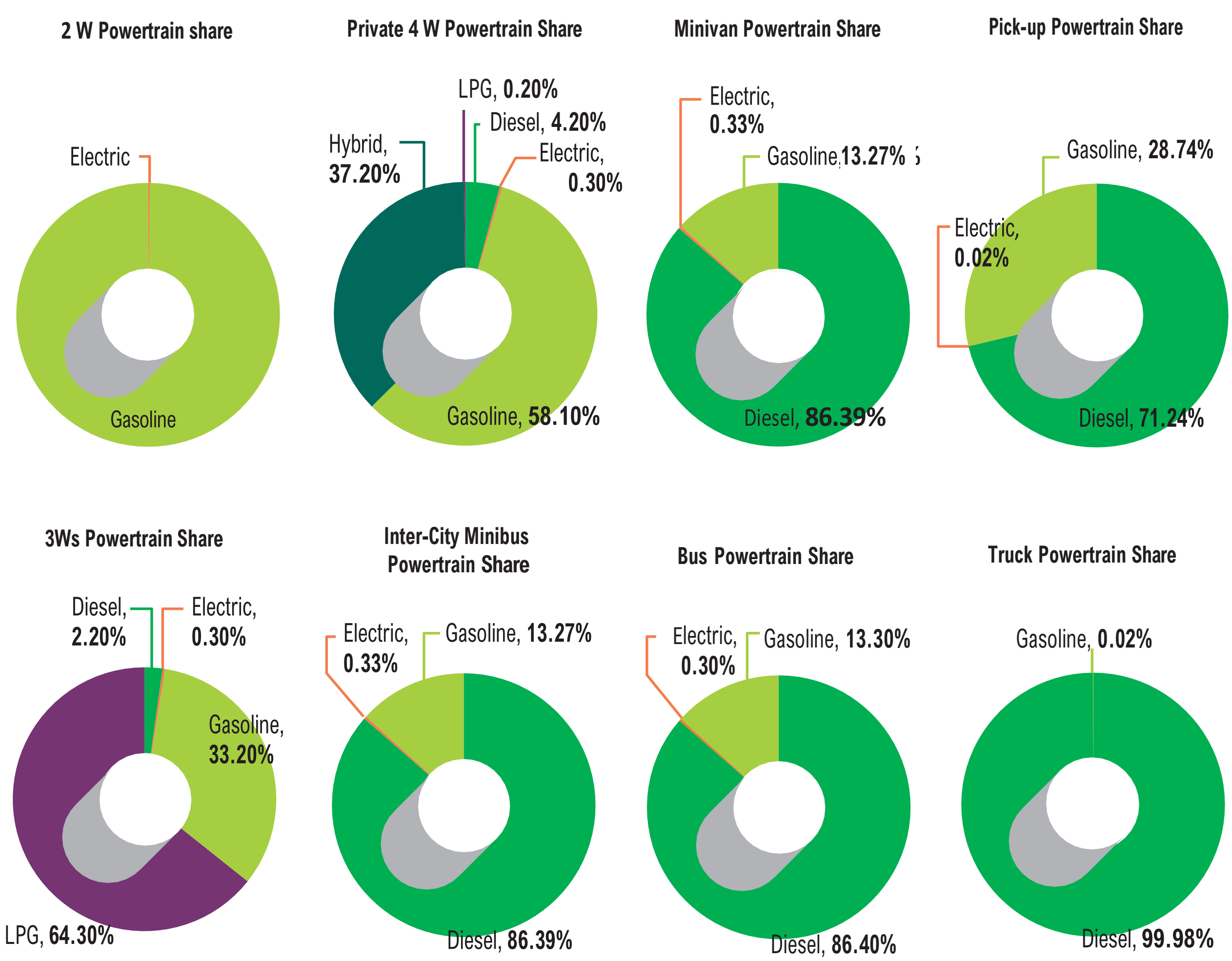
4 These buses are roughly 9 years due to a law in Korea that obligates buses to be scraped after this threshold.

Figure 13: Vehicles Imported by Fuel Type and Age in 2021



Source: MPWT, 2021.

Figure 14: Powertrain Types across Vehicle Segments (2021)



Source: Based on Import Vehicle Registration data from GDCE in 2021.

Overall, the transport sector consumed over 73 percent of the oil products imported to Cambodia in 2018.

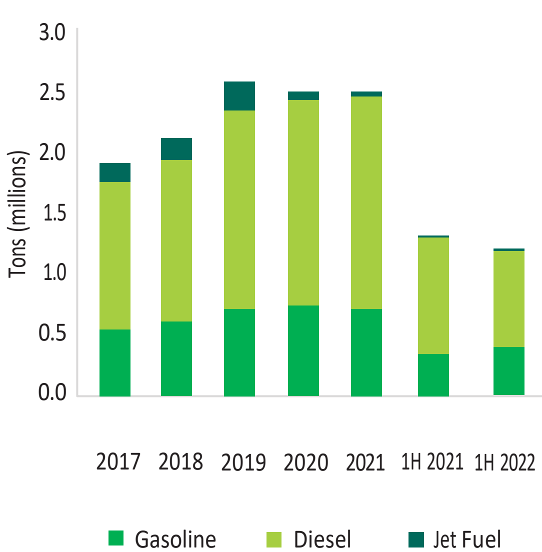
The current EV stock in Cambodia is negligible. Electric vehicles were estimated to make up 0.13% of all vehicle registrations in Cambodia in 2021 (MPWT 2022). By the end of 2022, there were estimated to be over 700 EVs registered, centralized in the Phnom Penh urban area. Most of the existing EVs are E-tuk tuks operated by ONiON. There are no e-buses and e-trucks registered at present. In terms of charging facilities, there are only nine dedicated EV charging locations and nine ONiON battery-swapping stations.5

Cambodia imports 100 percent of its petroleum products from Singapore, Thailand, and Vietnam to supply domestic consumption. Volumes are dominated by diesel and gasoline, with jet fuel making up a much smaller market. Between 2017 and 2019, the importation volume of petroleum, diesel, and jet fuel increased by 33, 34, and 50 percent, respectively. Unlike other commodities, volumes of petroleum and diesel continued increasing in 2020 and 2021 although by small magnitudes. Cambodia fuel importers spent in excess of US$1.47 billion importing 963 million liters of gasoline and 2,132 million liters of diesel to meet the country's vehicle use demand in 2021.[6] Because almost all fuels imported to Cambodia are from ASEAN countries, it receives preferential rates and is not subject to import duties in most cases.

Overall, the transport sector consumed over 73 percent of the oil products imported to Cambodia in 2018, which includes the oil used for international aviation bunkers. Diesel oil dominates the total oil consumption by the road transport sector, with a share of almost 55 percent in 2018. This is followed by gasoline at 27 percent and LPG at 13 percent.

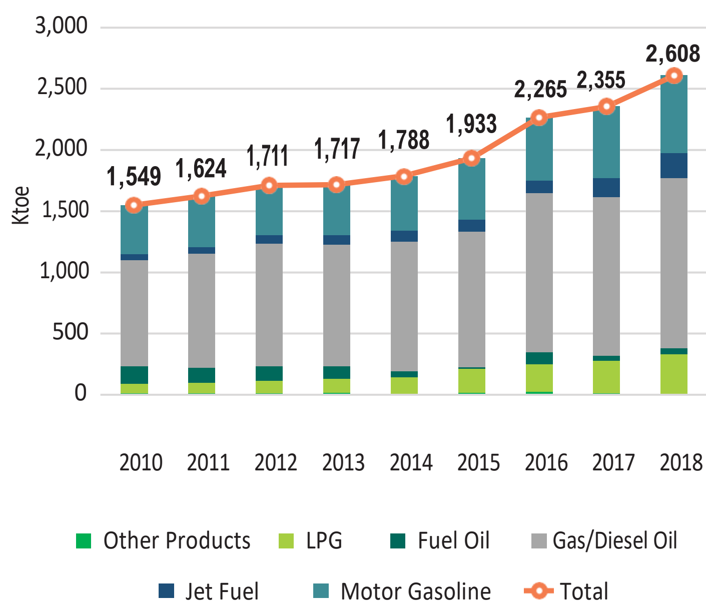
Currently, there is no mandatory fuel economy standard in Cambodia. In fact, according to ASEAN Fuel Economy Roadmap for Transport Sector 2018-2025, no ASEAN member states have such mandatory policy in place. Singapore, Thailand, and Vietnam have introduced voluntary fuel consumption limits for passenger cars. ASEAN has set an aspirational goal to reduce the average fuel consumption of new light-duty vehicles sold in ASEAN by 26 percent between 2015 and 2025, which leads to an improvement in average fuel economy to around 5.3 LGe/100km by 2025 from an estimated 7.2 LGe/100km in 2015.

Figure 15: Imports Volumes of Fuels, 2017-2022



Source: GDCE.

Figure 16: Oil Consumption 2010-2018

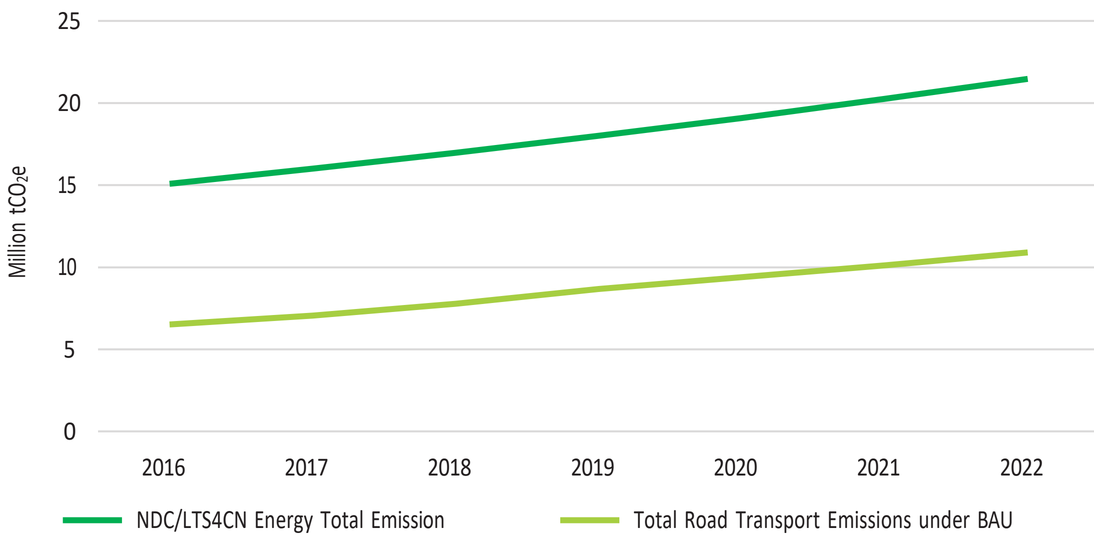


Source: Cambodia Petroleum Master Plan 2022-2024.

5 UNDP EV chargers, MPWT (November 2022) and ONION as of February 2023.

6 General Department of Customs and Excise. Fuel Import data (2021). Associated fuel import cost assumes latest fuel rates ($/liter) at $1.22 for Diesel, $1.293 for Gasoline, and $0.56 for LPG.

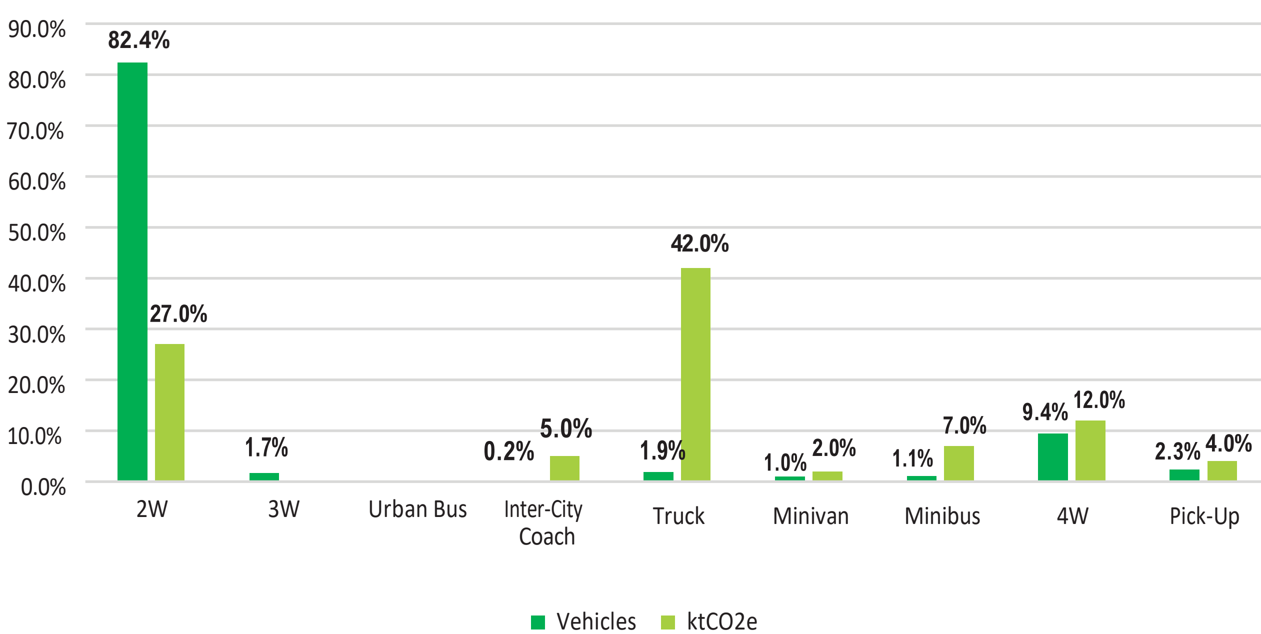
Figure 17: GHG Emissions from Road Transport Sector 2016-2022



It is estimated that the total GHG emissions from the road transportation sector in Cambodia is about 10.9 million tCO_2e in 2022, which is about 49 percent of total GHG emissions from the energy sector. Among the various road transport vehicles, trucks have the most significant impact on GHG emissions. Even though 2Ws represents the largest vehicle group in number, it only represents 27 percent of the total road transport emissions, while trucks that only account for 1.9 percent of total stock represent 42 percent of the estimated road transport emissions.

In addition to factors such as longer annual distance traveled and heavier in weight, trucks in Cambodia emit massive GHG emissions also due to their low fuel efficiency. Typically, trucks operating in Cambodia are imported as second hand with already 18-year service age. Their engine efficiency is much lower compared to new trucks of the same model.

Figure 18: Estimated Vehicle Stock and Emissions by Road Transport Segments in Cambodia - 2022



Source: MPWT, 2022; UNESCAP, 2023; ADB, 2019.

Power Sector

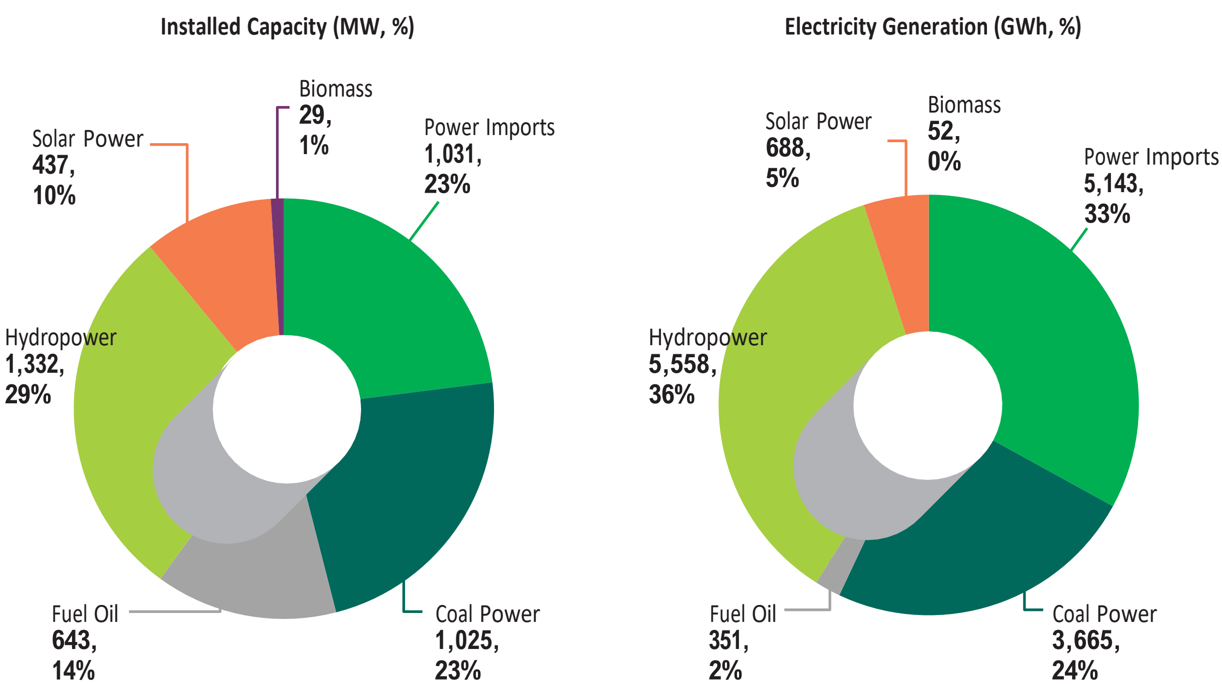
The fast-growing economy in Cambodia has been fueled by its growing energy supply while the energy consumption per capita is still kept at a low level, and the main types of fuels are still biofuel (for residential) and oil products (for transport). Cambodia is one of Asia's fastest growing economies. The growth is clearly reflected in energy use, which has seen an increase of 71 percent in total final energy consumption (TFEC) between 2010 and 2020 across all sectors. Residential and Transport were the two largest energy users, consuming 36 and 31 percent of TFEC in 2020, followed by the industrial sector using 24 percent.

Cambodia has experienced a strong growth in power demand over the past two decades, and the power sector has undergone a transformation to rely mainly on hydropower, coal power and power imports to reduce its reliance on oil-based generation. Two-digit annual growth of electricity demand has been maintained since early 2000s, with an annual average growth rate of 17.8 percent from 2003 to 2022, except for 2020 and 2021 (5.6 percent in each year) due to the impact of COVID 19, and it returned to 18 percent in 2022. Electricity consumption increased from 693 GWh in 2003 to 15,456 GWh in 2022, an increase of 22 times.

The domestic electricity supply relied on diesel generation before 2010, followed by development of hydropower in 2010s, and increasing penetration of coal power since mid-2010s. Total installed capacity of domestic generation amounted to 3,465 MW in 2022, of which hydropower 1,332 MW, coal power 1,025 MW, and fuel oil, solar and biomass accounting for 643 MW, 437 MW, and 29 MW, respectively. Coal and hydropower generation contributed to 24 percent and 36 percent of electricity supply respectively in 2022. Total capacity of power imports amounted to 1,031 MW and it contributed 33percent of total electricity supply in 2022.

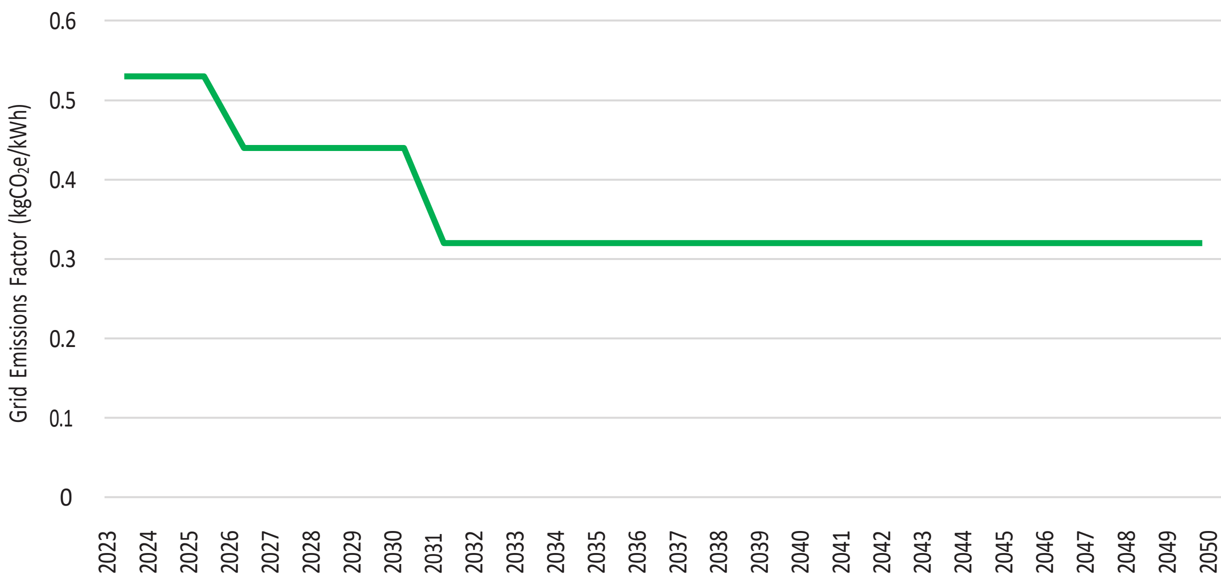
The development of new emerging variable renewable energy (VRE, i.e., solar and wind power) is still in its early stage, and power imports play a key role in meeting the growing demand. In 2022, about 4.5 percent of domestic electricity generation was sourced from solar power and there is no wind power in Cambodia yet although there has been phenomenal growth of solar

Figure 19: Installed Capacity and Electricity Generation in Cambodia (2022)



Source: World Bank Cambodia CCDR, 2023.

Figure 20: Cambodia PDP Grid Emissions Factor



Source: PDP, 2022.

Note: The power mix in the PDP has been projected through 2040. Grid emission factors from PDP have been assumed to stay constant from 2040 to 2050 at 0.32 tCO_2/MWh (or $kgCO_2e$/kWh).

and wind globally - total installed capacity of wind power increased to 3.6 times and solar power 11.8 times from 2011 to 2021 globally.7

Cambodia has made great advances in lowering its electricity tariff, but it is still one of the highest in EAP countries. The average retail tariff in Cambodia is about 15 US cents/kWh, and it is much higher than its neighboring countries.8 Historically, tariffs in Cambodia have been higher but have seen a consistent downward trend in the past decade. The electricity supplied to industrial consumers (connected to Medium Voltage level) in Phnom Penh went down steadily from 17.7 US cents/kWh in 2015 to 13.7 US cents/kWh in 2022, following the requirements of the regulator (Electricity Authority of Cambodia), while the electricity tariff for residential consumers also decreased from 610 Riels/kWh (about 15 US cents/kWh) to 480 Riels/kWh (about 12 US cents/kWh)9 in the same period. The annual decrease of electricity tariff was about 3-4 percent from 2015 to 2022.

The RGC is committed to achieving carbon neutrality by 2050, and it submitted updated Nationally Determined Contributions (NDCs) to the UNFCCC in December 2020 and issued its Long-term Strategy for Carbon Neutrality (LTS4CN) in December 2021. Following the LTS4CN, energy sector is anticipated to be the largest emitter by 2050, and its carbon emission will be offset by carbon sink in forestry and land use to achieve carbon neutrality.[10]

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7 Based on IRENA statistics, global wind power capacity increased from 216 GW in 2011 to 769 GW in 2021 while solar power capacity increased from 72 GW to 848 GW over the same period.

8 For comparison, average retail tariff in 2020 was about 9 US cents/kWh in Vietnam, 8.1 US cents/kWh in Lao PDR, and 7.4 US cents/kWh in Indonesia.

9 Tiered electricity tariff is applied for residential consumers, and the quoted tariff is applied to Tier 2, with their monthly electricity consumption between 11-50 kWh.

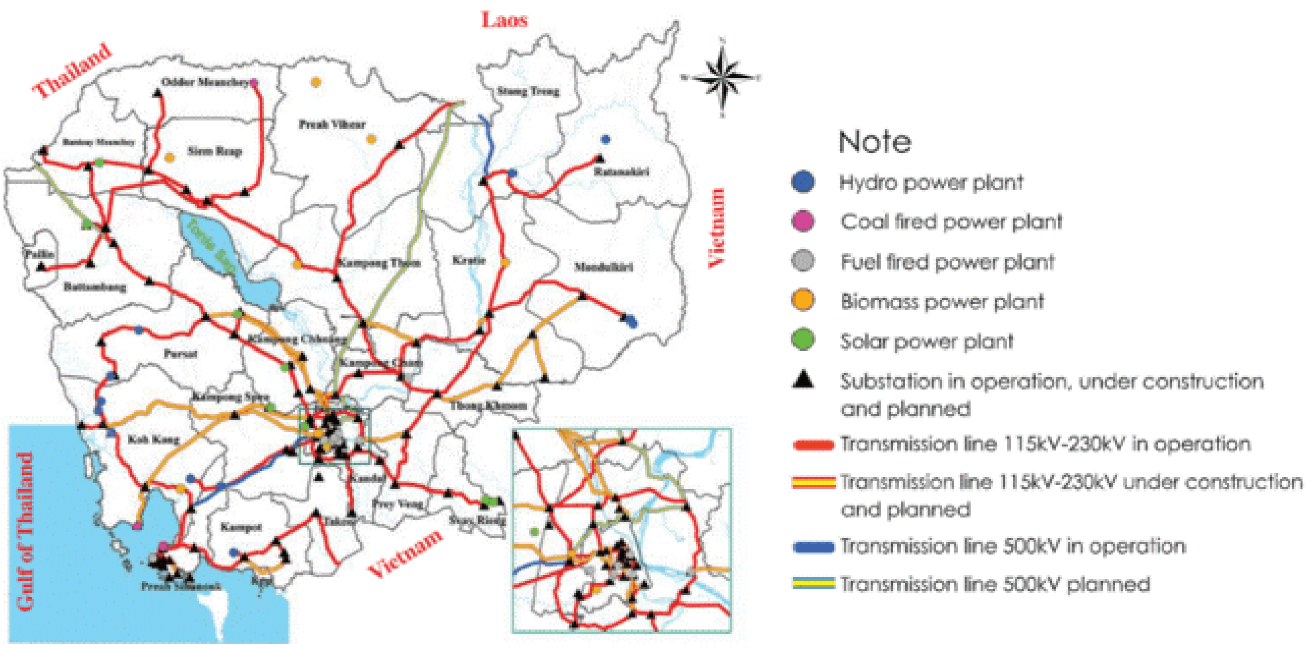
10 In the LTS4CN scenario, carbon emissions in 2050 in different sectors will be 19.3, 28.5, -50.2, 1.6, and 1.2 million tCO_2e in agriculture, energy, forestry and land use, IPPU (industrial processes and product use) and waste sector, respectively.

To prepare the energy sector in achieving its NDC, RGC commits to (a) no new coal generation capacity beyond already committed projects, (b) increase in solar, hydro, biomass and other renewables to 35 percent of the generation mix by 2050, of which 12 percent from solar – however no hydropower station will be built on the mainstream of Mekong River, (c) investments in grid modernization, flexibility and storage, (d) energy efficiency measures in buildings and industry, (e) fuel switching to electricity for cooking, (f) substitution of coal in the industrial and power sector, and (g) decarbonizing transport sector by promoting public transport and e-vehicles.

The Royal Government of Cambodia endorsed a new Power Development Masterplan (PDP) in late 2022 and it guides the power sector development in Cambodia. Following the PDP, the electricity demand in Cambodia will increase from 12,400 GWh in 2020 to 54,600 GWh in 2040 (medium growth scenario, taking into consideration of energy efficiency improvement), with an annual average growth rate of 7.7 percent in the coming two decades; the new demand will be met mainly by new coal power (before 2025 but no more new coal power after 2025), hydropower, solar power, gas power and increasing power import from Laos. The Bank team's analysis of the PDP's Scenario#4 indicated that (a) significant power supply surplus exists in 2025-2030 with the commissioning of all committed power plants (mainly coal power); (b) the carbon emission in power sector is likely to increase steadily till 2040 as REs and power imports are not adequate to meet the incremental demand growth; and (c) more aggressive RE development after 2040 can drive down carbon emission in the power sector. MME in 2024 revealed its intention to update the PDP which will also include more ambitious VRE.

In 2021, 99.98 percent of energy consumers were connected to the national grid, including almost 88.5 percent of households, with a total of 3.5 million electrical connections across the country. Since 2012, energy demand has grown at a rate of around 20percent per annum, leading to rapid expansion of the grid. The grid is composed of almost 4000km of high voltage transmission lines, 63 substations and the National Control Centre, with and addition of approximately 1450km of transmission lines planned to be rolled out by 2027. The network also includes infrastructure connecting Cambodia to Vietnam, Laos and Thailand for importing energy.

Figure 21: Current and Proposed Power Distribution Infrastructure



Source: EAC, 2022.

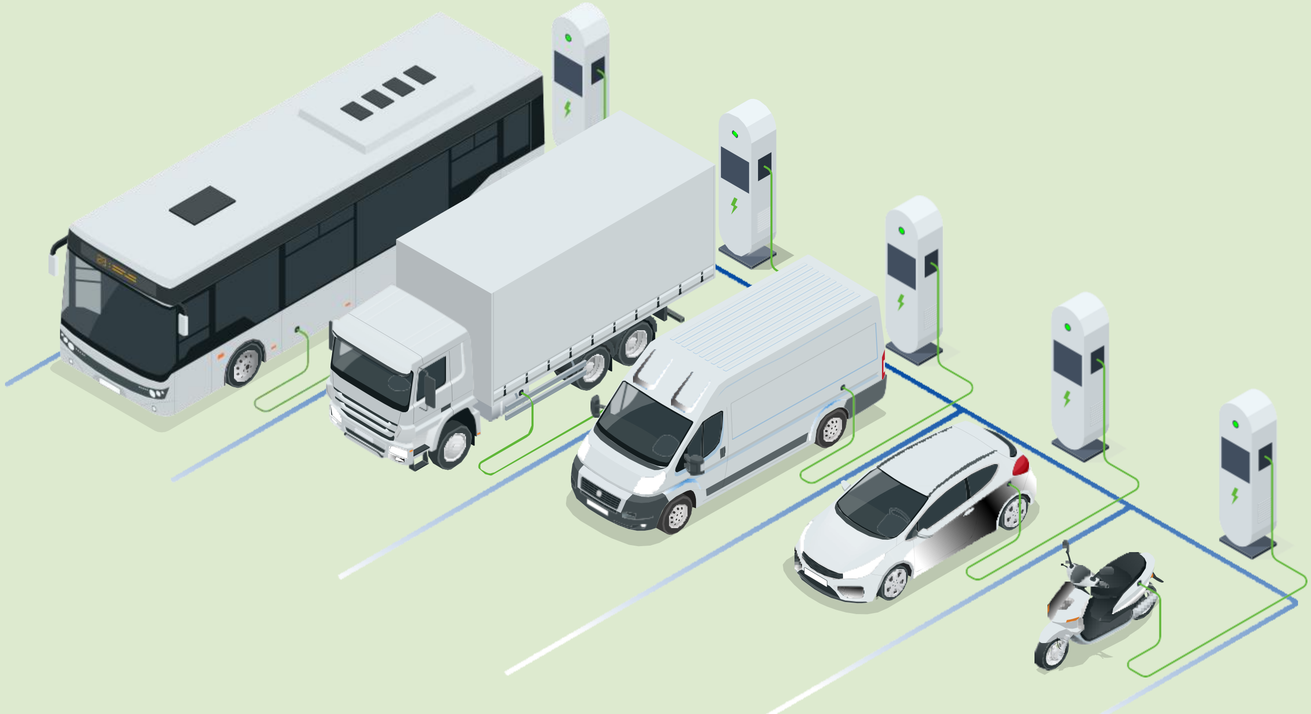
In Cambodia, power network generation and distribution are organized between two main organisations, Electricité du Cambodge (EDC) and the Electricity Authority of Cambodia (EAC). The EDC is responsible for power generation, transmission, and distribution in Cambodia. It operates and manages the overall electricity infrastructure. The EDC focuses on the practical aspects of generating and delivering electricity to end-users, ensuring a reliable supply of electricity throughout the country.

The private sector is also involved in generating and distributing energy. They operate under the category of Independent Power Producers (IPPs) and must apply to EAC and the Ministry of Commerce (MoC) to be able to generate electricity and transmit it. In 2019, 96percent of electricity generated in Cambodia was from IPPs.

EAC is the regulatory authority that oversees and regulates the electricity sector in Cambodia. Its primary role is to ensure fair competition, efficient operation, and sustainable development in the power industry. The EAC is responsible for granting licenses to power companies, setting tariffs, enforcing regulations, promoting consumer protection, and monitoring compliance with industry standards. It acts as a regulatory body to create a transparent and well-functioning electricity market.

In order to distribute energy to low and medium-voltage networks, specific licenses are needed. In total, EAC provides eight licenses as follows: (1) Generation, (2) Transmission (National & Special Purpose), (3) Dispatch, (4) Distribution, (5) Bulk Sale, (6) Retail, (7) Subcontract, and (8) Consolidate.

Photo: UNDP, 2022.



CHAPTER 2.

Transition Readiness Assessment by Market Segments

The transition to the electric mobility is as much a policy decision as an economic decision. The transition readiness is primarily determined by the technological readiness of EVs for a given vehicle segment, which translates into a corresponding total cost of ownership (TCO). TCO refers to the total costs involved in owning and using a vehicle, which includes upfront purchase price (including tax), costs for operation such as the gas price for ICE vehicles, power price for EV charging, and maintenance costs.

Generally speaking, the more mature an EV technology is, the larger the scale of its mass production globally, and the lower the TCO for individual consumers. For any vehicle segment, when the TCO of the EV reaches cost parity with its ICE counterparts, the market demand for the EVs would take off. Before the TCO parity is reached, EVs are more costly compared to ICE counterparts. The cost disparity prevents consumers from making the purchase switch. Governments may use fiscal incentives to either make EVs cheaper or ICE vehicles more expensive in order to expedite the arrival of cost parity.

To assess the overall E-Mobility Transition readiness across key vehicle segments in Cambodia, this study conducted a comprehensive TCO analysis across five key vehicle segments:

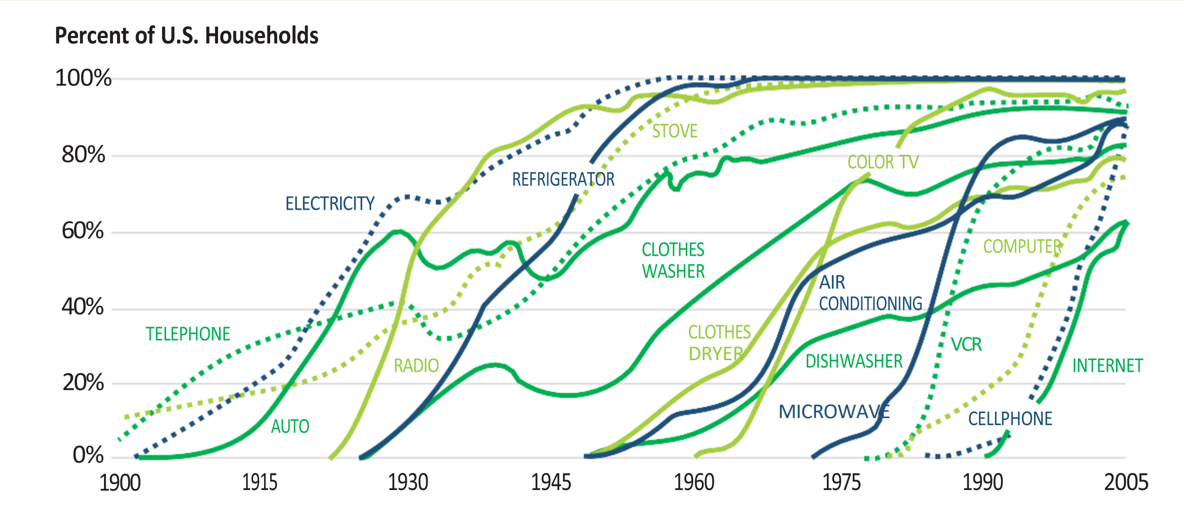
- Private 2Ws – account for 86percent of the total 2Ws stock;[11]
- Commercial 3Ws (or tuk-tuks): account for 100 percent of total 3Ws stock;
- Private 4Ws passenger cars: account for 90 percent of total light vehicle stock.
- Light trucks (Under 5t GVM): account for more than 50 percent of Cambodia's truck segment;[12]
- Urban buses: account for a small share of Cambodia's heavy-duty vehicle segment but a targeted segment by LTS4CN targets for a 30 percent mode share in urban area by 2050.

11 Ownership profiles of vehicles have been estimated by Urban Foresight following desktop research.

12 Local engagement with the World Bank and the Cambodian Trucking Association (CAMTA), as of February 2023.

Box 2. S-Curve in EV Penetration Projection

The sigmoid function is a mathematical function having a characteristic S-shaped curve. It is characterized by a shallow start followed by exponential growth that eventually plateaus. Only early adopters buy and invest while the technology is poorly understood and distributed. However, with better understanding of technology, progress picks up from a point and accelerates rapidly. At the maturity stage, saturation is reached, and growth slows down and flattens. Many innovative technologies have followed this path.



Inflection Point

In order to produce an S-curve, an initial starting value and an inflection year at which exponential growth starts are required. This study used EV penetration values for 2020 as a starting point. The Inflection Point refers to the year when at which the capex of EVs reaches parity with their ICE counterparts as key EV cost drivers such as battery costs declines across the global EV supply chain. Once EVs in a given vehicle segment reaches Inflection Point, the exponential growth of EV sales begins driven by market itself and the S-curve takes off.

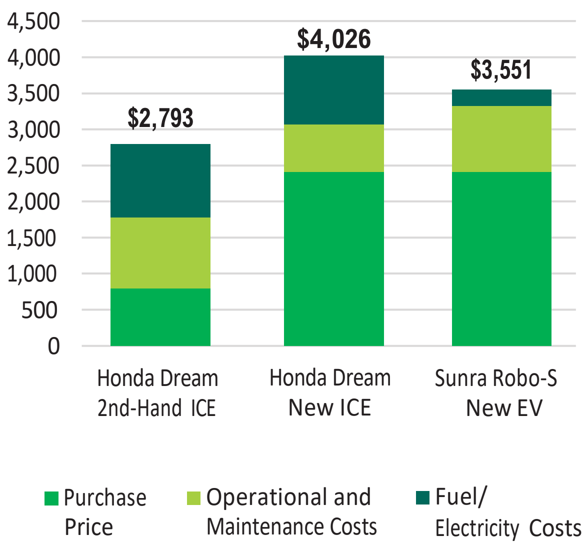
The TCO analysis included second-hand ICE vehicles, new ICE vehicles, and new EVs to provide an accurate representation of the Cambodian automotive market. A set of reference vehicle models are selected based on their popularity in existing automobile market in Cambodia. Wherever the EV model is currently not available in Cambodia, a popular model available in a neighboring market such as Vietnam or Indonesia is used as reference.

The TCO calculation considers purchasing cost, operational and maintenance costs, and fuel/ electricity costs. A sensitivity analysis introduces additional parameters such as fiscal incentives and alternative vehicle models. A full overview of the cost considerations and assumptions for each segment is provided in Appendix C.

2.1 Private 2Ws Market

For the private 2Ws segment, the TCO analysis uses gasoline-powered Honda Dream as the benchmarking ICE model and Sura Robo-S as the EV model. A total of 8-year lifetime usage is assumed, noting that in reality vehicles are used for as long as possible in Cambodia. The TCO comparison is shown in Figure 22.

Figure 22: 2Ws Reference TCO over an 8-year period



	Used ICE (US$)	New ICE (US$)	New EV (US$)
Purchase Price	800	2,400	2,400
Maintenance Cost Annual	120	80	50
Battery Costs	-	-	500
Road Tax	0	0	0
Fuel Costs Unit	1.16/liter	1.16/liter	0.17/kWh
Annual Fuel Costs Total	127	120	28

- Total km assumed as 7,627 km per annum.
- Purchase price based on market research via Khmer24.com.
- One battery replaced for E-2W in Year 5.

Source: World Bank Study Team, 2023.

The TCO for the E-2Ws over 8-years is about US$3,551, which is about US$475 or 12 percent cheaper compared with the new ICE 2Ws with a TCO of US$4,026, but is about US$758, or 27.1 percent more expensive than second-hand ICE 2Ws.

Purchase price is the single largest factor for the TCO disparity between ICE second-hand 2Ws and new E-2Ws compared with new E-2Ws that are three times more expensive. E-2Ws have much less maintenance costs due to fewer parts compared with ICE 2Ws, but a US$500 battery replacement cost is included to account for a possible one battery replacement over eight years.

In terms of refueling costs, E-2Ws have an advantage over both new and second-hand ICE equivalents, saving US$92 to US$99 per annum, respectively. This results in a net-savings cost of US$735 for new 2W and a net increase of US$800 for a second-hand 2W over the stated ownership period.

To make E-2Ws competitive, policy interventions need to be put in place to either ban second-hand 2Ws or make them more expensive by incorporating the environmental and social externalities for pollutions and road safety. Table 3 outlines four different parameters based on a set of fiscal interventions or market drivers and their impact on the TCO against the stated reference scenarios for E-2Ws.

Table 3: TCO Adjustment Options and the Impact on the 2W TCO

TCO Adjustment	Impact
It is unlikely that a proportion of consumers in Cambodia will be able to afford a new EV outright and may look for financing options. A new vehicle is purchased through a bank loan as opposed to outright purchase (GGGI 2021).[/a]	Increases the vehicle purchase cost by approximately US$750 due to interest rates over the ownership period, which increases the TCO by 19-21%.
EVs are predominantly charged (80%) at a reduced overnight electricity tariff of US$0.12/kWh.	Reduces EV refueling costs cost by US$6 per annum and decreases the EV TCO by around 1%.
Consumers purchase a cheaper electric 2W model with lower specifications and longevity (GGGI 2021).[/b]	Reduces EV purchase price and TCO by US$950 - US$1,510 and can decrease the EV TCO by 25%-41%.

TCO Adjustment	Impact
Consumers purchase a cheaper, second-hand ICE 2W.	Reduces second-hand TCO by US$300 - US$500 and increases purchase price disparity between new EVs and second-hand ICE vehicles by US$1,600

/a Loan APR Rate assumed to be 12.5% over 5 years.
/b TCO analysis has been carried out on a popular ICE 2-W (ascertained through a review of the Cambodian 2-W market) and an electric 2-W with comparable performance and build quality. Cheaper models are available to the Cambodia market with purchase price of US$890-1,450.

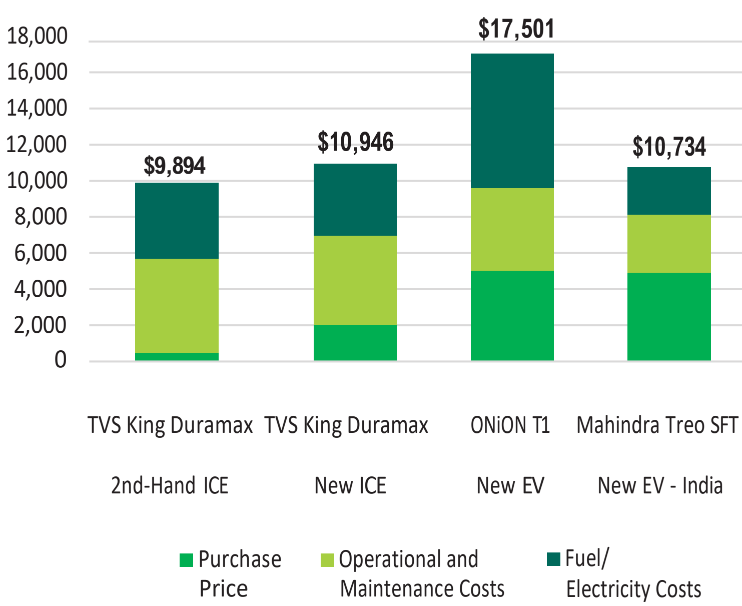
2.2 Commercial 3Ws Market

In 2021, Cambodia had an estimated 100,000 commercial 3Ws (tuk-tuks) on the road (Raksmey 2022). This is a relatively mature electric market globally valued at US$7.7 million in 2021. ONiON dominates the electric 3-W segment in Cambodia with one passenger model available to commercial operators.

For the commercial 3Ws segment, the TCO analysis uses LPG-powered TVS King Duramax as the benchmarking ICE model and ONiON T1 as the EV model. A total of 8-year lifetime usage is assumed, noting that in reality vehicles are used for as long as possible in Cambodia. For E-3Ws, no battery replacement costs are applied because a battery-swapping model is assumed to be the main charging model for this segment. The TCO comparison is shown in Figure 23.

The eight-year TCO of new electric 3Ws is US$6,100 higher than new ICE 3Ws and US$7,100 higher than second-hand ICE 3Ws. The purchase price is a major factor in this TCO disparity – E-3Ws retail price is 2.5 times and 10 times more expensive than the new ICE 3Ws and second-hand ICE 3Ws, respectively.

Figure 23: 3W Reference TCO over an 8-year period



	Used ICE (US$)	New ICE (US$)	New EV (US$)
Purchase Price	500	2,500	5,000
Registration fees	0	30.66	30.66
Maintenance Cost Annual	150	120	75
Road Tax	494	494	494
Fuel Costs Unit	0.56 /liter	0.56 /liter	3/swap
Annual Fuel Costs Total	527	487	930

- Total km assumed as 31,000 km per annum.
- Purchase price based on local market research and engagement.

Source: World Bank Study Team, 2023.

The typical advantage of EV having a lower fuel cost does not stand true for E-3Ws in Cambodia. According to MPWT data, 65 percent of 3-Ws imported into Cambodia in 2021 used LPG. LPG is cheaper than alternative fossil fuels in Cambodia and presents a cost-effective solution per kilometer (US$0.017 per km). In contrast, ONiON's commercial EV-operating model focuses on battery swapping, with each swap costing US$3 (equivalent to US$0.03 per km). This creates a significant fuel price disparity between new E-3Ws and new and second-hand ICE equivalents. The current operational model for LPG is therefore attractive to commercial organizations in Cambodia.

Table 4 outlines three parameters based on fiscal interventions or market drivers that could influence the TCO for 3Ws.

2.3 Private 4Ws Passenger Car Market

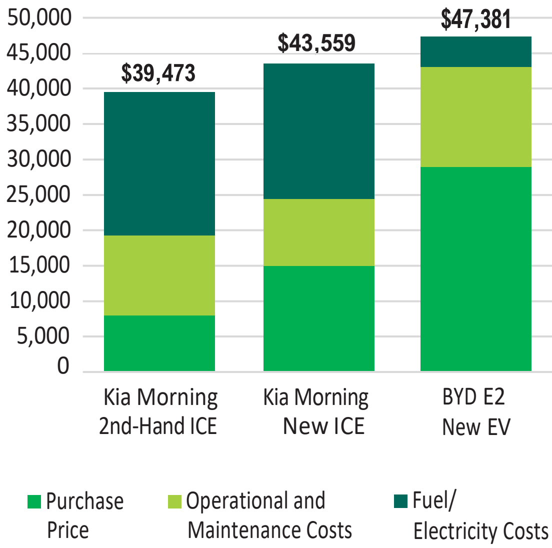
Private 4Ws, including cars and pick-ups, form approximately 12 percent of the current total vehicle stock in Cambodia. The number of cars and pick-ups on the road are expected to significantly rise to 2030 as a result of a growth in GDP per capita and cars becoming a more viable private transport option. The Chinese EV brand BYD has local retail shops in Cambodia with several E-4W models available to the market.

For the 4Ws segment, the TCO analysis uses petrol-powered Kia Morning as the benchmarking ICE model and BYD E2 as the EV model. These two models are both available in Cambodia and are within the comparable price and performance class. A total of 15-year lifetime usage is assumed, noting that in reality vehicles are used for as long as possible in Cambodia. The TCO comparison is shown in Figure 24.

Table 4: TCO Adjustment Options and the Impact on the 3W TCO

Adjustment	Impact
An alternative EV model is purchased in Cambodia. For example, a common Indian electric model, and the charging model is changed (from a battery swapping to depot or home charging).	TCO is significantly reduced over the stated period. Although the purchase price is of a similar magnitude, significant savings are seen in refueling. The lifetime electricity costs reduce by over 60% or, over US$4,800 by utilizing an alternative charging model (change from a battery-swapping model to depot or home charging).
A new ICE or EV is purchased through a bank loan as opposed to an outright purchase.	A bank loan to purchase a vehicle would increase the price disparity between new EV vehicles and new ICE vehicles. This would amount to an 18% increase in price disparity (EV-ICE) if loans are introduced at the same APR rates and repaid over the same time periods.
EVs are predominantly charged (80%) at a reduced overnight electricity tariff of US$0.12/kWh (can be done at a depot or at home).	A commercial tariff of US$0.17/kWh has been assumed for the general TCO. A reduced tariff to US$0.12/kWh has been used in this sensitivity. Reduces EV refueling costs cost by over US$5,500 thereby reducing the EV TCO by around 32%.
Battery-swapping costs are lowered to US$1.50/swap (50% reduction). This can be achieved by a more competitive market which would incentivize tuk-tuk manufacturers to reduce battery-swapping costs.	Reduces the battery-swapping costs by over US$3,700, thereby reducing the EV TCO by 22%.

Figure 24: 4W Reference TCO over a 15-year period



	Used ICE (US$)	New ICE (US$)	New EV (US$)
Purchase Price	8,000	15,000	28,900
Registration Fees	0	30.66	30.66
Maintenance Cost Annual	600	480	360
Battery Replacement	-	-	6,404
Road Tax	98	98	98
Fuel Costs Unit	1.16/liter	1.16/liter	0.17/kWh
Annual Fuel Costs Total	1,348	1,271	285

- Total km assumed as 15,224 km per annum.
- Purchase price based on local retail price.
- Electricity tariff uses residential tariff assuming all EVs are charged at home.

Source: World Bank Study Team, 2023.

The 15-year TCO of a new E-4Ws in Cambodia is 9 percent higher than a new ICE equivalent and 20 percent higher than a comparable second-hand vehicle. The purchase price is a major factor in this disparity, with a new E-4W passenger car around US$14,000 more than that of a new ICE-4Ws and US$21,000 more than a second-hand ICE-4Ws.

On the other hand, operational and fuel costs are favorable toward E-4Ws over the 15-year period assessed with approximate savings of US$700 to US$900 per annum. This results in an additional net cost of US$4,000 to US$8,000 over the stated ownership period.

The purchase costs for E-4Ws are the critical cost component and the key driver for cost disparity in this segment. Global battery price trends indicate E-4Ws will reach capital price parity with comparative ICE vehicles by 2027. The assumed inflection point however may be the capital interventions required to promote E-4Ws as a viable alternative in Cambodia in the short-medium term.

Table 5 outlines four parameters based on fiscal interventions or market drivers that could influence the TCO for 4Ws.

Table 5: TCO Adjustment Options and the Impact on the 4W TCO

Adjustment	Impact
A new ICE or EV is purchased through a bank loan as opposed to an outright purchase.	A bank loan to purchase a vehicle would increase the price disparity between new EV vehicles and new ICE vehicles. This would amount to a 51% increase in price disparity (EV-ICE) if loans are introduced at the same APR rates and repaid over the same time periods.
Reduced overnight tariff to US$0.12/kWh (assuming 80% of the charge occurs during the night).	Reduces TCO costs by approximately US$250 or by 0.5%.
Consumers purchase a new EV model within a more premium segment.	TCO could increase by up to US$42,000, which would account for a 88% increase.
Consumers purchase a second-hand ICE-2W model with lower specifications and longevity.	Could reduce second-hand TCO by about US$4,000 or 9%.

2.4 Urban Bus Market

The global E-bus market for fixed-route urban public transportation has seen recent technological development and expansion. However, in Cambodia, public transport development is in its nascent stages. Engagement with the Phnom Penh Bus Company indicates that only 178 ICE buses are currently in use across the city, which are all donated to Phnom Penh through bilateral development partners. There is no E-bus currently operating in Cambodia.

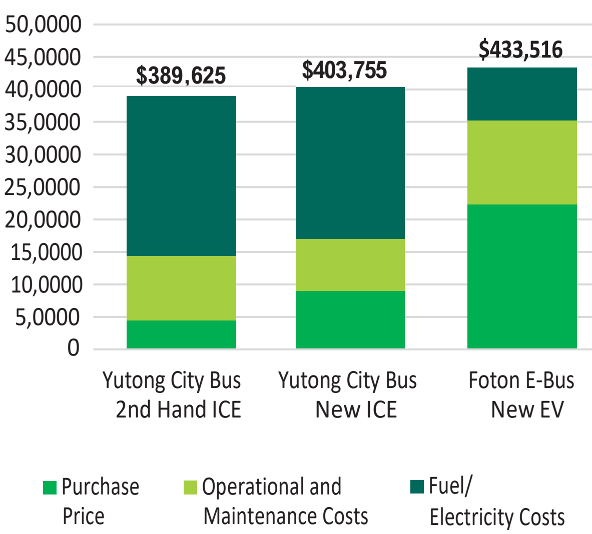
For the E-bus segment, the TCO analysis uses diesel-powered Yutong City Bus (ZK6108HGC) as the benchmarking ICE model and Foton E-bus (10 meter model) as the EV model.13 These two brands are both available in Cambodia and are within the comparable price and performance class. A total of 12-year lifetime usage is assumed.

As shown in Figure 25, the 12-year TCO for an E-bus in Cambodia is approximately 7 percent higher than a new ICE equivalent and 11 percent higher than a second-hand ICE bus equivalent, which cost about US$30,000 to US$44,000 more than an equivalent new or second-hand ICE equivalent. Despite the higher initial cost, E-buses have lower operation and maintenance costs and refueling costs compared to ICE vehicles. E- buses are expected to save between US$9,000 to US$11,000 per annum.

It is critical to highlight the fact that all existing urban bus fleets in Cambodia, which are concentrated in Phnom Penh and operated by Phnom Penh Bus Company, are donated by bilateral development partners from Japan, China, and South Korea. Although the operation costs are fully absorbed by Phnom Penh City Hall, there was no upfront costs involved for bus procurement. This means that unless similar donation programs could take place with E-buses, switching current diesel buses to E-buses through government-led E-bus procurement would be an unprecedented cost item for the country. In other words, the cost disparity for purchase cost in this context is zero vs. millions.

Table 6 outlines four parameters based on fiscal interventions or market drivers that could influence the TCO for urban buses.

Figure 25: Bus Reference TCO over a 12-year Period



	Used ICE (US$)	New ICE (US$)	New EV (US$)
Purchase Price	45,000	90,000	223,364
Registration Fees	0	30.66	30.66
Maintenance Cost Annual	7,618	6,094	4,571
Battery Replacement	-	-	63,858
Road Tax	247	247	247
Fuel Costs Unit	1.04/liter	1.04/liter	0.17/kWh
Annual Fuel Costs Total	20,470	19,485	6,758

- Total km assumed as 47,000 km per annum.
- Purchase price based on local retail price for ICE bus. E-bus cost is based on estimate from Foton's deal with Chile in 2022.
- Electricity tariff uses industrial tariff assuming all E-buses are charged at depots.
- Battery replaced for E-bus in Year 8.

Source: World Bank Study Team, 2023.

13 Foton is a Chinese E-bus brand that provides E-buses to a large number of cities in Latin America. In 2022, Foton signed a deal to provide 1,000 E-buses to Chile.

Table 6: TCO Adjustment Options and the Impact on the Urban Bus TCO

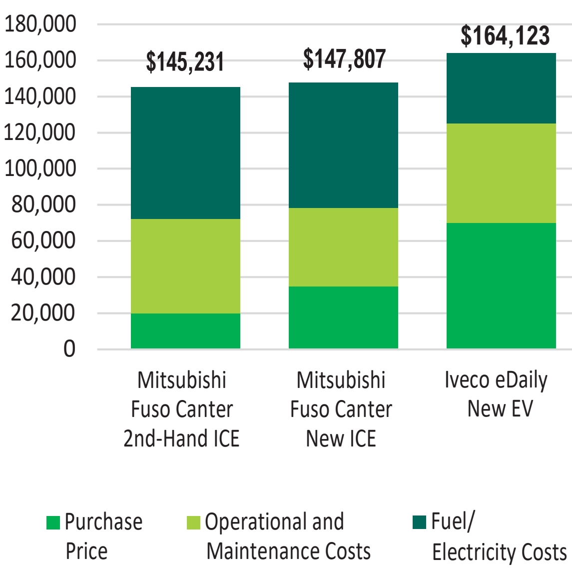
Adjustment	Impact
A new ICE or EV is purchased through a bank loan as opposed to an outright purchase.	A bank loan to purchase a vehicle would increase the price disparity between new EV vehicles and new ICE vehicles. This would amount to a 44% increase in price disparity (EV-ICE) if loans are introduced at the same APR rates and repaid over the same time periods.
Reduce overnight tariff to US$0.12/kWh (assuming 80% of the charge occurs during the night).	A commercial tariff of US$0.17/kWh has been assumed for the general TCO. A reduced tariff to US$0.12/kWh has been used in this sensitivity. This reduces TCO costs by almost US$19,000 or by 4%.
Consumers purchase a second-hand ICE 2W model with lower specifications and longevity.	Could reduce second-hand TCO by approximately US$14,000 or 3.5%.
The TCO analysis period is assumed to be 10 years, and no battery replacement is considered because of this.	TCO for an e-bus is observed to be approximately US$6,000 or 2% cheaper than that for a new ICE vehicle and US$13,000 or 6% more expensive than that for a second-hand ICE bus.

2.5 Light Trucks Market

As of Q1 2023, original equipment manufacturers of most heavy-duty trucks, including DAF, Volvo, Daimler Group, Renault, and Volkswagen, are still testing their first heavy-duty electric trucks. These trucks are not yet widely available for sale globally, with the exception of Chinese manufacturers such as BYD. The global inflection point for small trucks, when ICE and EVs are expected to reach price parity, is perceived to be 2039 (PwC 2023).

In Cambodia, light duty trucks (3.5 to 4.5 tons gross vehicle weight) are the dominant vehicle segment and have been considered for the TCO analysis instead of the nascent heavy-duty truck segment. Mitsubishi Fuso Canter 3.5T is used as the benchmarking model for ICE trucks and Iveco eDaily 3.5T is used for EV model. Iveco eDaily 3.5T is one of the models that Virak Buntham Express of Cambodia is considering for their future truck procurement.[14] A total of 15-year lifetime usage is assumed, noting that in reality vehicles are used for as long as possible in Cambodia. The TCO comparison is shown in Figure 26.

Figure 26: Light Truck Reference TCO over a 15-year period



	Used ICE (US$)	New ICE (US$)	New EV (US$)
Purchase Price	20,000	35,000	70,000
Registration Fees	0	30.66	30.66
Maintenance Cost Annual	2,848	2,278	1,708
Battery Replacement	-	-	18,635
Road Tax	494	494	494
Fuel Costs Unit	1.04/liter	1.04/liter	0.17/kWh
Annual Fuel Costs Total	4,860	4,629	2,595

- Total km assumed as 55,000 km per annum.
- Purchase price based on local retail price.
- Electricity tariff uses industrial tariff assuming all E-trucks are charged at depots.
- Battery replacement for E-truck in Year 11.

Source: World Bank Study Team, 2023.

14 Virak Buntham Express is one of the largest logistic/urban delivery companies in Cambodia.

The TCOs of new electric small trucks and new small ICE trucks are observed to be similar over the 15-year period, both with a TCO of approximately US$145,000-148,000. A new E-truck TCO is about US$19,000 higher compared with second-hand ICE small trucks, and US$16,000 higher compared with new ICE small trucks.

In terms of purchase costs, small electric trucks are expected to cost 100 percent (US$35,000) more to purchase than a new ICE equivalent and 250 percent (US$50,000) more than a second-hand ICE equivalent. Fuel costs contribute a large proportion of the TCO for ICE light-trucks (47-50 percent). Switching to E-trucks reduces fuel costs by nearly half each year compared with used ICE trucks, substantially offsetting the higher upfront costs from EV purchase.

Although the TCO for both new electric and new ICE models is similar over a 15-year period, commercial organizations will require significant upfront capital to adopt new models of light-duty electric trucks. Overcoming the upfront purchase price difference is therefore perceived to be the largest driver in achieving widespread adoption among commercial fleets.

Table 7 outlines four parameters based on fiscal interventions or market drivers that could influence the TCO for urban buses.

2.6 Key Insights from the Readiness Assessment

The TCO analysis was conducted for the private 2Ws, commercial 3Ws, 4Ws passenger cars, urban buses, and small trucks (<5 tons gross vehicle weight). It serves as a basis to assess the market readiness for E-Mobility Transition in these vehicle segments in Cambodia. The TCO analysis highlights the significance of key cost components as they stand at present as of early 2023 and the scale of cost disparity between existing EV models and ICE counterparts, both for new and used. Opportunities could be identified to prioritize government interventions and fiscal support in priority vehicle segments where the cost disparity is relatively low, and the overall transition readiness is higher.

Across all vehicle segments assessed with the selected reference models over their lifetime, private E-2Ws are already cheaper than new ICE-2Ws and close to cost-parity with used ICE-2Ws with a difference of about US$750. The overall market readiness for E-Mobility Transition is the highest in the private 2Ws segment, which accounts for the largest proportion of vehicle stock in Cambodia. In the 4Ws passenger car segment, electric cars are more costly than new and used ICE vehicle by

Table 7: TCO Adjustment Options and the Impact on the Light Truck TCO

Adjustment	Impact
A new or second-hand ICE is purchased through a bank loan as opposed to an outright purchase.	A bank loan to purchase a vehicle would increase the price disparity between new EV vehicles and new ICE vehicles. While the TCOs of EV and ICE trucks would be similar without a loan, the price disparity (EV-ICE) would increase by over US$9,400 if loans are introduced at the same APR rates and repaid over the same time periods.
Reduce overnight tariff to US$0.12/kWh (assuming 80% of the charge occurs during the night).	A commercial tariff of US$0.17/kWh has been assumed for the general TCO. A reduced tariff to US$0.12/kWh has been used in this sensitivity. It reduces TCO cost by over US$5,100 over 8 years, which would amount to a 5% decrease in TCO costs.
Consumers purchase a second-hand ICE 2W model with lower specifications and longevity.	Could reduce second-hand TCO by approximately US$2,500 or a 2% reduction.
The TCO analysis period is assumed to be 10 years, and no battery replacement is considered because of this.	TCO for an e-truck is observed to be approximately US$11,000 or 10% more expensive that for a new ICE vehicle and US$17,000 or 17% more expensive than that for a second-hand ICE truck.

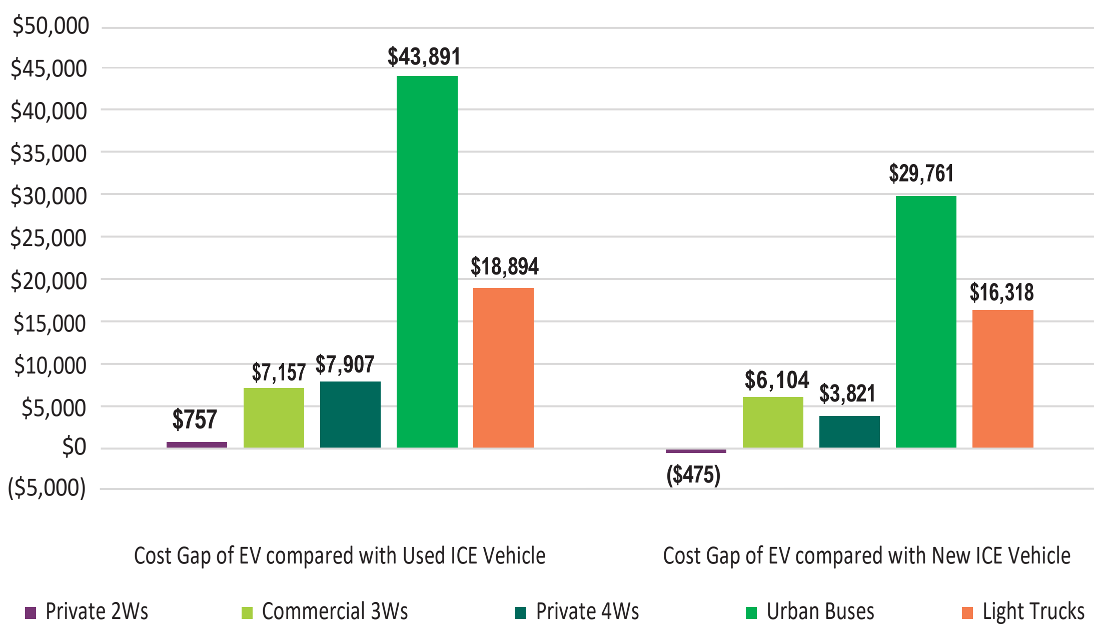
US$3,800 to US$7,900. In comparison, E-3Ws (tuk-tuks) have a higher cost premium to their ICE counterparts – US$ 6,100 more expensive than new ICE-3Ws and US$ 7,100 more than used ICE-3Ws.

In the heavy-duty vehicle segments, namely urban buses and small trucks, the TCO presents a quite different landscape. Electric urban buses have the highest cost premium compared with ICE buses – US$30,000 more expensive compared with new ICE diesel buses and US$44,000 more expensive compared with used ICE diesel buses. This TCO includes an assumed purchase cost for diesel buses, but it is important to highlight that all diesel urban public buses in Cambodia are donated hence had no purchase costs. Therefore, if the government is going to procure E-buses to replace the existing diesel buses, the actual cost premium is higher than TCO indicates.

Similarly, small electric trucks (<5t GVM) are unlikely to have reached cost parity with new ICE trucks of the same range in Cambodia. The TCO analysis of reference models indicates a US$16,000 cost premium over a 15-year lifetime. Drivers for this cost disparity include high purchase price of new electric trucks, the lagging efficiency of E-trucks versus their ICE counterparts comparatively with smaller vehicle segments, and battery replacement part-way through their lifetime. It is also important to highlight that the majority of trucks in Cambodia are used trucks imported from overseas. Compared with those used trucks, new E-trucks would entail a cost premium for about US$19,000 over 15-years.

For every TCO analysis conducted, purchase costs are always the single largest factor that leads to EV cost premium. When compared with new ICE counterparts, the purchase cost premium from EVs is less prominent. However, when compared with used ICE counterparts, such premiums become substantial. Given that the purchase costs of used vehicles vary depending on their age and conditions, EVs are much less competitive when compared with older used ICE vehicles selling at a low price. This indicates a critical need for motorization management across the used vehicle markets, both for imported and domestic, in order to make EVs competitive.

Figure 27: TCO Cost Premium of EVs Compared with ICE Vehicles



CHAPTER 3.

Modeling Cambodia's E-Mobility Transition

3.1 Modeling Cambodia's E-Mobility Transition Pathways

A comprehensive analysis was conducted to project the future demand for EVs in Cambodia and assess their environmental impact and the necessary energy and infrastructure requirements. This section provides an overview of the methodology, scenarios, and assumptions used in this analysis, with a more detailed explanation in Appendix A.

Methodology

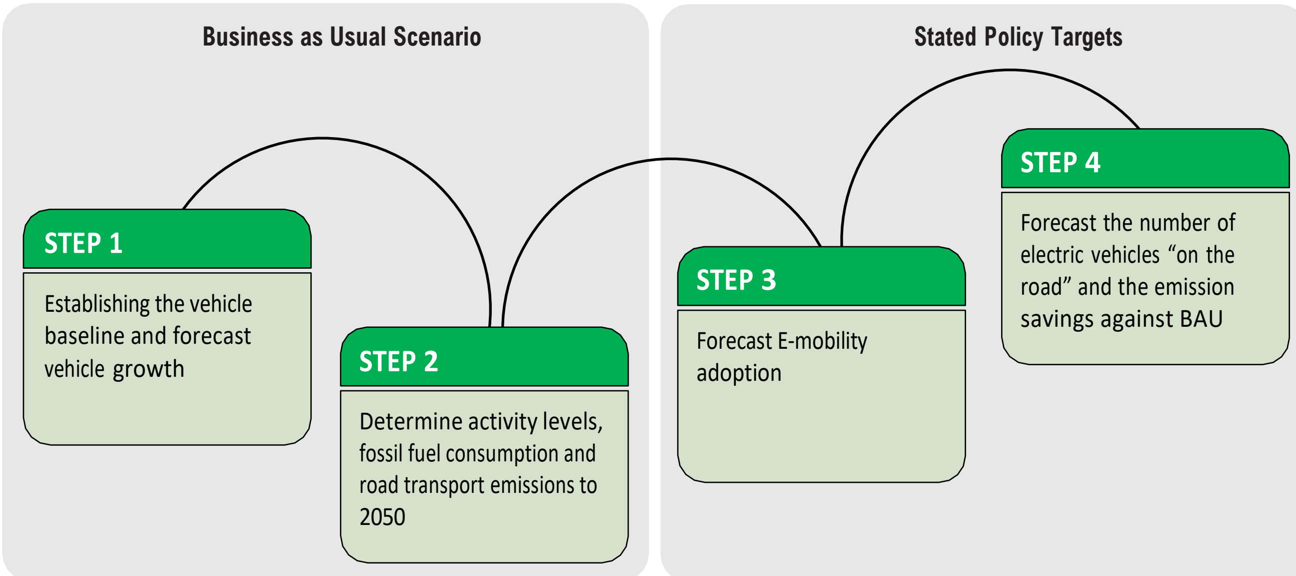
The primary goals of this analysis were to quantitatively evaluate the following:

1. What will be the level of GHG emissions in 2050 if there is no significant shift toward E-mobility in road transport in Cambodia and the current transport landscape remains unchanged?
2. What will be the impact on road transport in Cambodia if the EV adoption targets outlined in the LTS4CN are met?
3. What measures will be required to achieve these targets in terms of vehicle uptake, infrastructure investment, energy reinforcement, and financial incentives?

A four-step approach was adopted to achieve the identified objectives, detailed in Figure 28. This was modeled across two scenarios, business-as-usual (BAU) and stated policy scenario (SPS):

- The BAU scenario is a hypothetical reference scenario, akin to a "do nothing" scenario, whereby there would be no change to the makeup of the Cambodia transportation system shifting to electric vehicles.
- The SPS scenario is adapted from targets set out in the LTS4CN, which include achieving EV penetration of 70 percent among 2Ws, and 40 percent among urban buses and cars by 2050.

Figure 28: Four-Step Approach Adopted



Note: The modeling approach outlines the steps taken to achieve the key quantitative objectives of Cambodia's E-Mobility Transition. The success of this approach is largely dependent on the quality and reliability of available datasets, which are essential for conducting detailed analysis.

Charging Infrastructure

It is essential to understand where vehicle charging may take place for each vehicle segment to meet the future requirements for EVs. Building on the energy demand requirements, the modeling assessed the estimated level of infrastructure, investment, and power impact on the grid (kilovolt amperes or kVA) needed to support the E-Mobility Transition across each vehicle segment. The charging infrastructure requirements modeling requires a series of assumptions surrounding charging behavior and charging needs.

Table 8: Five Key Types of EV Charging Analyzed

Home charging	Home charging usually takes place overnight, with slower 3kW AC (2W and 3Ws) to 7kW AC (4Ws) chargers, which are connected to the domestic energy supply. A full charge with a standard home charger takes 4-8 hours, depending on the battery size and vehicle type.
Destination charging	Destination charging takes place in public places where an EV driver may leave their car for an extended period of time. This could be in a workplace, shops, or tourist attraction. Destination charging is usually 2-3kW AC (2Ws and 3Ws) to 7kW AC (4Ws) charging.
Rapid "Top-Up" charging	DC charging is usually found at key sites around major road networks, aimed at providing a top-up to EV drivers making long journeys. Charging is usually 50kW+ (DC) and can charge an average electric car up to 80% in 40 minutes to one hour.
Battery swapping	Battery swapping mainly applies to 2Ws and 3Ws. Mainly used by commercial EVs, battery swapping requires a standardized 2kWh battery that can be swapped with fully charged batteries at designated swapping stations.
Depot charging	Depot charging is used for charging commercial fleets, such as heavy vehicles, minivans or 3Ws. Heavy vehicles have much larger batteries than cars (300kWh vs 60kWh), so may require DC chargers of 50kW+. Tuk-tuks and such 3Ws can also use depot charging; but due to the smaller battery size (around 2kW), they use slower, 7kW AC charging.

3.2 Projected Motorization Rate through 2050

Historically, motorization rate has aligned with the rate of GDP growth in Cambodia. In 2022, Cambodia had 351 units of 2Ws per 1,000 population and 44 units of light-duty passenger cars per 1,000 population. Each vehicle segment has seen significant recent growth with the average annual growth in motorization rate in the five past years rising at 9 percent and 12 percent, respectively, between 2017-2022. This exceeds the economic growth of GDP per capita average of 5 percent over the same period. As Cambodia rapidly develops and people have more disposable income to spend on purchasing vehicles and goods, the demand for transportation services is expected to increase (Bangkok Post 2022; Cheng 2023).15

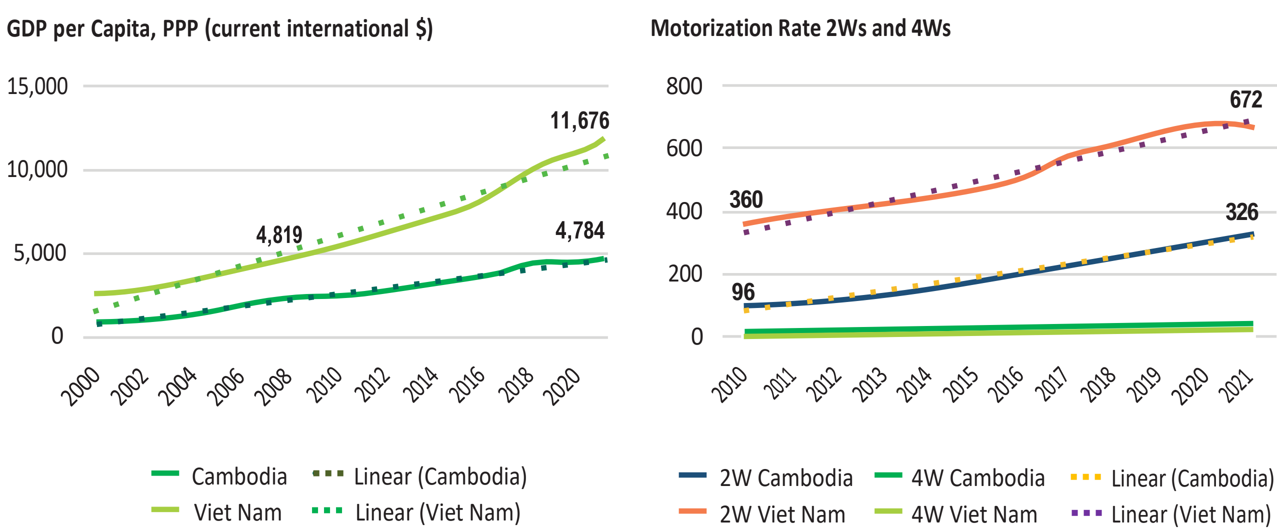
In projecting Cambodia's future motorization trajectory, Vietnam is used as a benchmarking country. The rationale of using Vietnam as a reference country for Cambodia includes: (a) both countries have been growing at a similar pace in terms of per capita GDP over 2000-2021 with Vietnam at a compound average growth rate of 7.5 percent and Cambodia at 7.4 percent (current international USD). (b) Both countries have a similar road transport structure, which is dominated by 2Ws and slow but steady growth in passenger car ownership. Public transport accounts for a very small mode share in both countries. (c) Both countries follow similar characteristics in terms of road network development and urban street features.

Table 9: Key Assumptions used to construct the Motorization Projection

Parameters	Historical 2000-2022	Assumptions Used Between 2023-2050
GDP growth	Increased by 7.4% per annum	GDP per capita expected to increase at 7.4% per annum, reaching US$37,481 (in current international USD) in 2050.
Population growth	Increased by 1.5% per annum	Population expected to increase at 1.5% per annum, reaching 25.6 million in 2050.
Urbanization gate	Increased by 1.5% per annum	Urbanization rate expected to increase at 1.5% per annum, reaching 38% of total population in 2050.

Source: World Bank, 2023.

Figure 29: Benchmarking Cambodia's Motorization with Vietnam



15 Cheaper vehicle models, specifically SUVs, imported from China may also result in an increase in E-4Ws.

As of 2021, the per capita GDP of Cambodia is about US$4,784 (current international USD), comparable to Vietnam's per capita GDP in 2008. The current motorization rate of 2Ws in Cambodia is comparable to that of Vietnam in 2010 at around 350 units per 1,000 population. Assuming the per capita GDP of Cambodia continues growing with the current rate of 7.4 percent a year, it will reach Vietnam's 2022 per capita GDP level of about US$11,00 by 2033. Following the similar trendline of motorization growth in two countries, it is reasonable to predict that Cambodia's 2W ownership would reach Vietnam's current level of more than 650 units per 1,000 population.

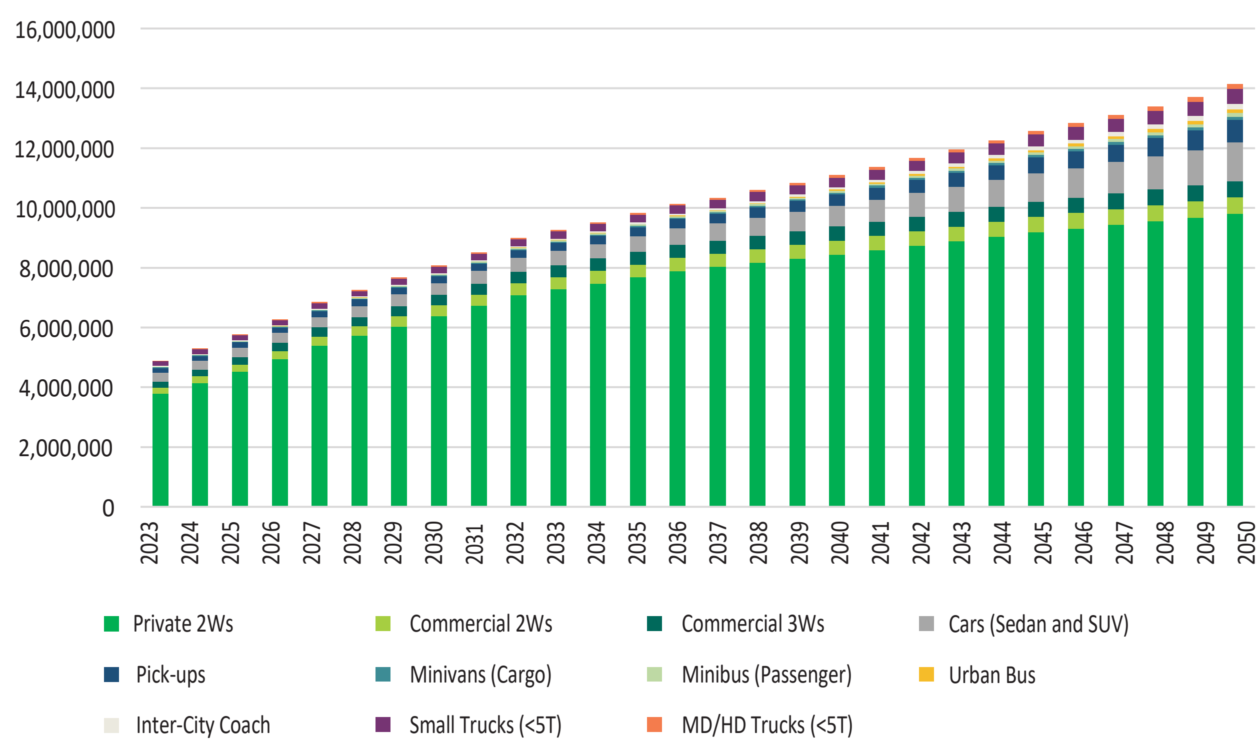
However, Cambodia's motorization growth in the passenger car segment is stronger than that of Vietnam. This is largely driven by second-hand car importation, which is banned in Vietnam. Cheaper second-hand passenger cars in Cambodia's market favor car purchase among the wealthy households. In light of stronger demand for passenger cars, this study capped Cambodia's 2W ownership at around 660 units per 1,000 population for this projection. The rates for all other segments continued to rise in parallel with the economic growth in Cambodia along with the forecasted increase in population.

It is estimated that Cambodia will reach a motorization level of 574 units of 2Ws per 1,000 population, and 57 units of passenger cars per 1,000 population by 2030. By 2050, levels of 2Ws rise to 655 units per 1,000 population and of passenger cars to 138 units per 1,000 population. This leads to a total active vehicle stock of more than 8.1 million in 2030 and 14.2 million in 2050, assuming 65 percent of registered vehicles are in active use.

Travel Demand

The shift in the economy from agrarian to tertiary is likely to result in longer commutes for many people, encouraging them to travel longer distances more frequently. The total energy demand from road vehicle use, is either fossil fuel for ICE vehicles or electricity for EVs, depends on the activity or travel demand of road vehicles.

Figure 30: Projected Growth of Total Registered Vehicles by Vehicle Segment (in units of vehicles)



Source: World Bank, 2023.

Based on surveys conducted under Cambodia Petroleum Master Plan 2022-2024 across Phnom Penh City, provinces of Preach Sihanouk, Kampong Speu, Kampong Cham, Battambang, and Siem Reap, the baseline daily vehicle-kilometer traveled (VKT) per annum is established for private 2Ws, 2W-taxi, 3W tuk-tuks, sedan and SUV, minivan, pick-ups, trucks, and minibuses (Table 10). The assumptions on annual VKT under different vehicle segments are applied for future travel demand projection. Based on the vehicle segments and use characteristics in Cambodia, an annual increase rate is applied to the baseline VKT across different vehicle segments, between 0.5 – 1.5 percent annually through 2050.

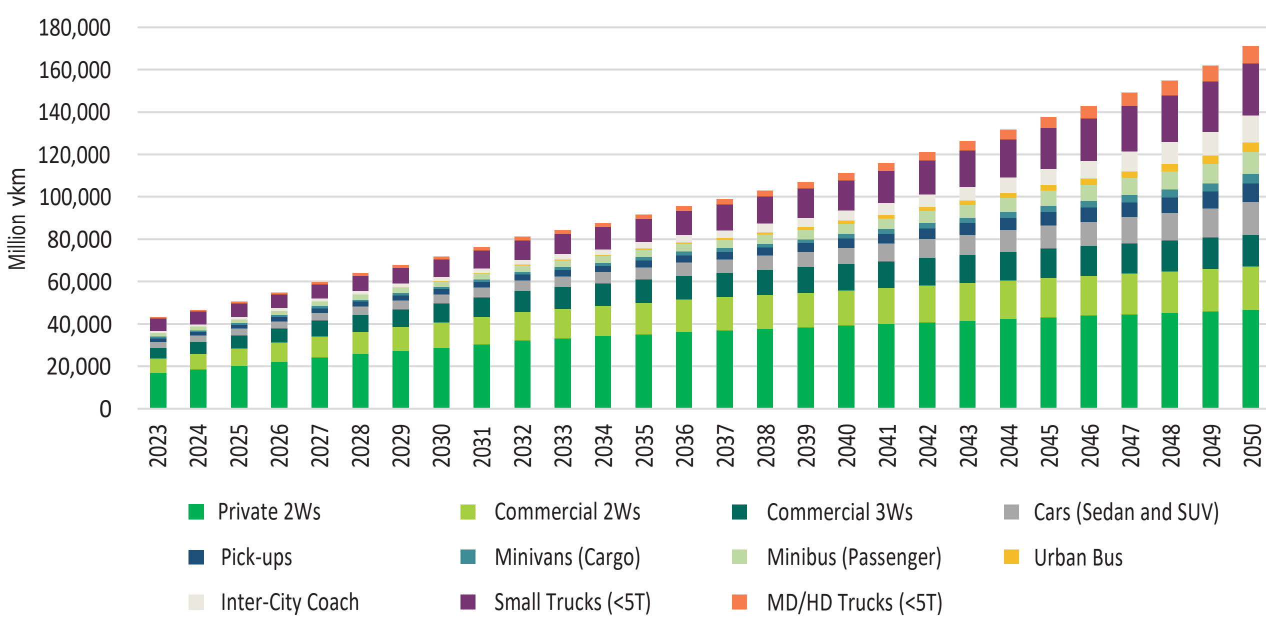
Using these stated assumptions, it is projected that the total VKT in Cambodia by road vehicles will increase from about 37 billion km in 2022 to 72 billion km by 2030 and 171 billion km by 2050 (Figure 31). Private 2Ws are projected to remain carrying most road transport demand, followed by small trucks under 5 tons, commercial 2Ws and 3Ws, and cars. This projection does not consider modal shift from road vehicles to other modes of transport such as railways, inland waterways, and aviation.

Table 10: Assumed Baseline (2021) VKT by Vehicle Segments

Baseline (2021)	Private 2Ws	2Ws Taxi	Tuk-Tuks	Private Car	Taxi	Pick-Ups
Daily travel distance (km)	14	101	74	32	345	33
Annual distance (km)	4,427	32,356	23,837	10,253	110,386	10,446
Baseline (2021)	**Van (Cargo)**	**Minibus**	**City Bus**	**Coach**	**Small Truck**	**Heavy-duty truck**
Daily travel distance (km)	187	440	83	320	233	230
Annual distance (km)	28,418	66,912	26,560	48,640	35,385	34,960

Source: Cambodia Petroleum Master Plan 2022-2024.

Figure 31: Projected Total Vehicle Kilometers Traveled 2023-2050



Source: World Bank, 2023.

3.3 Business-as-Usual Scenario through 2050

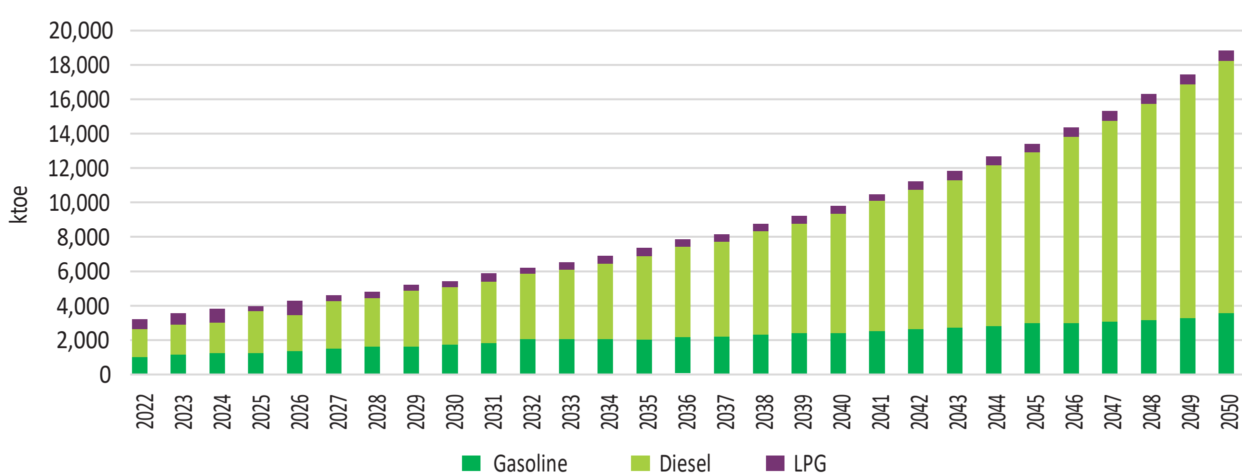
Under the BAU scenario, it is assumed that EV development will unfold organically without any state-led support programs. This BAU is hypothetical and mirrors EV development context before 2022. The hypothetical BAU is constructed to serve as a baseline in order to quantitatively understand the scale of efforts required to move from the status quo toward achieving Cambodia's ambitious EV targets. The BAU scenario incorporates the following model:

1. All motorization across vehicle segments takes place with ICE vehicles following the current powertrain structure. EV penetration remains at a neglectable level through 2050.
2. All road vehicle activities are powered by combustion of fossil fuels, including gasoline, diesel, and LPG. For each vehicle segment, the share of different ICE powertrains remains the same as in 2022. The stated targets in LTS4CN regarding fuel economy standards and switching interregional coaches and trucks to CNG are not included in the BAU.
3. Private modes, namely private 2Ws and gradually private passenger cars, remain serving as the dominant means for road transportation. The model share of public transport remains low at around 0.74 percent of urban passenger kilometers.[16]

Fossil Fuel Consumption

Under the BAU scenario, all road vehicle activities projected — around 72 billion kms by 2030 and 171 billion kms by 2050 — are carried by ICE vehicles using fossil fuels. The fossil fuel consumption by ICE vehicles will increase significantly across gasoline, diesel, and LPG, the three major oil products currently used by road vehicles. The consumption of gasoline will increase from about 995 kilotonne oil-equivalent (ktoe) in 2022 to 1,664 ktoe by 2030 and 3,541 ktoe by 2050. For diesel, the consumption will increase from 1,996 ktoe in 2022 to 3,359 by 2030 and 14,644 ktoe by 2050. For LPG, it is projected to increase from about 212 ktoe in 2022 to 372 ktoe by 2030 and 644 ktoe by 2050 (Figure 32). The consumption of diesel in particular rises disproportionately, driven by the increase of vehicle number and use across high-duty segments, including inter-city coaches and trucks.

Figure 32: Projected Fuel Consumed by Type under BAU



Source: World Bank, 2023.

16 Assumption based on Phnom Penh bus engagement and Urban Foresight Analysis of urban travel demand.

Road Transport GHG Emissions

Based on surveys conducted under Cambodia Petroleum Master Plan 2022-2024 across Phnom Penh City, provinces of Preach Sihanouk, Kampong Speu, Kampong Cham, Battambang, and Siem Reap, the baseline fuel efficiency is established for private 2Ws, 2W taxis, 3W tuk-tuks, sedans and SUVs, minivans, pick-ups, trucks, and minibuses. The assumptions shown in Table 11 on fuel efficiency are applied for different vehicle segments. A conservative assumption is applied for stock-wide fuel efficiency improvement between 1.0 – 1.5 percent annually through 2050.

Under the BAU scenario, the total tank-to-wheel GHG emissions from the road transport will increase from about 10.9 million tCO2e in 2022 to 18.4 million tCO2e by 2030, and 65.1 million tCO2e by 2050 (Figure 33). Despite the dominance of motorcycles in terms of vehicle stock, motorcycle segments (including private 2Ws, and commercial 2Ws and 3Ws) account for only 24 percent of the road transport GHG emissions by 2030, compared with 37 percent from trucks. Light-duty vehicle segments, including private cars (sedans, SUVs, pickups), taxis, minivans, and minibuses will account for 22 percent of total road emissions. Heavy duty city buses and interregional coaches will contribute to 15 percent of emissions. By 2050, the total emissions will be around 9 percent from motorcycles, 19 percent from light-duty vehicles, 35 percent from trucks, and 37 percent from buses and coaches. This projection does not consider model shift of passenger and freight demand to railways, waterways, and aviation.

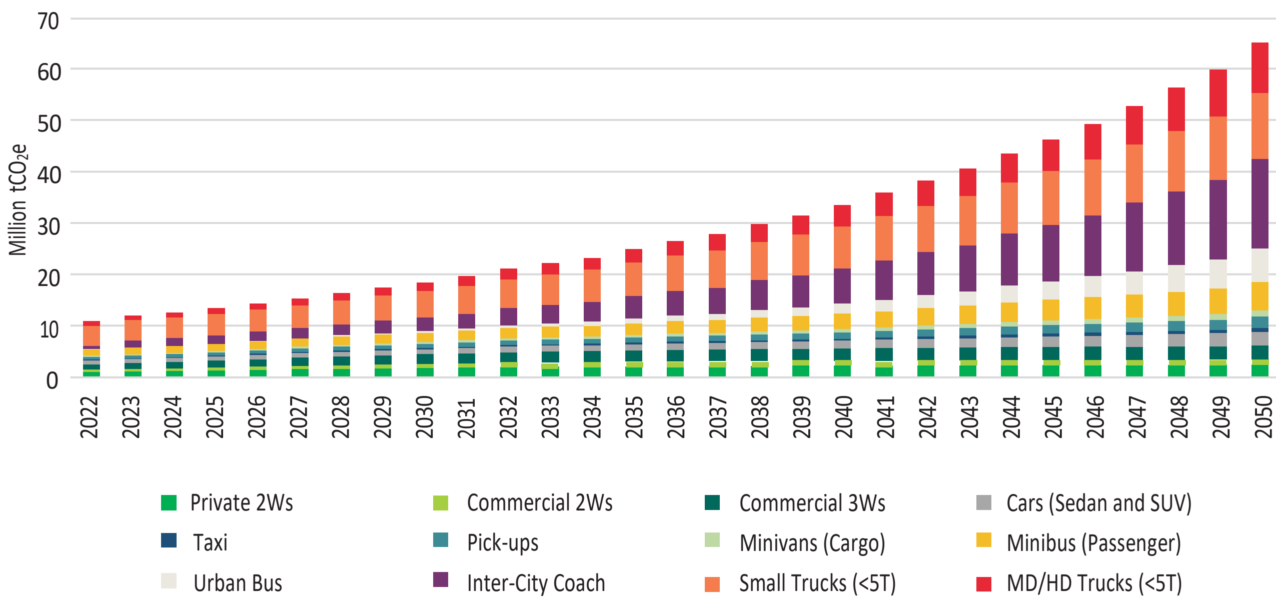
Table 11: Assumed Baseline (2021) Fuel Efficiency by ICE Vehicle Segments

Vehicle Segments	Baseline ICE Vehicle Fuel Efficiency (in liter/100km)			
	Gasoline	Gasoline hybrid	Diesel	LPG
Private 2Ws	2.18	-	-	-
Commercial 2Ws	2.31	-	-	-
3Ws	2.54	-	-	10.34
Cars (sedan and SUVs)	9.92	4.96	8.33	10.00
Taxi cars	-	-	-	10.00
Pick-ups	12.00	-	10.53	-
Minibus	29.55	-	22.73	-
City bus	-	-	45.00	-
Interregional coach	58.50	-	45.00	-
Minivans (cargo)	15.60	-	12.00	-
Small trucks (<5T)	21.43	-	27.86	-
Medium- to heavy-duty trucks (>5T)	-	-	40.00	-

Source: Cambodia Petroleum Master Plan 2022-2024, and market research conducted under this study.

Under the BAU scenario, the total tank-to-wheel GHG emissions from the road transport will increase from about 10.9 million tCO2e in 2022 to 18.4 million tCO2e by 2030, and 65.1 million tCO2e by 2050.

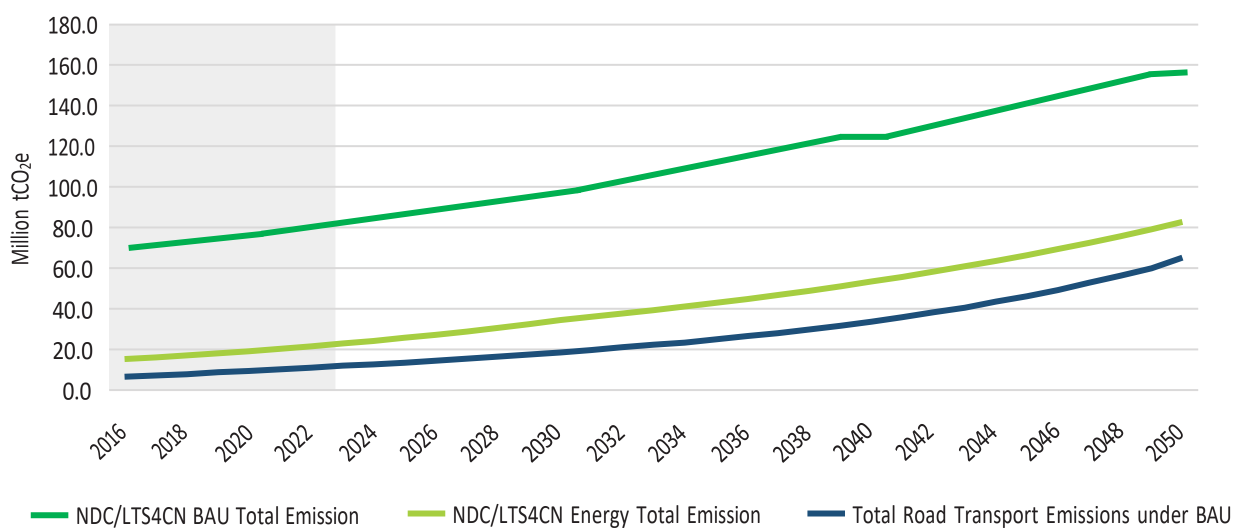
Figure 33: BAU Projected GHG Emissions by type of segment (million tCO_2e)



Source: World Bank, 2023.

To put it into perspective, under the BAU scenario projected here, the total GHG emissions from the road transportation will reach 18.4 million tCO_2e by 2030, accounting for 54 percent of total energy sector emissions under the NDC BAU scenario. By 2040, total road transport emissions will reach 33.6 million tCO_2e, equivalent to 63 percent of total energy sector emissions (Figure 34).

Figure 34: GHG Emissions Compared with NDC/LTS4CN BAU. (in million tCO_2e)



Source: Cambodia LTS4CN, 2021, WB Calculation

3.4 Stated Policy Scenario through 2050

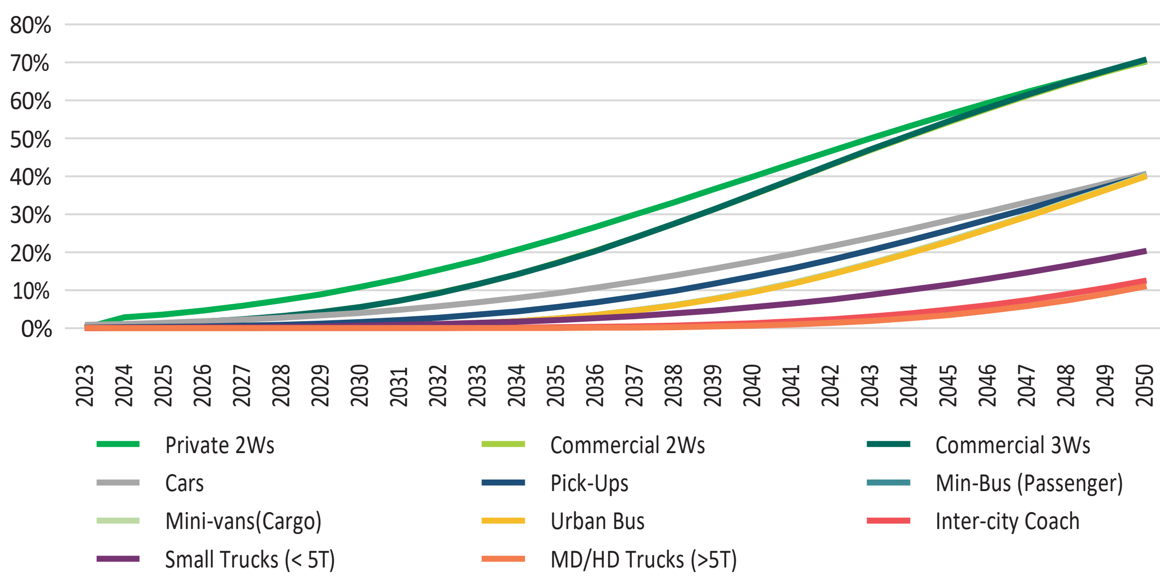
In LTS4CN, the RGC has set ambitious targets in regard to the electrification of road vehicles, modal shift from passenger vehicles to public transport, and switching trucks and interregional coaches and trucks from using diesel to CNG. Specifically, the stated policy targets aim to have:

- 70 percent of motorcycles to be electric by 2050,
- 40 percent of cars and urban buses to be electric by 2050,
- 30 percent modal share for public transport in urban areas by 2050,
- 80 percent trucks and interregional coaches using CNG by 2050.

The Stated Policy Scenario (SPS) models when all four stated policy targets are achieved by 2050 regarding powertrain change or fuel efficiency improvement through electrification and using lower carbon fuel. Model shift from private modes to public transport is not included in this model as it requires a different modeling approach. The SPS reveals what it would be the implications to achieve these targets in terms of energy consumption by road transport vehicles, associated GHG emissions, and infrastructure requirement.

Under the SPS, EVs gradually replace ICE vehicles in Cambodia's active vehicle stock. The EV penetration across each vehicle segment is predicted using a sigmoid S-curve that mirrors the typical trajectory for adopting new technologies. It is characterized by a shallow start followed by exponential growth that eventually plateaus. In order to produce an S-curve, an initial starting value and an inflection year at which exponential growth starts are required. The EV penetration level as of 2022 is used as a starting point. The inflection year is estimated for different vehicle segments based on the falling rate of battery costs, which is the primary cost factor for EV costs. Once the apex of EVs reaches parity with ICE counterparts, the inflection takes off (Figure 35).

Figure 35: Electric Vehicle Growth by Vehicle Segment under SPS, 2023-2050



Source: World Bank, 2023

Achieving the LTS4CN targets for EV penetration by 2050 – 70 percent among motorcycles, 40 percent among cars and urban buses – would require the total EV stock to reach around 751,000 by 2030 and 8.8 million by 2050 (Figure 36, Table 12). The SPS assumes the target set for motorcycles applies to private 2Ws and commercial 2Ws and 3Ws. It also assumes that targets set for cars apply to all light-duty vehicle segments, including sedans, SUVs, pickups, minivans, and minibuses. Although there is no target set for trucks and interregional coaches, these two segments are included in the projection – although the estimated EV penetration level is only about 11-12 percent by 2050 given the technology and cost constraints. This EV penetration would lead to about 7.3 million ICE vehicles remaining in active use by 2030, which will decline to about 5.4 million by 2050.

This level of EV penetration would result in about 6 percent of road VKT (or 5.9 billion kms) to be electrified by 2030 and subsequently reach to 48 percent road VKT (or 83.9 billion kms) by 2050 (Figure 37). Most electrified VKT are carried by E-2WS and E-3Ws. Correspondingly, the increase rate of total VKT carried by ICE vehicles will slow down. By 2030, about 7.3 billion kms are carried by ICE vehicles and 90.3 billion kms by 2050. In 2050, the non-electrified VKT will mainly concentrate on ICE small trucks (22 percent); private sedans, SUVs, and pickups (16 percent); private 2Ws (15 percent); and intercity coaches (12 percent).

Figure 36: EV Penetration in Active Vehicle Stock under SPS

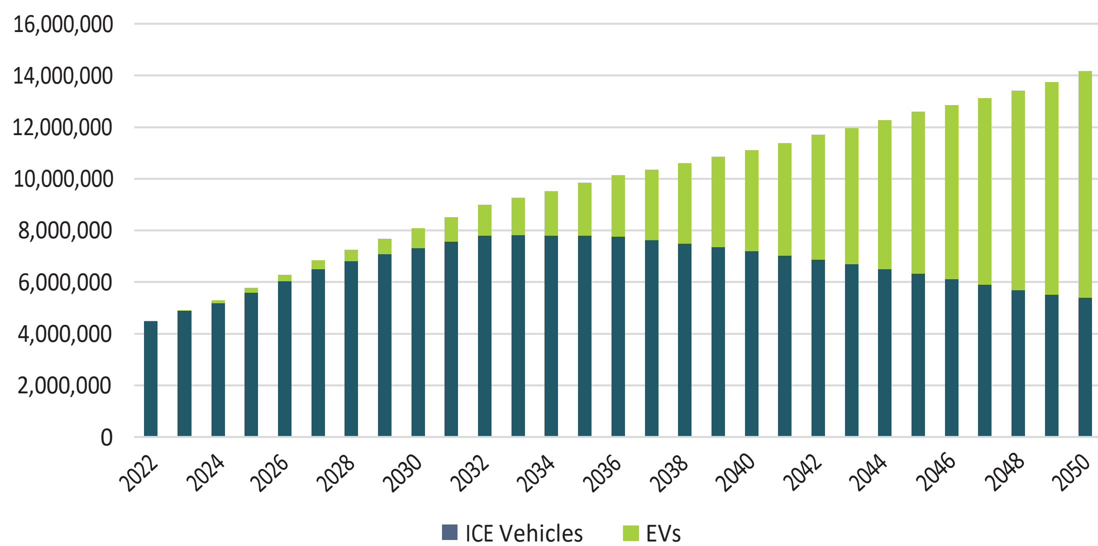
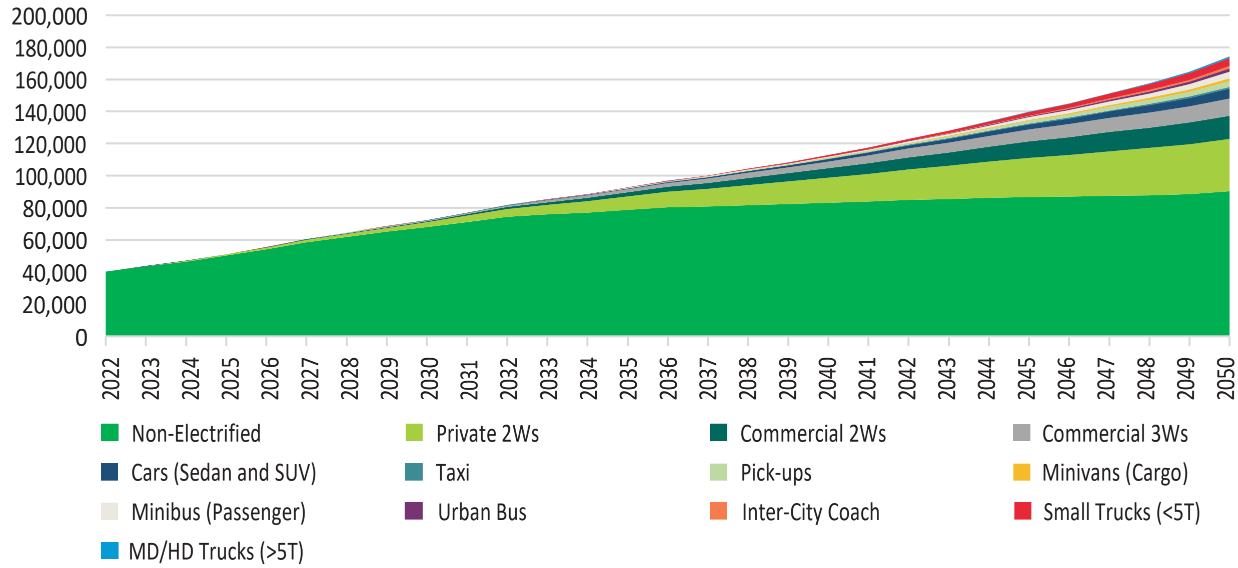


Table 12: Projected EVs by Segment to Achieve the Stated Policy Targets in the LTSC4N (in units of vehicles)

Vehicle Segment	2025	2030	2035	2040	2045	2050
Motorcycles	169,394	729,471	1,957,779	3,705,167	5,739,944	7,652,548
Light-duty vehicles	4,993	20,337	67,781	186,593	451,505	929,965
Urban bus	-	32	519	4,282	17,446	53,929
Interregional coaches	-	7	118	1,036	5,922	22,900
Small truck (<5T)	247	1,313	5,523	17,755	47,356	99,647
Medium- to heavy-duty trucks (>5T)	-	1	28	506	3,723	18,043

Source: World Bank, 2023.

Figure 37: Electrified VKT by Segment vs. Non-Electrified VKT



Source: World Bank, 2023.

The fossil fuel demand and GHG emission reduction are further differentiated into two sub-scenarios: (a) without switching 80 percent of interregional coaches and trucks to CNG; and (b) switching 80 percent of interregional coaches and trucks to CNG. The first sub-scenario shows the upper limit of GHG emission reduction impact from electrification only. The second sub-scenario shows the synergy of combining electrification with fuel economy improvement in decarbonizing the road transport sector.

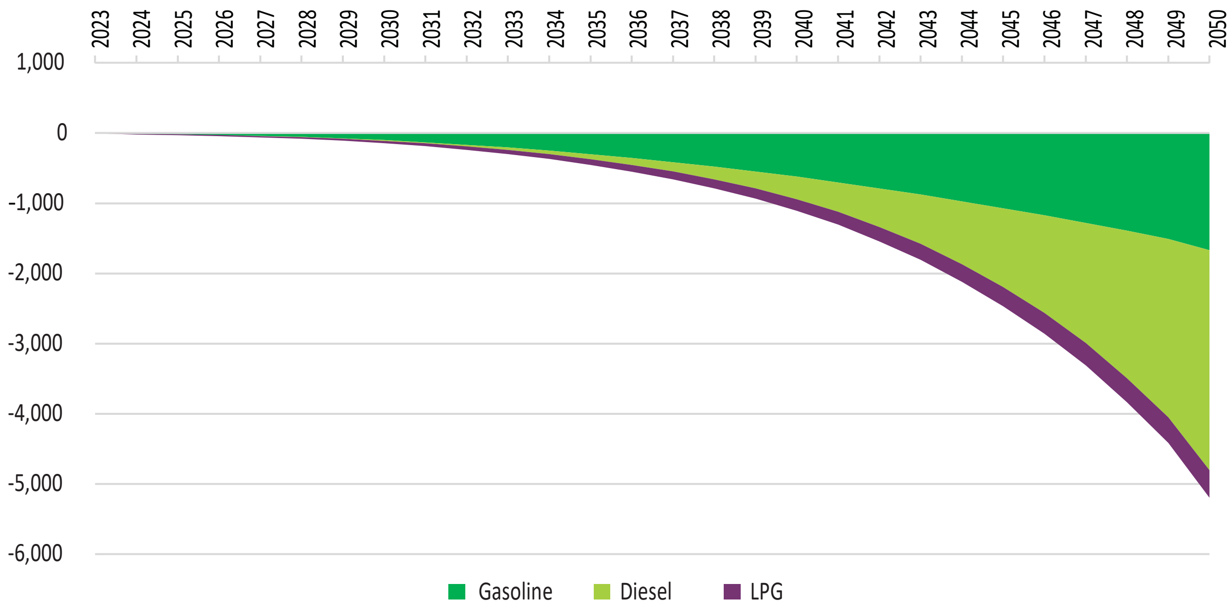
Fossil Fuel Demand and GHG Emission Reduction – Without Switching to CNG

Without switching interregional coaches and trucks to CNG, the powertrain of these two heavy-duty and highly emissive vehicle segments will remain dominated by diesel. The projected electric travel demand would lead to a total fossil fuel consumption by ICE vehicles of 5,251 ktoe by 2030 and 13,633 ktoe by 2050. Compared with the BAU scenario, this represents a reduction of fossil fuel demand by 143 ktoe by 2030 and 5,196 ktoe by 2050. The cumulative fossil fuel demand reduction from 2023-2050 is about 34,942 ktoe (Figure 38).

In terms of GHG emissions, the total emissions from the road transport under SPS scenario will reach 18 million tCO_2e by 2030, and 82.7 million tCO_2e by 2050. Compared to the BAU scenario, this represents a reduction of GHG emissions by 0.49 million tCO_2e by 2030, and 17.75 million tCO_2e by 2050. The cumulative GHG emission reduction between 2023-2050 is about 118.37 million tCO_2e (Figure 39).

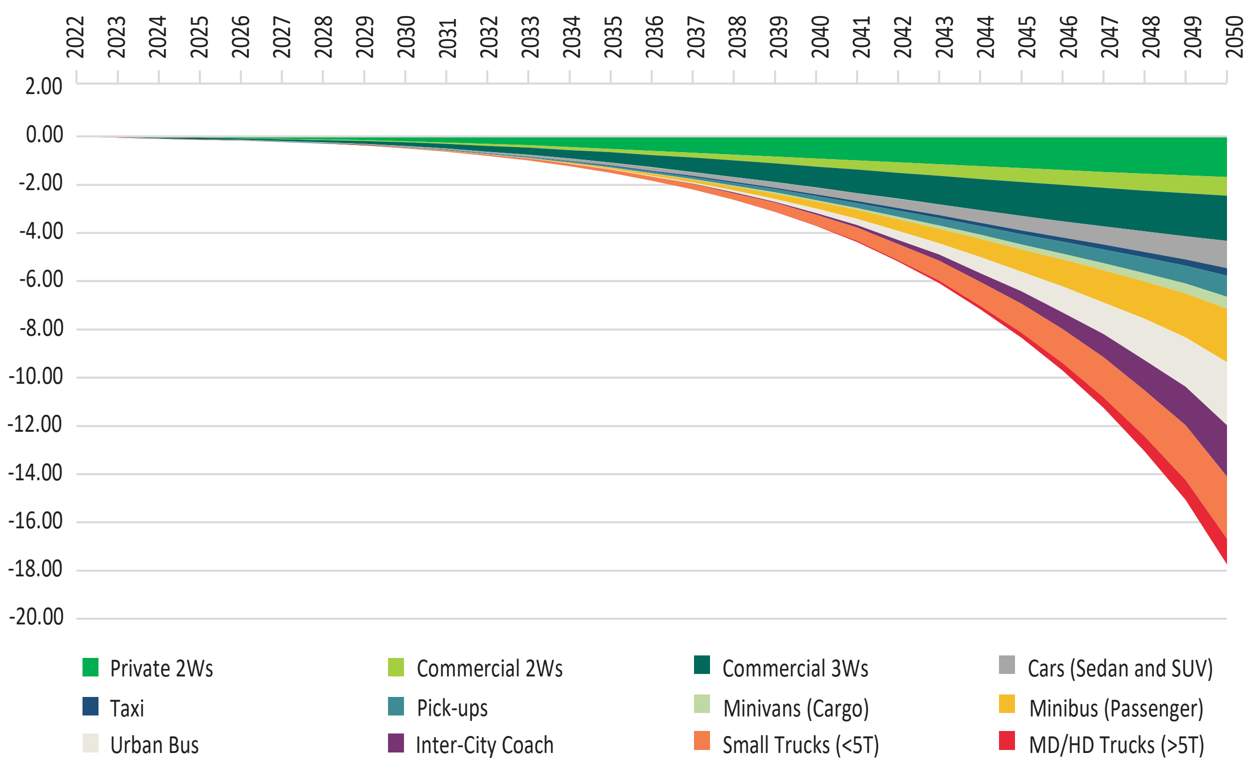
In terms of GHG emissions, the total emissions from the road transport under SPS scenario will reach 18 million tCO2e by 2030, and 82.7 million tCO2e by 2050. Compared to the BAU scenario, this represents a reduction of GHG emissions by 0.49 million tCO2e by 2030, and 17.75 million tCO2e by 2050.

Figure 38: Fossil Fuel Demand Reduction Compared with BAU (in Ktoe)



Source: World Bank, 2023.

Figure 39: GHG Emission Reduction Compared with BAU – Without CNG (in tCO2e)



Source: World Bank, 2023.

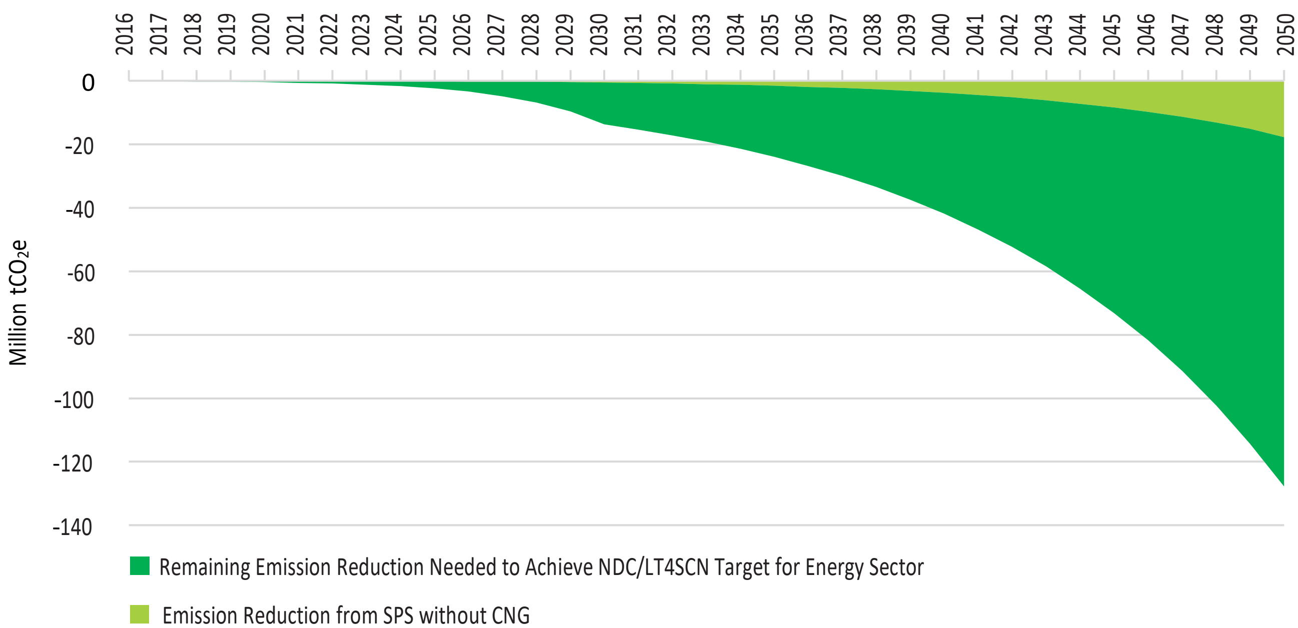
Under the NDC/LTS4CN Emission Reduction Scenario, the RCG aims to reduce the total emissions from the energy sector, which includes the transportation sector, by 13.7 million tCO2e by 2030 and 127.8 million tCO2e by 2050 compared to the BAU scenario. Achieving all targets related to road vehicle electrification under LTS4CN alone will only contribute a small portion of the GHG emission reduction required – about 4 percent of what is needed for 2030 and 14 percent of what is needed in 2050. It is clear that achieving these targets on electrification alone is not sufficient for achieving the emission reduction scale needed for the energy related sectors, and broadly for the net-zero target (Figure 40).

Power Demand from EV Charging through 2030

Powering transport activities on EVs instead of ICE vehicles would lead to an increase of power demand and decline of fossil fuel demand. With the validated battery efficiency of EV models shown in Table 13, the total charging demand to power the projected EV activity levels is estimated.

With the projected EV penetration level illustrated in Table 13, the total power demand for EV charging would be about 135 GWh by 2030 and 1,235 GWh by 2040 (Figure 41). This respectively represents about 0.45 percent and 2.6 percent of the projected power demand for 2030 (30,080 GWh) and 2040 (54,597 GWh) under Cambodia's PDP. Over the timeframe of 2023-2040, the projected EV charging demand could be accommodated by the planned generation capacity under the PDP.

Figure 40: Emission Reduction from SPS (without CNG) vs. Emission Reduction Required by NDC/LTS4CN for Overall Energy Sector



Source: World Bank, 2023.

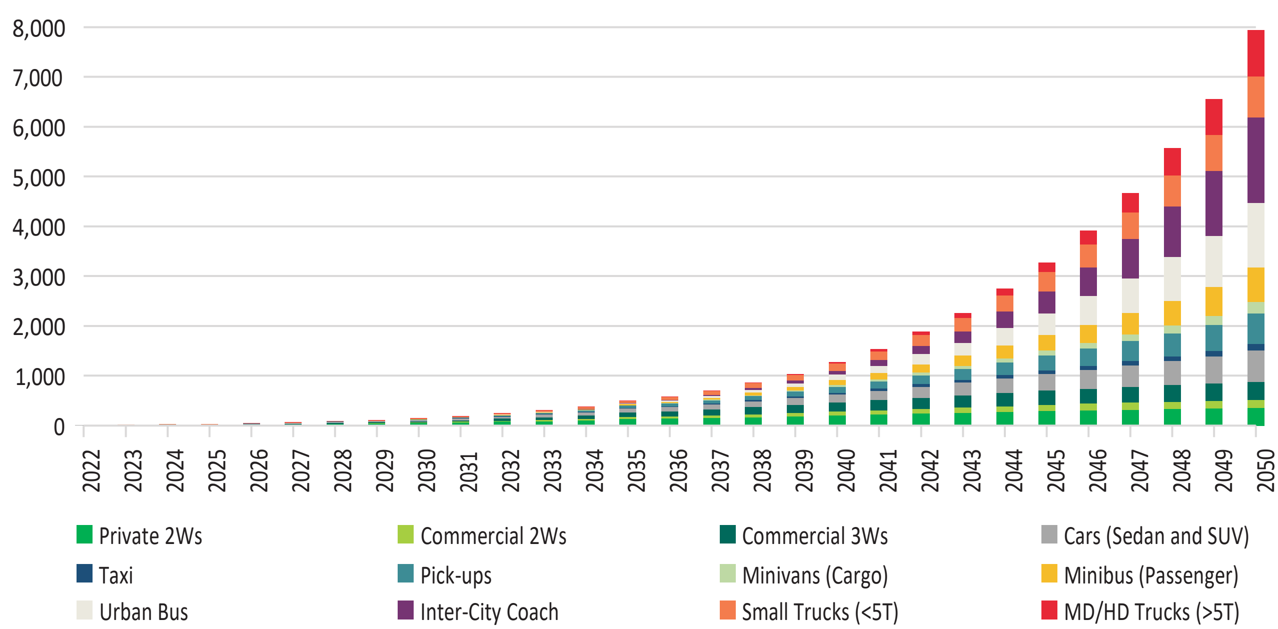
After 2040, the power demand from EV charging would raise exponentially for Cambodia. By 2050, the total charging demand would reach nearly 7,803 GWh. This increase of charging demand is driven by the increased EV penetration in large commercial vehicles segments, particularly medium- to heavy-duty trucks, inter-urban coaches, and urban buses. Medium- to heavy-duty trucks with about 11 percent EV penetration and inter-urban coaches with about 12 percent EV penetration would respectively generate over 1,700 GWh and 930 GWh charging demand by 2050. Urban buses, which have a much smaller vehicle stock size, would demand 1,300 GWh for charging once EV penetration reaches 40 percent as targeted by LTS4CN. Small trucks with 20 percent of EV penetration in 2050 would generate the fourth highest power demand for charging, at around 820 GWh. Motorcycles and light-duty vehicles together would require 3,200 GWh to charge.

Table 13: Assumed Electric Vehicle Efficiency Parameters by Vehicle Segment

Vehicle Segment	Electric Efficiency (kWh/100km)					
	2025	2030	2035	2040	2045	2050
Private 2Ws	0.017	0.016	0.016	0.013	0.012	0.011
Commercial 2Ws	0.018	0.016	0.016	0.013	0.012	0.011
Commercial 3Ws	0.054	0.050	0.050	0.041	0.037	0.034
Cars	0.159	0.145	0.145	0.121	0.110	0.100
Pick-ups	0.270	0.246	0.246	0.205	0.186	0.170
Minivans (Cargo)	0.203	0.185	0.185	0.154	0.140	0.128
Minibus (Passenger)	0.272	0.248	0.248	0.206	0.187	0.171
Urban Bus	1.072	0.977	0.977	0.811	0.739	0.673
Inter-City Coach	1.402	1.333	1.268	1.205	1.146	1.090
Small Trucks (<5T)	0.213	0.202	0.192	0.183	0.174	0.165
Medium- to heavy duty Trucks (>5T)	1.343	1.277	1.214	1.155	1.098	1.044

Source: World Bank Study Team, 2023.

Figure 41: EV Charging Demand by Vehicle Segments under SPS



Source: World Bank, 2023.

CHAPTER 4.

Key Implications for Achieving the Target

4.1 Implications to Cambodia's Policies on Vehicle Importation and Usage

E-Mobility Transition requires EVs to replace ICE vehicles in both annual new vehicle sales and the overall vehicle stock in-use. The primary driver for consumers' purchase choice between EVs and ICE vehicles is cost, both in terms of purchasing cost and total ownership cost over the lifetime of vehicles. As a new technology, EVs are gradually have been adopted across the world in recent years. Most of EVs operating today are new and well within their first economic lifetime. Therefore, the global second-hand EV market has not come about.

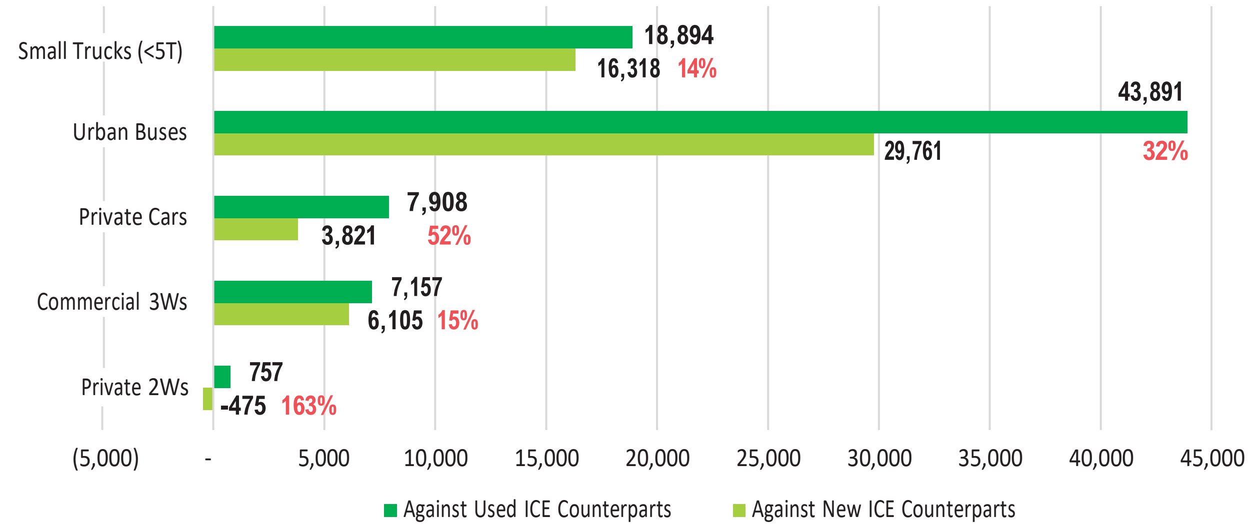
This has been a profound implication applied to Cambodia where the vehicle market is dominated by imported second-hand ICE vehicles, particularly in the passenger car and truck segments. It forces new EVs to compete with second-hand ICE vehicles. It enlarges the cost disparity, particularly purchasing costs, between EVs and ICE opponents as second-hand ICE vehicles are generally 20-50 percent cheaper compared with new ICE vehicles of the same model.

Based on the transition readiness assessment (Chapter 2), the TCO cost premium of EVs compared with second-hand ICE vehicles is 52 percent higher than compared with new ICE vehicles for passenger cars, 32 percent higher for buses, and 14 percent higher than trucks. In other words, in order for consumers to switch from purchasing the cheaper second-hand ICE vehicles to new EVs, the RGC would need to use its fiscal resources to subsidize the additional cost premium.

As the cost of EVs continues dropping, driven by global mass production and advancement of battery technology, new EVs are expected to reach full cost parity against new ICE vehicles across all vehicle segments. Once such cost parity is reached, the need for government subsidies to incentivize EV uptake among consumers would become minimum.

This is already the case for Cambodia for the 2Ws segment. As of 2022, the TCO of E-2Ws over 8 years is already cheaper by about US$475 compared to a new ICE-2Ws, which makes it financially attractive for 2W users in Cambodia to switch to E-2Ws provided the supply is not a constraint. In this case, the RGC only needs to incentivize consumers for the transaction rather than subsidizing the purchase. With about 82 percent of 2Ws imported in Cambodia

Figure 42: TCO Cost Premium of EVs Compared with ICE Vehicles



being new ICE vehicles in 2022, the 2W markets are ready for leveraging the cost parity of EVs against new ICE vehicles.

In comparison, if second-hand ICE vehicles are allowed to continue dominating the market, the fast-reaching cost parity between EVs and new ICE vehicles will become irrelevant. Second-hand ICE vehicles with their low selling prices would wipe out EV competitiveness unless large subsidies are offered by the government. It is worth highlighting that with advanced economies gradually phasing out ICE vehicles in their domestic markets, more second-hand ICE vehicles could enter Cambodia's market with even lower prices.

In summary, unless RGC gradually bans the importation of the second-hand ICE vehicles, large EV uptake in Cambodia would be either massively fiscal-intensive to subsidize the cost disparity between second-hand ICE vehicles and new EVs, or infeasible to achieve.

Another key policy decision is the vehicle-age limit. Currently, there is no mandatory vehicle-age limit for usage in Cambodia. As long as vehicles pass the mandatory annual safety inspections managed by MPWT, they could be used for as long as possible in theory. The lack of mandatory vehicle-age limit allows old, used ICE vehicles to circulate in the market for decades, and being available for resale multiple times with a lower price each time.

This significantly prolongs the transition of the total vehicle stock toward EVs. Policies need to mandate existing ICE vehicles to retire once reaching their economic lifetime or a certain age limit. This will free up demand for purchasing new vehicles where EVs are becoming cost competitive. Without a mandatory vehicle-age limit, demand for new vehicles would remain low which subsequently prevents EV penetration in the total vehicle stock.

Unless RGC gradually phase out the importation of the second-hand ICE vehicles, large scale EV uptake in Cambodia would be either massively fiscal-intensive to subsidize the cost disparity between second-hand ICE vehicles and new EVs, or impractical to achieve.

4.2 Implication to Macro Revenues and Expenditures

E-Mobility Transition is a systemic transition across Cambodia's energy and transport sectors, which would trigger a structural shift of macro revenues and expenditures from the old ICE vehicle/fossil fuel-based regime to an EV/power-based regime (Figure 43). Understanding the mechanism and the scale of this shift is critical for the RGC to plan for the E-Mobility Transition and optimize the cost-efficiency of fiscal policies to facilitate this transition.

Motor vehicles and fossil fuels are the first and third largest source of excise tax revenues for Cambodia, respectively accounting for 62 percent and 10 percent of the country excise revenue. In 2021, vehicle excise tax revenue for Cambodia was about US$0.58 billion (KHR2.4 million). Among motor vehicles, cars contribute the largest share across vehicle segments, followed by trucks. Motorcycles, although account for more than 70 percent of Cambodia's vehicle importation volume, contribute only a fraction of vehicle excise tax revenue (Figure 44). For fuels, gasoline and diesel collectively contribute to nearly 90 percent of total excise tax revenue from fossil fuels. As Cambodia imports nearly all vehicles and fuels, their excises are collected by GDCE under MEF.

The excise tariff for motor vehicles is governed by a complex excise tax systems in Cambodia. It uses a myriad of harmonized system codes to distinguish between various attributes of vehicles, including the type of vehicle, engine type, engine size, and purpose (Table 14). In general, motorcycles are taxed between 2-25 percent depending on engine size. Similarly, smaller 4-W passenger vehicles (carrying less than 10 people) are taxed based on engine sizes, with rates typically ranging from 50-55 percent. Large passenger vehicles (carrying more than 10 people) are taxed based on the gross weight of the vehicles, with rates typically ranging from 35-40 percent. For commercial freight vehicles and trucks, the tax rate is typically between 10-40 percent. Electric vehicles enjoy a lower excise tax rate at 10 percent.

Figure 43: Real Vehicle Excise Tax Revenues in Cambodia, 2017-2021

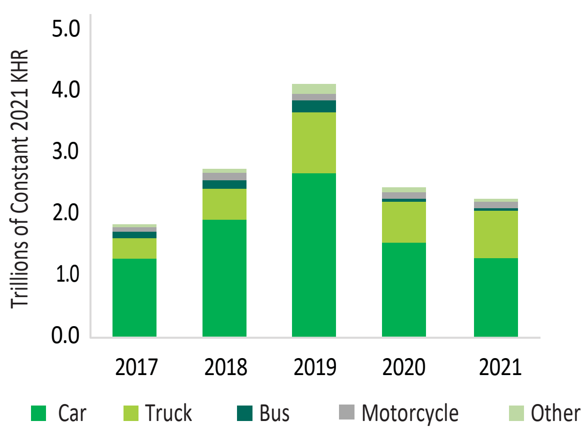
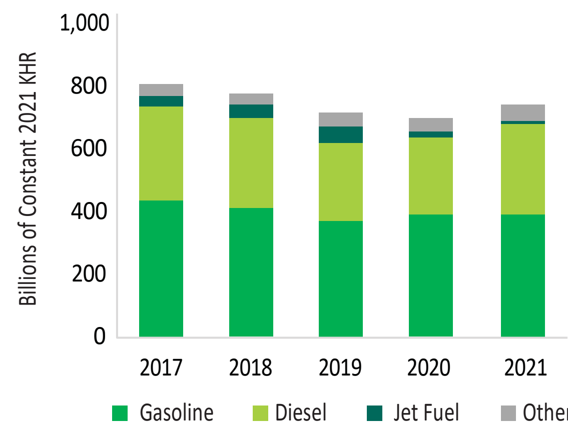


Figure 44: Real Fuel Excise Tax Revenues in Cambodia, 2017-2021



Source: GDT; GDCE; GDP; World Bank World Development Indicators.

Table 14: Selected Motor Vehicle Excise Tax and Tariff Rates, 2022

Category	Also including	Harmonized System Code	Excise rate (%)	Tariff (%)	Other
Motorcycles	Scooters, mopeds, and motorcycles	8711	5 to 25	15	
Motor cars	Includes recreational vehicles, trikes and motor cars	8703	10 to 55	35	Lower rates on electric vehicles (10%) and trikes (20%); most sedans and larger motor cards taxed at 50%
Motor cars (>10 people)	Motor coaches, buses and minivans	8702	10/40/55	15/15/35	Higher rates on luxuries (e.g., limousines); lowest rates on electric vehicles
Trucks	Wide range of commercial vehicles	8704	10 to 40	15	
Heavy duty vehicles	Buses, cranes, drilling, concrete mixers, etc.	8705	30	15	
Tractors		8701	25	15	
Works vehicles	Forklifts, airport ground handling, etc.	8709	10 to 20	15	

Source: GDCE.

Most fuels in Cambodia attract an excise of 10 percent; however, diesel attracts a lower rate of 3 percent (Table 15). Unlike other excisable products, excise tax rates on gasoline and diesel have varied substantially in recent years, with rates being reduced in 2021 (35 to 20 percent on gasoline, and 15 to 7 percent on diesel) and then again in 2022 (to 10 percent on gasoline and 3 percent on diesel). Reductions in rates coincide with increases in global energy prices and attempt to cushion the multiplier effect on retail prices and excise revenue.

Fuel tax revenues are expected to be volatile since the value on which the ad valorem tax is levied is a function of volatile global energy prices. Excise tax revenues on fuels declined in real terms between 2017 and 2020. Revenues increased dramatically in 2021 as global energy prices soared, increasing the value of the tax base. The ad valorem tax structure multiplies the volatility in prices and excise tax revenues generated by volatility in global energy prices. For example, for every US$1 that global market prices increase, retail prices would increase by US$1.10, because the ad valorem tax is applied to the price increase. Retail prices have risen by 64 percent and 86 percent, respectively, on gasoline and diesel since January 2021. Future revenue trends are difficult to predict.

Table 15: Selected Fuel Excise Tax and Tariff Rates, 2022

Category	Also including	Harmonized system code	Excise rate (%)	Tariff (%)	Other
Gasoline		2710	10	15%	Additional specific import tariff of US$0.02/liter
Automotive diesel		2710	3	0	Specific import tariff of $0.04/liter
Jet fuel	Kerosene	2710	10	7	Some fuels for piston aircraft have a higher excise rate of 15%; no import tariff on kerosene
Natural gas		2705; 2711	0	0	
Crude oil		2709	0	7	
Electricity		2716	0	7	Import tariff mostly moot since all neighboring countries are ASEAN

Source: GDCE

While the price controls aim to mimic the development of crude oil prices, the price stabilization mechanism can lead to a "silent subsidy" whereby retail price increases are smaller than the increase in global prices. At the time of writing, no official information has been provided on the magnitude of the silent subsidy. The stabilization of the gasoline prices led to a subsidy of US$83 million in 2018, and in November 2018, the subsidy was reported to be KHR 160 and KHR191, respectively, per liter of gasoline and diesel (Khmer Times 2018). While in 2020, the subsidy of both gasoline and diesel was reported to be KHR 260 per liter (Khmer Times 2022b). While the "silent subsidy" does not directly undermine revenue generation, it forms a tax expenditure and either crowds out other government expenditure or increases the fiscal deficit and/or debt.[17] It also undermines the environmental effect via the reducing the indirect carbon price set by excises.

Photo: Khmer Times.

Under the E-Mobility Transition, motor vehicle imports will shift from ICE vehicles, particularly second-hand ICE vehicles, to EVs. Although the current excise tax policy provides a positive incentive for EV importation by imposing a lower excise rate of 10 percent as compared with 30-55 percent for ICE vehicles, corresponding policies need to be introduced to raise taxes on 'dirtier' or more emissive ICE vehicles. Without such supporting policy, Cambodia faces a high risk of excise tax revenue reduction from motor vehicles as more EVs are imported at 10 percent rate and fewer ICE vehicles are imported.

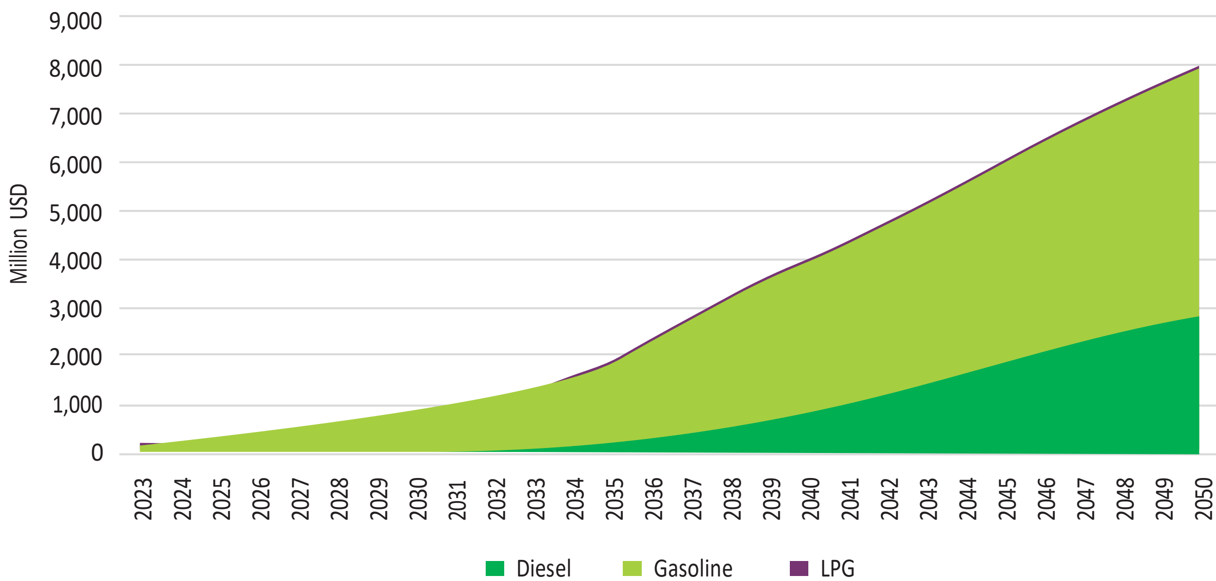
A key decision RGC needs to make for E-Mobility Transition is how to reform the current excise tax policies for motor vehicles in order to minimize the transition impact to vehicle excise tax revenue as more EVs get imported.

A key decision RGC needs to make for E-Mobility Transition is how to reform the current excise tax policies for motor vehicles in order to minimize the transition impact to vehicle excise tax revenue as more EVs get imported. This could be done by linking excise taxes to vehicle emissions rather than other parameters currently used such as engine size and gross vehicle weight. Specifically, RGC could consider setting excise tax rates based on specific vehicle fuel efficiency standards for new ICE vehicles and vehicle-age for second-hand ICE vehicles. The lower the fuel efficiency standard is for new ICE vehicles the higher the excise rate. The older the vehicle-age is for second-hand ICE vehicles, the higher the excise rate. The overall excise rate for new ICE vehicles should be lower than second-hand ICE vehicles while both are substantially higher than for EVs.

Similarly, E-Mobility Transition will lead to a decline of demand for gasoline and diesel by ICE vehicles and an increase of demand for electricity. From an expenditure perspective, this transition generates positive impact as it reduces Cambodia's dependency on fuel importation and fuel energy security as well as exposure to global fossil fuel price volatility. Cambodian importers as well as the government will save significantly from a reduced need for a silent subsidy for gasoline and diesel to cushion the price volatility. The economy-wide estimates indicate a savings of US$8 billion from fuel importation and usage by 2050 under the PSS EV uptake scenario (Figure 45).

17 It may indirectly undermine revenue generation if the increased revenue from excise is used to fund the subsidy. Assuming that the ad valorem tax rate remains unchanged, an increase in global prices will result in an increase in excise tax revenue, which may be used to finance the tax expenditure later in the supply chain. However, this is complicated by reductions in the excise tax rate as global prices have risen in the last two years. Without detail on the magnitude of the silent subsidy, it is not possible to know the indirect impact on revenue generation.

Figure 45: Gross Fiscal Savings from Fossil Fuel Reductions (constant 2023 prices)



Source: World Bank, 2023.

From the perspective of fiscal revenue, the decline in gasoline and diesel demand will lead to a corresponding decline of excise tax revenue generated from these fuel products. As demand for fueling motor vehicles shifts from combustion of fossil fuel to electricity, the revenue stream will transfer from fossil fuel tax revenue to electricity tariff revenues. In order to mitigate the transition impact, RGC is advised to design tax and tariff mechanisms to capture the revenue transferred from fossil fuel consumption to power consumption.

In the meantime, the current excise tax policy for fossil fuel could be reformed to cushion the tax revenue reduction following the E-Mobility Transition. It can be done by equalizing specific taxes on gasoline (10 percent) and diesel (3 percent) by increasing taxes on diesel to 10 percent. Additionally, RGC could introduce a price on carbon for all fossil fuels based on their carbon contents. Such price on carbon could be raised over time as demand for gasoline and diesel decline with EV penetration. It would both incentivize the E-Mobility Transition while acting as a buffer for fossil fuel tax revenue reduction.

In order to mitigate the transition impact of declining excise tax revenue from gasoline and diesel demand, RGC is advised to design tax and tariff mechanisms to capture the revenue transferred from the fossil fuel consumption to power consumption.

4.3 Implications to the Grid Level Energy Planning and Charging

The total energy demand from EV is projected to be around 1.5 percent of projected power demand under PDP by 2030. However, a further steep increase in vehicles transitioning to electric after 2030 will significantly impact the energy demand as it is estimated to reach over 8.9 percent of the energy demand projected by the PDP by 2040.

The PDP forecasts up to 2040 are based solely on high voltage networks and do not fully consider the impact of where and how the vehicles may charge. Therefore, it is important to note that these forecasts should be used for illustrative purposes only and that the impact of outside factors, such as technological and societal factors, could significantly alter the trajectories.

Additionally, PDP does not consider the full fleet in their forecasts which are only looking at high-voltage networks and not low-voltage networks that are directly impacted by home charging. Therefore, it is essential to recognize the potential impact of factors outside of PDP on the E-mobility market and the importance of ongoing reassessment and adaptation to changing circumstances.

In order to realize the target EV scenarios, a new zero-emission infrastructure model is required. The traditional oil-based transport refueling model, serving all vehicle types, will likely not fit the future transport system as different EV segments will require bespoke charging speeds and power requirements. Table 16 presents the assumed charging models by vehicle segments.

Detailed charging infrastructure results are presented in Appendix B.

Home Charging

The majority of electric motorcycles and cars/pick-ups are privately owned and are likely to be charged at home at the most cost-effective rate in the future. This is based on charging habits in other countries, and the convenience of home charging, which is particularly relevant for E-2Ws as their small battery can be charged using a standard plug. The existing E-2Ws models in the Southeast Asian market typically require 6-8 hours for a full charge using home charging.

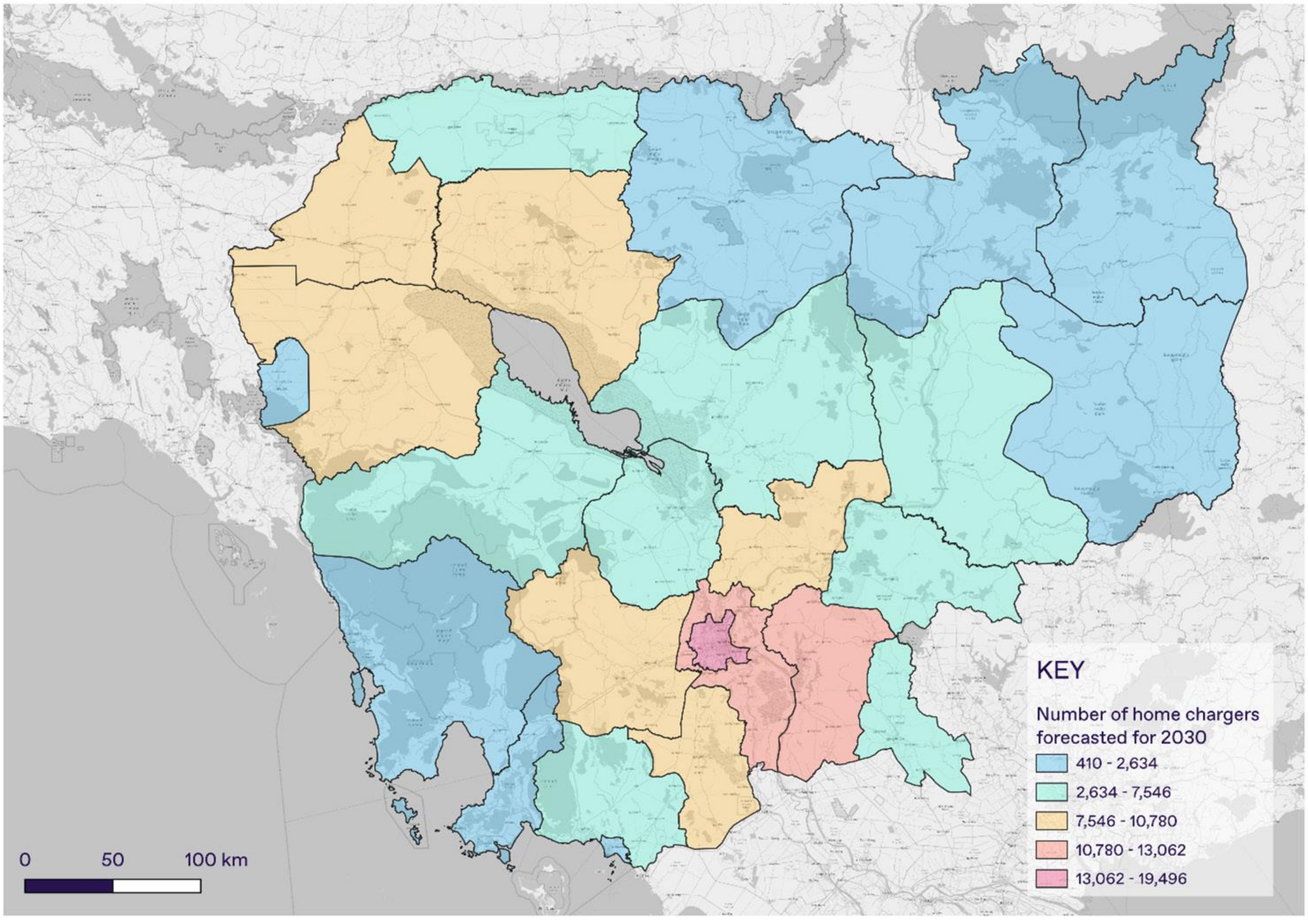
Private 4-Ws are expected to charge through a dedicated home charging unit (typically 7kW), which can charge a vehicle in 4-8 hours, depending on the battery size and vehicle type. Figure 46 illustrates the project 4-W home charging demand to 2030. The projected demand for home charging is focused on Phnom Penh, resulting in an estimated 6 percent of properties requiring a form of home charging provision.

The projections indicate 272,248 motorcycles and 164,285 4-Ws will home charge by 2030. It is assumed only one home charger will be installed per property.

Table 16: Assumed Charging Types by Segment

	Charging Type				
Vehicle Segment	**Home**	**Destination**	**Top up**	**Battery swapping**	**Depot**
Charging Power	2.3-7kW	10kW	50kW	20kW	7-50kW
Private 2W	X			X	
Commercial 2W				X	X
Commercial 3W				X	
Private 4w and Pick-ups	X	X	X		
Minivans		X	X		X
Buses and heavy-duty vehicles					X

Figure 46: Provincial Home Charging Demand By 2030 For Private 4Ws



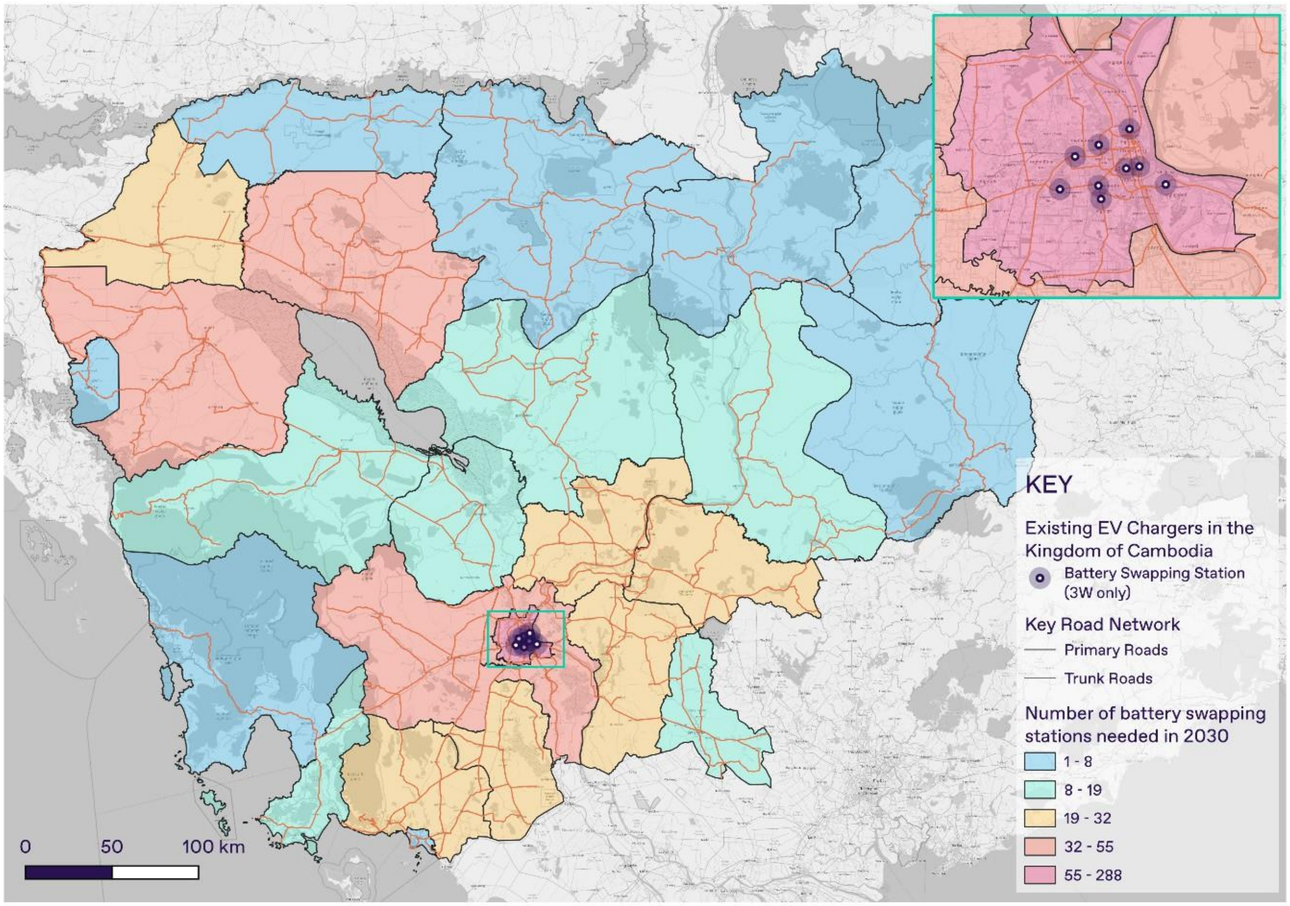
Source: World Bank, 2023.

Battery Swapping

For 3-Ws (tuk-tuks), which are expected to be mostly commercial vehicles, battery swapping is likely to be the preferred model as it offers the opportunity of a longer range without waiting to charge. Figure 47 illustrates the magnitude of battery-swapping stations that may be required per province in Cambodia by 2030. Urban centers and surrounding areas are expected to require the highest demand for battery swapping, as a result of commercial vehicle density. Phnom Penh and neighboring provinces, Kampot and Prey Vang, are expected to require 35 percent of the battery-swapping demand by 2030 to cope with demand of increased EV adoption in the motorcycle segment.

It is estimated that the cost of the required public battery-swapping infrastructure for motorcycles will be in the region of US$5 million by 2030, based on an average cost of US$10,000 per unit. It is important to note that the exact mix of charging between home, work, public, and battery-swapping stations is still uncertain and will depend on consumer preference and technological developments.

Figure 47: Battery-swapping Requirements by Province



Source: World Bank, 2023.

Public Charging (Destination & Rapid Top-Up)

Four-wheelers are likely to follow a similar pattern to 2-Ws, with around 80 percent of charging expected to take place at home (this may be higher in rural areas and lower in urban settings). For those not able to charge at home or requiring a rapid opportunity charging or "top-up" charge on longer journeys, public infrastructure will be required to meet the ongoing demand. By 2030 Cambodia is forecasted to require between 750 rapid chargers and 1,800 fast chargers rolled out throughout the 25 provinces.[18]

Public EV charging stations offer various charging speeds and are strategically located in cities and towns. They offer the opportunity of having higher-powered chargers (50kW and above) and can incorporate additional technologies such as battery storage and solar photovoltaic canopies. They can also support key destinations such as tourist attractions, town-center car parks, and leisure facilities. It is estimated that the cost of the required public infrastructure for 4-Ws will be in the region of US$50 million by 2030, based on an average cost of US$50,000 per rapid charge point and US$7,500 per fast charger.

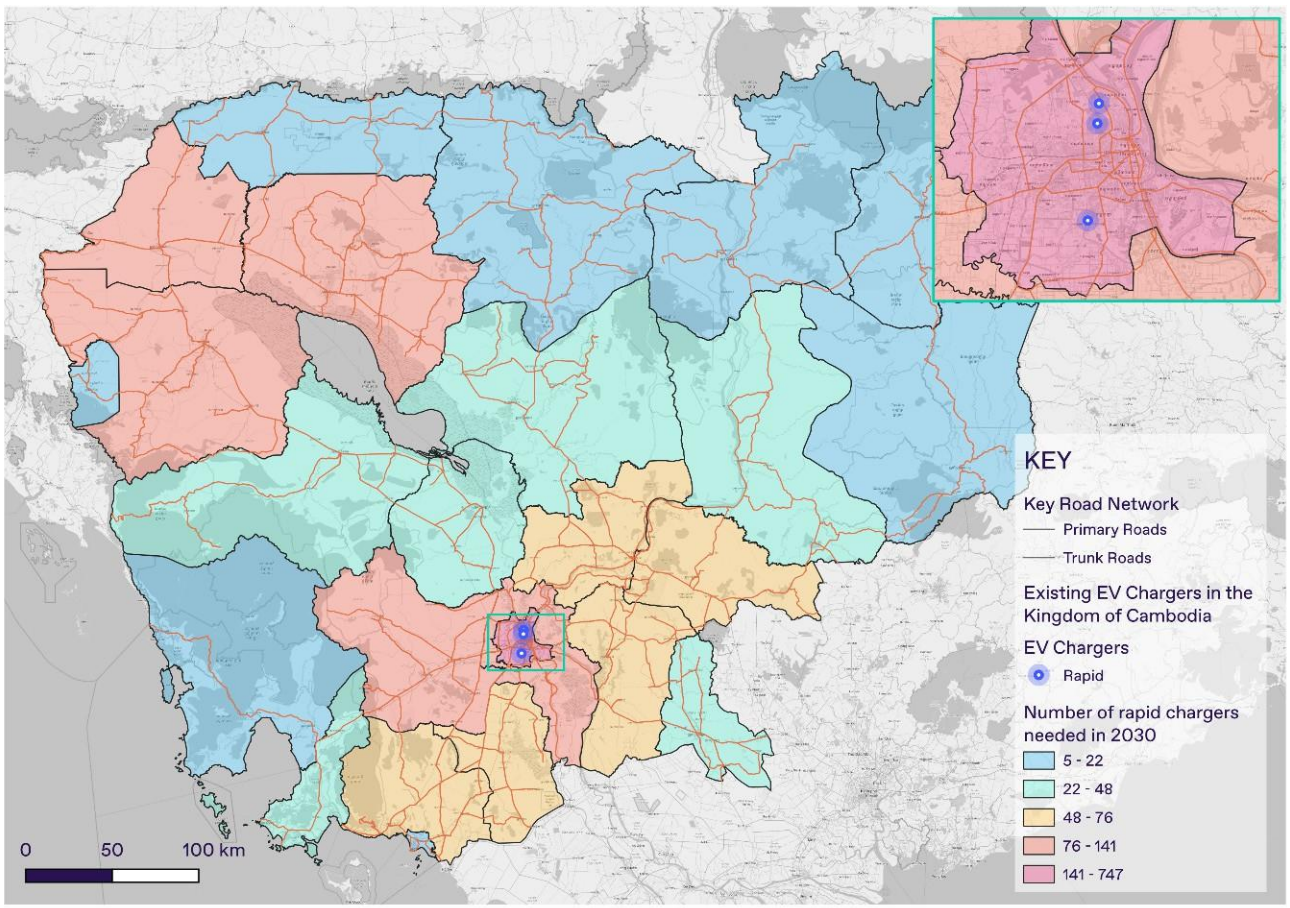
18 These numbers go up to 7,000 and 15,000, respectively by 2050.

Heavy-Duty Vehicle Depot Charging

Commercial organizations with their own fleet may install dedicated private charging infrastructure for their vehicles (e.g., 4Ws, minivans, buses and heavy-duty vehicles) to charge at their own depot location at night and/or day. This may also be the case for commercially owned 2W fleets (e.g., transporter fleets) that may use a private battery-swapping system at their depot for carriers to swap batteries between morning and afternoon shifts.

By 2030 Cambodia is forecasted to require approximately 1,200 chargers, at varying charging speeds, at depot locations to support commercial fleets in their transition to EVs. It is estimated this investment could cost commercial organizations up to US$8 million to complement their electrified fleet activity.

Figure 48: Map of Rapid Charger Demand 2030



Source: World Bank, 2023.

Box 3. What will this Public Infrastructure Look Like?

Selecting the Right Site

Site selection and size must complement charging behavior, locating charging at strategic points on major road networks, following the petrol station model. This should be complimented by charging at locations where vehicles are parked for a considerable period of time (such as home, work, or destinations) and should be in smaller numbers.

Sites should be selected in areas with the greatest demand to provide charging and facilitate EV uptake. Sites along major road networks should prioritize direct current fast charging to attract drivers who make long journeys. Charging stations at workplaces or in existing car parks are more likely to be left for longer periods of time, so a range of chargers can be installed.

To provide the energy to charge EVs, charging stations must be connected to the electricity distribution network. The type of connection needed depends on the specifications of the site, but high speed and direct current charging require a 480-volt, 3-phase electrical supply.

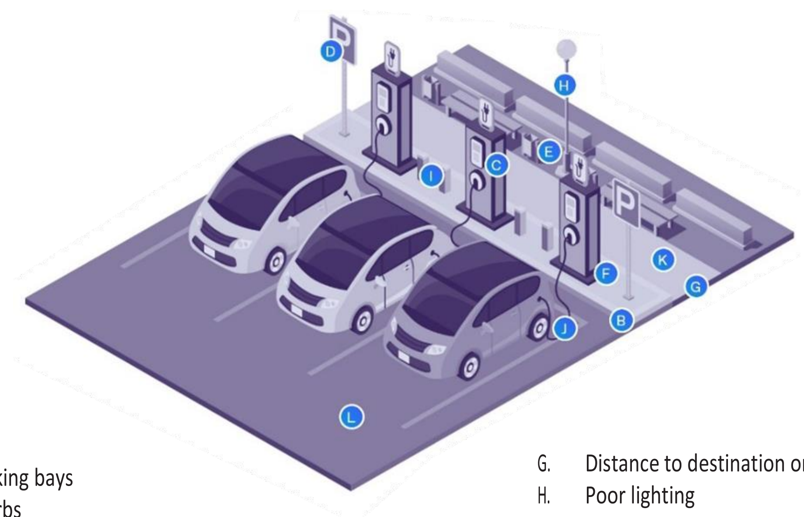
Sites can be 'future-proofed' by building charging stations that can be updated and expanded as the EV market and technology evolves.

Design for an Intuitive, Safe and Accessible Environment

It is critical to ensure that the infrastructure is perceived as inclusive and accessible to encourage the adoption of EVs. In the United Kingdom, public EV charging spaces must adhere to building regulations that require them to be 4.8 meters long by 2.4 meters wide, with an additional 1.2 meters of space on the sides and at the back, allowing for wheelchair access.

In addition to the parking space, the entire environment of the EV charging station must be accessible to all users. Standardized design across charging sites can foster familiarity, reducing user anxiety about EV infrastructure. Seating provision is also essential, especially in remote locations. Any street furniture such as bollards and curbs must be designed to avoid obstructions for users. It is important to avoid bollards that increase reach, curbs that limit access, and any other obstacles that could hinder the use of a charging point.

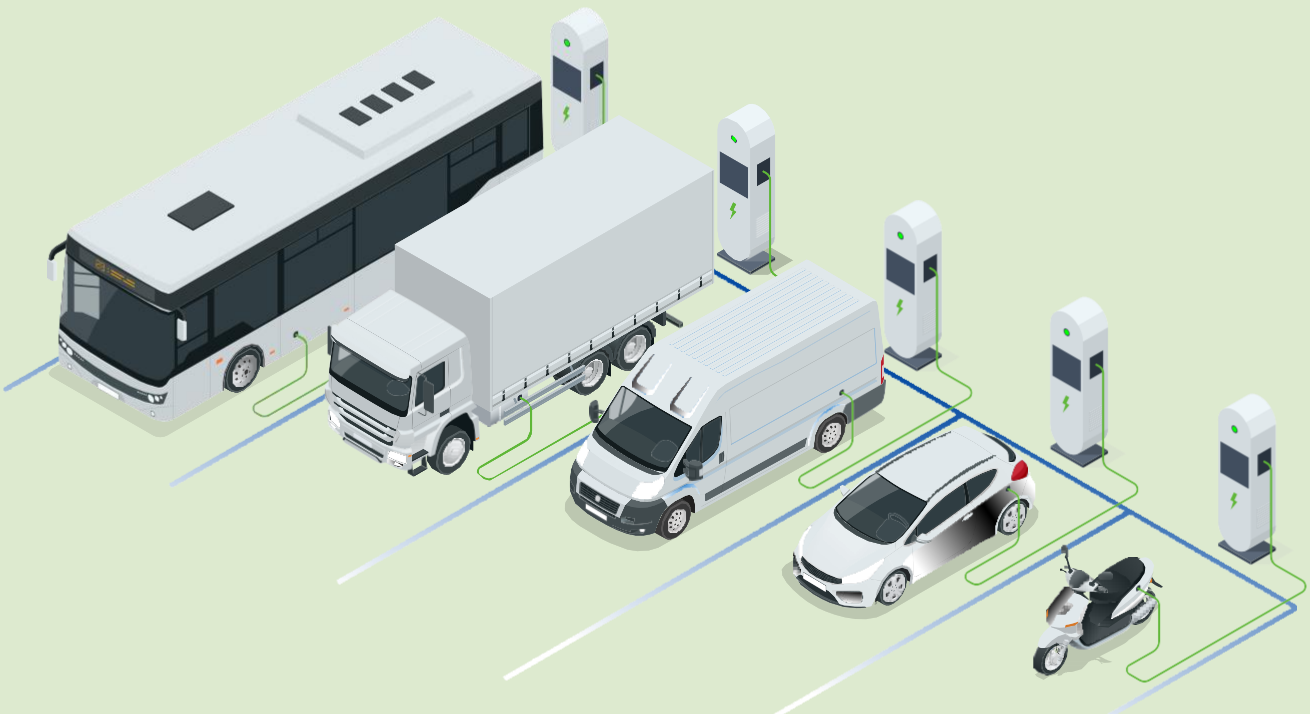
Figure 49: Considerations for Accessible EV Charging Bay and Infrastructure



A. Small parking bays
B. Raised kerbs
C. Height and orientation of sockets and screens
D. Poor inconsistent signage
E. Street clutter
F. Insufficient space around charge point
G. Distance to destination or facilities
H. Poor lighting
I. Bollards prevent access to charge point
J. Trailing cables
K. Ease of pedestrian access and proximity to exit
L. Inappropriate surface materials and gradients

Source: World Bank Study, 2022

Paying for charging should not present a barrier to EV uptake. Charge points should accept a range of common payment methods (i.e., contactless or QR codes) without the need for subscriptions or registration. Pricing should be clearly stated in a standard unit, such as KHR/kWh.

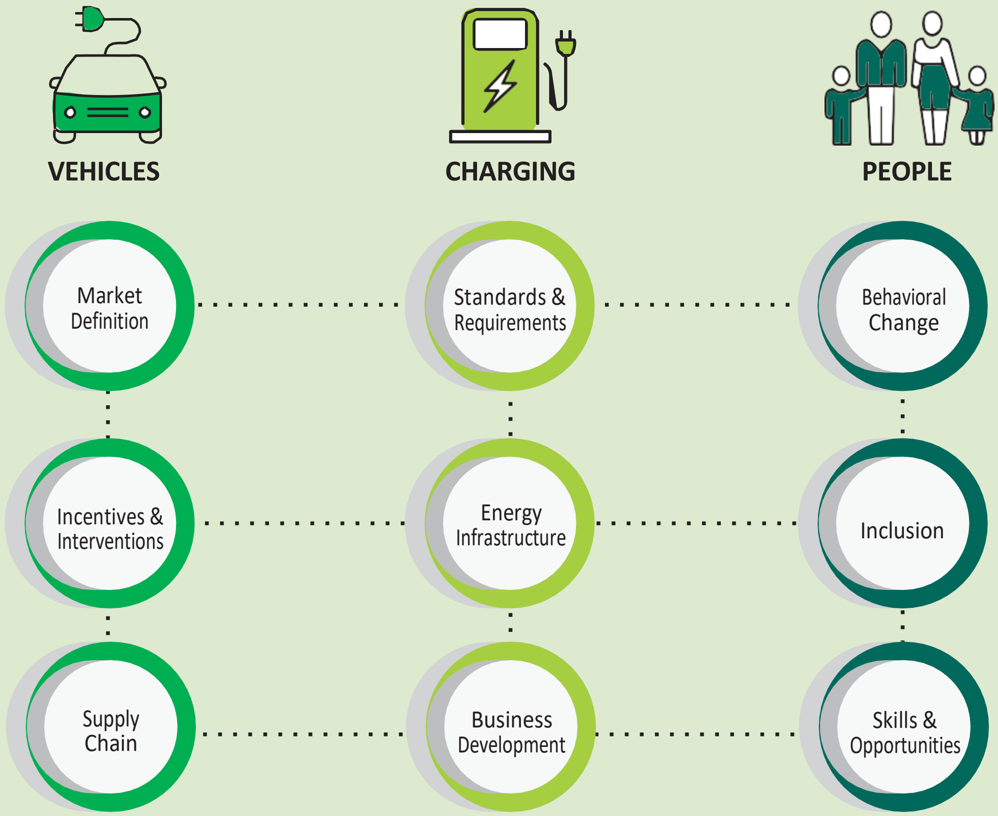


CHAPTER 5.

Recommendations and Action Plan

Based on the market readiness assessments, EV uptake projections, and key implications previously discussed, this chapter provides a recommended roadmap to RGC to steer the E-Mobility Transition toward the stated policy targets by 2050. The proposed roadmap cuts across three key dimensions of the E-Mobility Transition – (a) vehicles, (b) charging, and (c) people – with specific interventions identified for each dimension under a specific implementation timeline.

Figure 50: Framework for E-Mobility Transition Roadmap



Source: World Bank Study, 2022.

Phases	Recommendation Categories
Short term (2024 – 2026)	Market Interventions
Short and medium term (2024 – 2030)	Priority Regulatory Measures
Medium and long-term (2030 - 2050)	Medium and Long-term Policies

5.1 Summary of Market Interventions

The following market interventions are actionable items, which could be adopted by RGC between 2024 and 2026. Taken together, these interventions would kick-start and accelerate the E-Mobility Transition in Cambodia based on the analysis in the previous chapters. The focus is on targeting the segments with the greatest impact and level of maturity and removing the most pressing barriers. All the interventions aim for financial sustainability, generating revenue for RGC over this timeframe. The proposed seven market interventions are detailed in the following sections.

E-Mobility dimension	Proposed Intervention	Location	Approximate costs (US$)
Data	1. **Developing a data platform to monitor trends in vehicle type**, usage, and scrappage across Cambodia.	Nationwide	500,000
EV Supply	2. **De-risking and incentivizing E-2Ws uptake**, recognizing that while they have a higher purchase price than ICE equivalents, they are already cheaper over lifetime.	Nationwide	19,000,000
EV Supply	3. **Establishing a scrappage scheme for ICE-3Ws**, creating an incentive to get a wider range of E-3Ws on the market in Cambodia.	Phnom Penh	4,500,00
EV Demand	4. **Introducing disincentives for new ICE-2W purchases**, encouraging drivers to adopt EVs instead while preserving access to transport.	Nationwide	Revenue: 31,000,000
EV Demand	5. **Deploying a large-scale public communications campaign** about the benefits of EVs generally and the cost savings arising from E-2Ws, specifically.	Nationwide	1,000,000
EV Demand	6. **Explore the feasibility to convert a greater number of government fleets to EVs**, starting with MME and MPWT.	Phnom Penh	1,875,000
Charging	7. **Establishing a network of EV charging hubs** – rest areas with EV chargers along main routes, delivered through a concessionaire model.	Expressway 4	3,000,000

Intervention 1: Data Platform to Monitor Trends and Manage the Transition

Rationale:

The lack of accurate data on total stock, sales, and scrappage can rapidly become a blocker to the E-mobility uptake. The projections used within this roadmap have been constrained by a lack of data, requiring various assumptions about vehicle stock and usage. As the number of vehicles rises, collecting specific data on vehicle types and scrappage is essential, particularly for charging infrastructure planning and revisions of the EV uptake incentive policies. This will allow evidence-based policy planning as well as monitoring and evaluating the impact of any changes.

Intervention Description:

Establishing a data platform will enable MPWT and GDCE to monitor the total stock of electric vehicles imported and on the road in Cambodia. Three additional data collection points will be necessary:

1. When electric vehicles are imported to Cambodia, GDCE needs to be able to register the numbers of EVs imported by vehicle segments.
2. When vehicles are registered for the first time in Cambodia, data should be collected and stored on a government digital system. The data should be classed according to manufacturer, model, fuel type, and the price paid for the vehicle.
3. When vehicles are scrapped, taken off the road, or deregistered for road tax, this should also be noted on the digital system.

A clearer understanding of the total vehicle stock can be obtained by monitoring vehicle flows on and off Cambodia's roads. This information is beneficial for various planning purposes, including predicting the need for road infrastructure, parking, and electric vehicle charging infrastructure. Establishing a digital platform will simplify operations and automate data collection from the vehicle registration system. This platform also provides an opportunity for RGC to enhance its relationships with the automotive industry, which holds much of the required data and can benefit from market insights provided by the platform.

A detailed breakdown of the vehicles will enable the government to closely monitor the effects of policy levers and make subtle adjustments based on the desired results. By tracking the impacts of these policy tools on the vehicles, the government can determine whether the expected outcomes are being achieved and take corrective measures as needed. Eventually, hosting the data on an Open Data platform could promote a transparent and competitive marketplace for the private sector to target and plan investments in E-mobility projects.

Expected project cost	US$500,000
	Establishing the platform will require two phases – design and operation. Costs for these can be minimized through rigorous and transparent procurement, but the estimated design could cost would be around US$500,000, including the resources required to train RGC officials in the system's operation. The RGC could then undertake operations without additional costs.
Location	Nationwide
Investment model	Since monitoring the number of vehicles on the road is not a revenue-generating activity, it is unlikely to appeal to private investors. However, as this intervention offers significant sustainability benefits, it may attract support from development partners. Ongoing costs from a slight increase in registration fees may also be a way to part-fund the platform
Risks and risk allocation	Low
	Care must be taken to ensure data is stored and managed securely.
Monitoring and evaluation	This forms an important part of the monitoring and evaluation framework for the other interventions and will also be crucial to informing a much broader range of transport policies.

Intervention 2: Incentives and De-risked Financing for Electric 2-Ws

Rationale:

The market readiness assessment conducted for this roadmap has demonstrated that E-2Ws are already cost-competitive over their lifetime when compared to ICE (gasoline) equivalents. These TCOs are conservative and assume battery replacement halfway through the 8-year lifetime for the electric model.

Based on this study's calculations, a new E-2W will cost US$3,551 over an 8-year lifetime (based on a Sunra Robo-S), compared to US$4,026 for a new ICE equivalent (Honda Dream). Both EV and ICE models are on the market for an identical purchase price of US$2,400; and the typical constraint to EV adoption – high upfront costs with savings distributed over the vehicle's lifetime – is not present. Cambodia is therefore close to achieving mass adoption of E-2Ws if accessible financial options are available to avoid increasing the demand for ICE secondhand 2Ws.

Two constraints remain:

1. **Limited supply of used E-2Ws.** At present, a typical used Honda Dream in good condition has a TCO of US$2,793 over 8 years meaning that a used option will be over US$800 cheaper than a new EV over the whole lifecycle. According to MPWT, over 82 percent of motorcycles imported into Cambodia were new in 2021, but 72 percent of all motorcycles purchased in Cambodia are second-hand. This therefore suggests that the main supply of used vehicles is domestic.
2. **Lack of financing options for E-2Ws.** This was identified by GGGI in 2021 as an issue and, based on primary research undertaken for this roadmap in late 2022, continues to present a challenge. The underlying challenge is the consumer's low confidence level in expected resale value for E-2Ws, leading financial institutions to have concerns whether loans can be settled if an EV is sold.

These constraints are connected with the uncertainty around the battery service life, which forms a reasonably large part of the purchase price. The TCO calculations have assumed a battery replacement cost of US$500 at some point during a 8-year ownership. The expectation that a driver will need to pay for this out of pocket to maintain the asset's value is also a concern from a financing perspective.

Microfinance institutions are an essential source of credit for 2W purchases, particularly in rural areas. The National Bank of Cambodia Prakas with regard to interest rate ceiling on loans has limited the interest rate to 18 percent, while another Prakas has introduced controls around the types and nature of the collateral (National Bank of Cambodia 2017). While these policies have played an important role in protecting vulnerable borrowers, they may also have reduced the ability of microfinance institutions to support lending for vehicles, particularly for new technologies such as EVs.

Intervention Description:

Improving access to affordable finance would act as a key factor to unblock the uptake of E-2Ws in Cambodia. State-backed guarantees could increase lender confidence in the E-2Ws market. These state-backed guarantees can take the form of backing a portion of the bank's loan books for E-2Ws or providing subsidies against higher interest rates to ensure parity with ICE financing offers.

An alternative approach could be to subsidize the cost of higher interest rates; but given the above-mentioned Prakas, this has been discounted for the purposes of this roadmap. The direct public sector provision of loans could also be considered but would likely be much more costly and logistically challenging.

Expected project cost	US$19,000,000 This intervention's cost would depend on the policy's specific design. For instance, if it is assumed that 10% of loans for E-2Ws are at risk of default, guaranteeing these loans between 2024 and 2026 could cost about US$19 million. Both of these figures are based on projected registrations of ICE and E-2Ws outlined earlier in the roadmap.
Location	Nationwide

Investment model	This intervention could be managed either as a public sector guarantee or subsidy available to all banks making loans against E-2Ws. Alternatively, it could be established as a PPP with a specific lender. While a PPP would be easier to manage and reduce the risk exposure to RGC, it could also crowd out the number of banks prepared to lend in the market due to the strengthened position of the PPP concessionaire.
Risks and risk allocation	Medium
	The main risk associated with this intervention is RGC exposure to unpaid loans on E-2Ws. A PPP would help to reduce this by enabling a proportion of the risk to sit with a private sector concessionaire. This risk could also be mitigated by seeking data from existing auto-finance firms about default rates.
Monitoring and evaluation	The data platform (Intervention 1) will support the monitoring and evaluation of this intervention. A key metric will be the number and types of 2Ws purchased, enabling decision-makers to understand which sub-segments (i.e., based on size) are transitioning to EVs more quickly than others.

Intervention 3: Scrappage Scheme for ICE-3Ws

Rationale:

In Cambodia's major cities, 3Ws (tuk-tuks) are a crucial part of the transport mix and a significant source of income for vulnerable informal workers. However, they also contribute to air pollution and GHG emissions. With pressure from ride-hailing apps (Leith 2023) and reduced demand due to Covid-19, 3W drivers have experienced income reductions.

While electric tuk-tuks are present in Cambodia, they are currently a niche product supplied by only one firm (ONiON). Cost-wise, they are not competitive with new ICE vehicles as seen in the market assessment in Intervention 3.[19] Facilitating a wider range of E-3Ws being imported or manufactured locally could drive down costs and increase competition, ultimately reducing emissions.

For instance, the most common model of E-3Ws in India (Mahindra Treo) can be purchased for around US$3,000 (in India), including the battery, which can be charged at home or commercial charging stations. A 130-km range can be achieved with a battery of 8 kWh – which, if charged at home in Cambodia, would yield a fuel cost of just over US$0.01/km. There is, therefore, a need to increase the diversity of models and supply of E-3W in Cambodia's cities – which will create a virtuous circle of competition and gradually reduce costs.

Intervention Description:

Introducing a scrappage scheme would involve incentivizing drivers of older LPG-powered tuk-tuks to scrap their vehicles and purchase a new electric tuk-tuk by providing a subsidy. This would increase demand for electric tuk-tuks and make them more affordable for drivers, potentially positioning Cambodia as an attractive market for E-3Ws. Similar schemes are being proposed in other countries with established 3W markets such as India (India Times 2021).

A subsidy of US$1,000 paid directly to the tuk-tuk supplier could be effective to close the initial purchase price gap between electric and new ICE vehicles. A vehicle importer could administer the subsidy to ensure the proper use of funds. Proper disposal of scrapped ICE tuk-tuks should be ensured with the responsibility for this should place on the scheme operator to promote material recycling.

19 At present, drivers purchase E-3Ws for around US$5,000 without ownership of the battery, which is recharged by battery swapping for US$3. A fully charged battery can provide 80-100 km in range and has an average fuel cost per km of around US$0.03. By contrast, new ICE-3Ws can be purchased for around US$3,000. Efficiency can range between 30-40 km per liter of LPG, and the cost of LPG at the time of writing in Cambodia is US$0.56, implying a fuel cost of around US$0.02/km.

Expected project cost	US$4,500,000 This project is scalable and adaptable to available funding. To achieve the desired outcomes, a minimum scale of 1,000 units per year would be necessary to attract a wider range of E-3Ws onto the market, potentially even resulting in building opportunities for a new assembly in Cambodia. The subsidy cost for 1,000 units per year would be US$1 million annually. Costs associated with the disposal of ICE vehicles could be offset by selling recycled materials. After administrative expenses, the total cost is estimated at US$1.5 million per year. Over 3 years, the total project cost would be approximately US$4.5 million. If implemented with the project on 2Ws mentioned earlier, the costs could be offset against the revenue generated from taxing new ICE-2Ws.
Location	Initially, Phnom Penh, and then could be expanded to other cities.
Investment model	There are two possible investment models. The preferred option would be establishing a PPP for the scheme's operation. Public or development partner finance could be made available to cover the scheme's costs, with the private operator being responsible for importation or manufacture of the electric tuk-tuks and the disposal of ICE models. The private operator would be incentivized to market the scheme heavily to drive uptake. An alternative model would be public-led and involve the issuance of vouchers. Private sector operators could be left to demonstrate that they have sold a new E-3W and scrapped an ICE model. Once they demonstrate this with a clear audit trail, they could claim the subsidy from the public sector.
Risks and risk allocation	Medium The major risks associated with the project are limited interest from importers, lack of effective messaging, and insufficient funding. The project should be designed to be attractive to importers by providing sufficient incentives, clear criteria for eligibility, and streamlined grant administration to mitigate these risks. The public awareness campaign should be targeted and well-coordinated to ensure effective messaging. The risk allocation will depend on the investment model chosen, with the government or international organizations assuming the majority of the risk in a public-led model and private investors sharing the risk in a PPP model.
Monitoring and evaluation	The data platform will support the monitoring and evaluation of this intervention. The scrappage scheme operator should be required to monitor the number of 3Ws scrapped and the number of EVs sourced. It should also be required to follow up with drivers of E-3Ws to understand how the transition has affected their income and costs so that TCO data for different models can be refined and improved over time and to inform later policies and programs.

Intervention 4: Introducing Disincentives for New ICE-2W Purchases

Rationale:

The total cost of ownership is one of many factors taken into consideration by those looking to purchase a vehicle. Many consumers have a deep-seated preference for ICE vehicles based on familiarity, which can be overcome in a number of different ways. Driving up demand for E-2Ws is particularly important, given their significant role in the transport mix and the fact that they are already cost competitive with their ICE equivalents.

Since this state has been reached, putting in place disincentives for the adoption of ICE-2Ws no longer reduces access to transport as a whole but acts as a push factor toward EV adoption. This approach has been taken around the world in various forms ranging from the adoption of statutory age limits on ICE vehicles, to restrictions on their usage in certain parts of major cities, to significant additional taxation.

Consideration should be paid to the Cambodian domestic 2W assembly industry. There are numerous firms operating in both the electric (Voltra, VeryWords) and ICE (Honda) sectors. Any disincentives applied to ICE vehicles will need to be calibrated so as to enable the ICE assembly sector to adjust to EVs.

Intervention Description:

Of the several policies, which could be selected to dis-incentivize ICE-2W usage, three are presented below. Attention has been paid to modest interventions which can generate revenue to support the wider package of measures discussed in this chapter.

1. **Road tax liability for new ICE-2Ws.** This could be based on the year of registration, for instance, requiring road tax for ICE-2Ws registered from 2024 onwards. This would broaden the TCO gap between E-2Ws and ICE equivalents. At present, the rate is zero for all 2Ws. Even introducing an annual road tax of US$50 (roughly equivalent to half the rate for 4Ws) would widen the TCO gap by US$300 and make EVs over 15 percent cheaper than ICE equivalents. Limiting this measure to new ICE-2Ws ensures that no consumer need pay more for a vehicle than they otherwise would have without this policy in place; used vehicles can still be purchased, and new EVs will be cheaper and more readily available than ICE equivalents.
2. **Changes to the import and specific taxation system.** As an alternative to introducing road tax liability, changes could be made to taxes applied at the border. This would be less visible, impacting on the purchase price of new vehicles rather than the cost of ownership. It would likely omit domestically assembled vehicles and so may have a more limited effect than a road tax-based intervention.
3. **Age limits on ICE-2Ws (and potentially other segments).** This would require the introduction of the data platform (Intervention Project 1) and would necessitate used vehicles being scrapped after a period of several years. The exact lifespan would need to be determined, likely somewhere between 5 and 10 years.

Expected project revenue	US$31,000,000
	The level of any taxation would affect the revenue yielded for RGC. For illustrative purposes, assuming a US$50 annual charge and a 6-year lifecycle of each vehicle would yield approximately US$31m between 2024 and 2026.
Location	Nationwide
Investment model	These interventions would need to be led by RGC ministries given the role of the taxation and vehicle regulation systems.
Risks and risk allocation	Low
	Introducing road taxes on new ICE-2Ws is a low-risk option. Although it would be necessary to ensure the purposes of the policy were explained clearly to the public along with the scope and level of the tax.
Monitoring and evaluation	The data platform (Intervention 1) will support the monitoring and evaluation of this intervention. A key metric will be the number and types of 2Ws purchased, enabling decision-makers to understand which sub-segments (i.e., based on size) are transitioning to EVs more quickly than others.

Intervention 5: Major Public Information Campaign

Rationale:

The rapid urbanization of Cambodia has led to a surge in traffic congestion, air pollution, and GHG emissions. Promoting EVs is one of the ways to decrease these emissions related to road transport. However, it is important to note that adopting EVs is not a straightforward process, and providing infrastructure is insufficient. There may be reluctance among people to shift to this new technology as is the case with many innovations.

One of the major barriers to EV adoption in Cambodia is the general public lack of awareness and information. A comprehensive public information campaign can be an effective solution to overcome this challenge. This campaign can raise awareness and educate the public about the numerous benefits of EVs, including the cost-parity against ICE vehicles for certain segments while dispelling any negative myths and preconceptions. By doing so, will create demand for EVs and drive the adoption of this transformative technology.

Intervention Description:

To ensure that the public information campaign is effective, it will focus on educating the public about the benefits of EVs such as their ability to reduce air pollution, improve public health, and lower GHG and costs.

- **Focus groups and surveys.** Before launching the campaign, it is essential to conduct workshops and surveys with communities and the targeted users to gain insights into the psychological and practical barriers preventing drivers from adopting EVs. For instance, a lack of awareness of range anxiety is a practical challenge the campaign must address. The focus groups will also help identify the most effective messages to help drivers understand how to overcome these barriers.
- **Governmental awareness campaign.** To ensure the widespread adoption of EVs in Cambodia, educating young and future car owners about the benefits of EVs will be critical. A multi-faceted approach can be employed to achieve this goal, such as implementing school programs in partnership with MEF to introduce EV benefits in high schools and universities. Additionally, working with MLVT to encourage large employers to promote EV use among their staff and displaying communication in shared areas can be effective ways to increase awareness about the benefits of EVs. Finally, a wider awareness campaign in partnership with the industry can be used to increase the impact and outreach of the campaign. To illustrate this, the Go Ultra Low was a joint campaign between government and the industry to drive the uptake of EVs.
- **Public information.** The proposed public information campaign will effectively leverage various media channels such as television, radio, social media, and billboards to achieve broad and far-reaching coverage. Additionally, the campaign will plan and execute events and workshops in key urban centres to provide hands-on experience to potential EV buyers. By doing so, the initiative will promote a favorable perception of EVs and increase the demand for this technology among the general public. This approach is expected to have a quick and significant impact and can be led by the private sector, particularly companies in the automotive industry, chambers of commerce (such as EUROCham and BritCham), banks, and other financial institutions that offer EV loans and undertake corporate social responsibility activities.
- **EV champions.** Early EV shifters such as E-tuk-tuk drivers who have benefitted from the scrappage scheme (Intervention 3) or E-2W users who have used incentives from Intervention 2 can be used as examples and role models for other people to shift, taking part in the public campaign and coming to the focus groups.

In order to drive a coherent and consistent message regarding E-mobility, an independent association with different industry members (original equipment manufacturers, banks, car dealers, representatives of the government, etc.) can be created.

Expected project cost	US$1,000,000
	The estimated cost of the major public information campaign is around US$1 million, including the cost of media production, advertising, event organization, and staffing. This is expected to be mostly funded by the private sector. Activities in schools and promotional materials designed by the government should be a one-off investment.
Location	Nationwide

Investment model	This campaign must be a mixed approach between governments and the private sector. The investment model for the major public information campaign can be a public-led initiative funded by the government or international organizations or a PPP model, where private companies partner with the government to fund the campaign.
Risks and risk allocation	Low
	The approach includes conducting focus groups and surveys to identify practical and psychological barriers to EV adoption, partnering with government agencies and private sector organizations to increase awareness about the benefits of EVs, and creating an independent association to drive a coherent message about E-mobility. However, the approach may face challenges such as limited impact, inadequate targeting, limited resources, and the risk of greenwashing. These issues will need to be carefully addressed for the campaign to succeed. Additionally, partnerships with key stakeholders such as local governments, non-governmental organizations, and EV manufacturers can help to mobilize resources and support for the campaign.
Monitoring and evaluation:	This can be monitored via the data platform to see if EV uptake coincides with the start of the campaign. The supplier of the communications campaign, the public or private sector, should monitor the online interactions and impressions of their advertisements. Surveys can be done at the start and end of the 3 years to compare opinions, reluctance, and misconceptions.

Intervention 6: Explore the feasibility to converting Government Fleets to Electric Vehicles

Rationale:

Government fleets are a highly visible mechanism by which electric mobility can be promoted. Particularly in tandem with a public information campaign (Intervention 5), they are an opportunity for the government to be seen as “championing” the E-Mobility Transition through committing resources in line with its policy thereby encouraging the public and the private sector to do the same.

This process has already begun with the development of a small EV fleet and suite of chargers at MPWT, supported by UNDP. The MME is also home to a battery-swapping station for E-2Ws. There is clear scope to expand this, initially with 4Ws at MPWT, MME, and EDC but eventually expanding across RGC.

Intervention Description:

In the near term, it may not be practical to convert the entire MPWT and MME fleet to EVS. It may be more appropriate to focus solely on vehicles in Phnom Penh and other major cities. It may also be more cost-effective to purchase EVs when existing vehicles are sold or retired.

Expected project cost	US$1,875,000
	Intervention 6 assumes 50 vehicles will be needed between 2024 and 2026. Based on EV models identified earlier in this roadmap, an assumed average cost of US$30,000 per vehicle is used for calculations (average purchase price of BYD E2 is US$28,900). Each vehicle requires charging infrastructure to the value of US$7,500. This yields a total project cost of US$1.875m.
Location	MME office in Phnom Penh initially, expanding to offices in other provinces over time.

Investment model	The simplest option would be to purchase these vehicles outright, although an ongoing service and maintenance contract could also be established with a private operator. To part-fund this transition, MME could potentially use current allocations for conventionally fueled vehicle replacements as well as ongoing revenue savings on fuel and maintenance once vehicle is purchased.
Risks and risk allocation	Low
	Care should be taken to ensure the fleet can be maintained, and the installation of appropriate chargers takes place.
Monitoring and evaluation:	The TCO of the fleet should be monitored over time and compared with the historical expenditure on ICE vehicles. The net GHG emission benefits can also be calculated. Users of the fleet should be surveyed on their satisfaction. This can be fed into future fleet investments.

Intervention 7: Developing Electric Rest Stops

Rationale:

A lack of publicly accessible charging infrastructure and range anxiety are globally perceived barriers to widespread EV adoption. Government policies and interventions therefore play a key role in enabling EV adoption, mitigating these perceived barriers, and ensuring public confidence in EVs.

A comprehensive EV charging network forms part of the solution to reducing these barriers. However, it requires significant infrastructure roll-out and investment. A mix of locations and charging types, as highlighted in the modeling analysis in Chapter 3, are therefore required to facilitate the transition to EVs and to meet the targets set out in LTS4CN.

Intervention Description

Cambodia's development of a new expressway network is expected to significantly reduce travel times, facilitate passenger and freight transport services, and enable strategic regional development across the country.

The first route, Expressway 4 from Phnom Penh to Sihanoukville, officially opened in October 2022 and covered 190 kilometers with three dedicated rest areas in each direction. The second 138-kilometer route from Phnom Penh to Bavet is planned to commence construction in June 2023 (The Phnom Penh Post 2023), with six further potential expressways identified for further feasibility of planning stages (JICA 2013).

As the transition to EVs increases, the new expressway network and the existing road networks will require rest stops to provide EV charging facilities.

The Electric Rest Stops Project is formed of two actions:

1. Developing and enabling PPP EV charging hubs at service locations on existing public-owned roads such as Expressway 4.
2. Creating a specification framework for future EV hub deployment at rest stop locations on new roads and expressways.

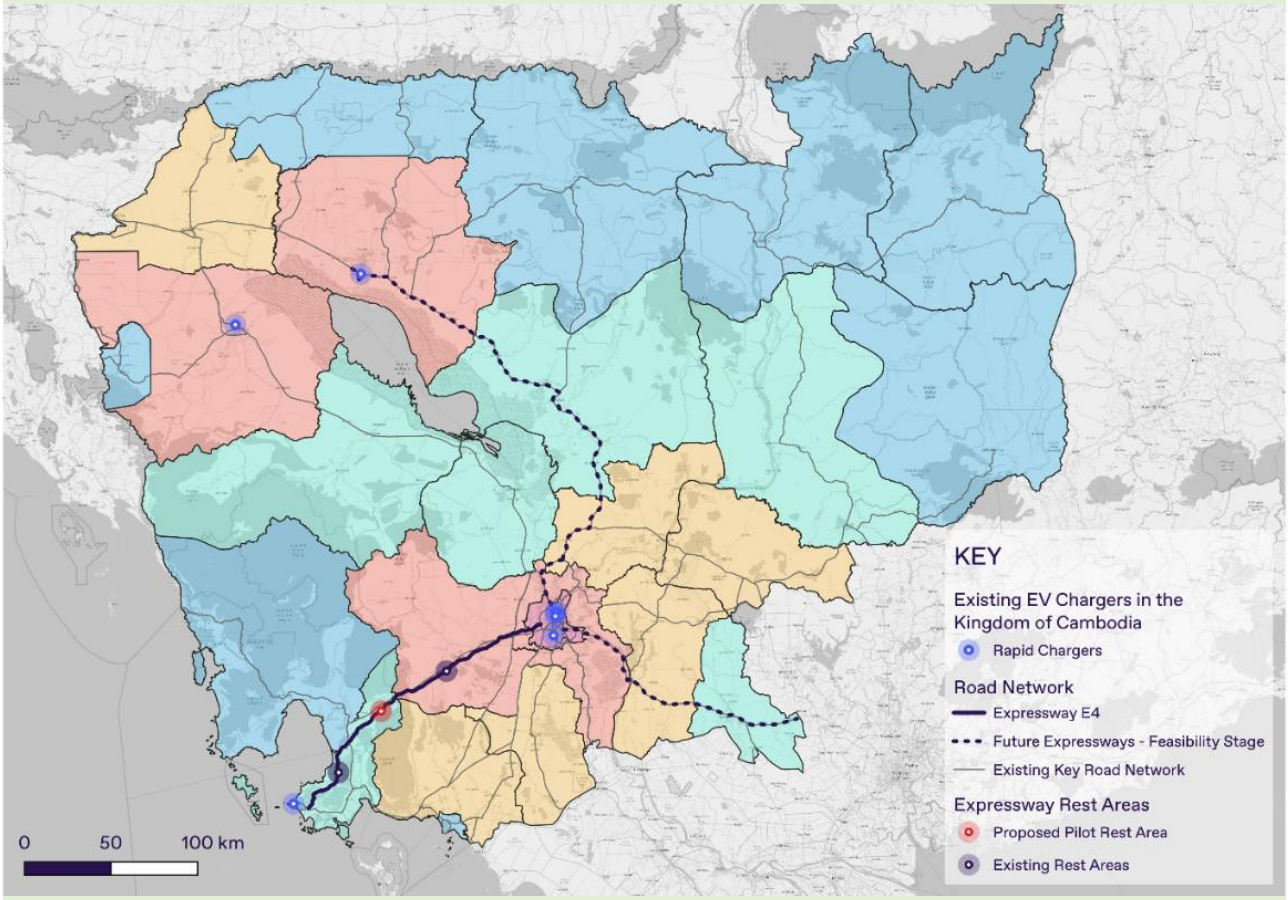
The first action will see rapid charging hubs developed across the existing road network at rest stops and service stations. As shown in Figure 51, the project proposes an initial hub of charging provision in each direction at the Kompong Seila Rest Area along Expressway 4, situated 110 km from Phnom Penh and 80 km from Sihanoukville.

The charging hub would provide confidence in the ability to refuel and demonstrate the feasibility of EVs for key passenger-carrying vehicles, such as private 4Ws, on inter-regional journeys. A typical EV charging hub site could provide between five to ten rapid chargers supported by on-site renewable energy generation such as solar photovoltaic and complemented by battery energy storage.

The second action will ensure dedicated EV charging hubs are included as a must-have feature in future design specifications. This framework will develop EV charging hubs at rest stops across Cambodia on the existing strategic road network and the expressway network, enabling long-distance travel by EVs.

The Intervention 7 project will provide prospective and current EV owners in Cambodia with a clear vision that long journeys are feasible by EVs in Cambodia.

Figure 51: Proposed Rest Stop Intervention and Expressway Network



Source: World Bank, 2023

Expected project cost	US$3,000,000 (2x charging hubs each direction on E4)
	The estimated capital cost of delivering a rapid EV charging hub, including solar photovoltaic and a battery energy storage system, is around US$1– 1.5 million. It is expected that a hub of this size and scale could be developed within two years of project commencement. Ongoing operational costs in years 2-7 will include electricity costs and infrastructure maintenance. However, it is anticipated that energy costs will be offset by on-site renewable generation and covered by the end-user through an appropriate US$ per kWh tariff rate.
Location	Expressway 4 (for the first phase)

Investment model	A concessionary contract through a PPP between key government stakeholders, such as MME and MPWT, and a private charge point operator. It is anticipated a concessionary contract may take the form of a lease-type agreement (RGC receiving a fixed rate for leasing publicly owned land to a private organization) or through a revenue share model.
Risks and risk allocation	Medium
	The main project risk is that EV uptake does not meet the required demand for the site to break even, meaning assets become stranded and commercially unviable. The majority of the operational risk is expected to be allocated to the private partner in the hub development.
Monitoring and evaluation:	Regular monitoring of EV charging sites is crucial to assess utilization and success, which can then inform the design of future sites. Evaluating the design and build stage can also provide best practices for future installations and streamline processes for low-carbon technology installations through regulatory changes. For example, the UK energy regulator, Ofgem, changed how consumers are charged for electrical network connections to enable large-scale EV charging infrastructure development. Including renewable energy generators, such as solar photovoltaic, can help estimate the level of carbon offset from energy generated through traditional fuels.

5.2 Priority Regulatory Measures

Cambodia has a significant opportunity to accelerate EV adoption, yielding meaningful advantages in carbon emissions reduction and decreased reliance on foreign fuel imports. To actualize this transformation, a range of regulatory and policy modifications across various RGC ministries is necessary.

While some of these modifications may necessitate investment, the bulk of financing should come from the private sector. For example, RGC can support the establishment of public charging sites by streamlining the process for charge-point operators to obtain requisite permits and approvals. Further, RGC can assist consumers in obtaining financing to purchase EVs. By establishing a business-friendly climate, RGC can propel the E-mobility market's expansion without incurring exorbitant costs.

In order to attain the outlined policy goals and the anticipated volume of EVs on the streets, RGC, in addition to the seven market interventions previously outlined, must address four primary regulatory concerns:

- **Priority 1:** Significantly increasing the uptake of E-2Ws in a safe and responsible manner.
- **Priority 2:** Establishing a safe, reliable, and interoperable charging infrastructure.
- **Priority 3:** Clarify how CPOs can legally use the electricity law to establish charging stations.
- **Priority 4:** Ensuring clear governance across ministries for the implementation of E-mobility and EV charging infrastructure.

Priority 1: Significantly Increasing the Uptake of Electric 2Ws

To achieve the targeted acceleration of EV adoption, a focused approach on the E-2W vehicle segment having the least barriers to transition is recommended. As indicated by the TCO analysis, the E-2W segment is close to reaching price parity and benefits from the convenience of home charging. Although private sector involvement will likely drive this segment, public involvement is necessary to enable E-2W uptake through accessible financing solutions, as explained in Market Intervention 2.

- For private 2Ws, upgrading the housing electrical grid and low voltage grid is necessary to ensure safe charging at home, particularly regarding the fast increase beyond 2030.
- Regarding commercial motorcycles, they will likely rely more on battery swapping. This will require significant investment in upgrading the grid and ensuring safe charging at battery-swapping stations.

Key actions needed from RGC:

- Undertake electrical housing assessment to ensure people can safely charge at home
- Publish the *Technical Standards of The Kingdom of Cambodia for Electrical Wiring and Safety for Buildings and Households* (MME 2015) with an added section on EV charging for property developers to ensure all new housing developments answer safety norms
- Provide a clear route for CPOs to provide battery-swapping stations and EDC to strengthen their access to the grid and ensure grid capacity at planned locations.
- Collaborate with original equipment manufacturers and financiers to provide financing solutions and insurance schemes to make EVs affordable and protect batteries. (See Market Intervention 2).

Priority 2: Adopt Standards and Develop Safety Guidance

Developing of E-Mobility Transition, a range of standards have been created to ensure a positive and safe user experience equivalent to refueling at traditional gas stations. However, installing a public EV charging infrastructure across all vehicle segments poses several key risks, including electrical safety, fire hazards, overloading, physical safety, and cyber security.

Charge Points Connections and Specifications

Currently, three charging standards are recognized for DC charging vehicles in the global electric automotive market:

- Combined Charging System (CCS): a standard driven by European and North American automakers.
- CHArge de MOve (CHAdeMO): A standard created by the main Japanese car manufacturers and the only one currently to allow for bi-directional charging, commonly known as Vehi- cle-to-Grid (V2G).
- Guobiao (GB/T): standard for AC and DC charging used by Chinese car manufacturers.

Cambodia is already home to vehicles using all three technologies, and charging networks should be regulated to ensure coverage of all relevant technologies. It is likely in future years, this may further condense; however at the early adoption stage, it is important to offer all options to ensure all drivers have ease of access, no matter the vehicle type.

In other countries where EVs have been on the roads for a decade, such as the United Kingdom, the proliferation of charger types and operators has resulted in a complex charging infrastructure where each CPO has their own payment and registration process.

As Cambodia is starting to deploy the first EV chargers, having inter-operability standards from the beginning, following the Dutch model, will be key to facilitating the EV uptake.

Key actions needed from RGC:

- Ensure the three main connection standards are included in ISC standards and available on the market.
- Set standards for interoperability and simple payment for all suppliers.

Charging Infrastructure

Currently, the Institute for Standards of Cambodia (ISC) has adopted 9 standards for E-mobility, covering various aspects of EV charging, including connector specifications, communication protocols, and safety requirements (Table 17). However, these standards alone are insufficient to ensure the safety of a nationwide EV charging infrastructure as depicted in the Market Intervention 7.

Additional standards and consistency in design processes are necessary to ensure the deployment of rapid charging hubs, substations, and depot upgrades. This will enable the creation of a safe, reliable, and seamless charging experience for EV users, ensuring that they can confidently recharge their vehicles.

The standards provided in Table 18 are key for the early-stage development of a nationwide EV charging infrastructure. Covering rapid charging hubs and battery-swapping stations, these could be added to current ISC 9 standards, of which will need to be continuously adapted as the infrastructure develops.

Other standards, particularly the ISO/DIS5474, are still at the draft stage and may be considered in the longer term when published officially.

Regarding accessibility of EV charging infrastructure, the industry is only at its start. The United Kingdom has released the BSI PAS 1899:2022 guidance (Electric vehicles – Accessible charging – Specification) (BSI 2022). This guidance covers the several aspects of the charger and environment around the charger to build an inclusive EV charging infrastructure. Even if made for the UK, this guidance can be used as a steppingstone for RGC to ensure inclusivity and accessibility of the charging infrastructure through specifications in procurement for PPP.

Key actions needed from the RGC:

- Update standards repository with relevant IEC and ISO standards and continuously keep track of the evolution of standards in the industry.
- Include design and EV charging accessibility best practices in procurement for public-private partnership.

Table 17: Existing ISC Standards for E-Mobility in Cambodia

Standard	Description
CS IEC 62196-1:2022	Plugs socket-outlets, vehicle connectors and vehicle inlets – conductive charging of electric vehicles – Part 1: general requirements
CS IEC 62196-2:2022	Plugs socket-outlets, vehicle connectors and vehicle inlets – conductive charging of EVs – Part 2: Dimensional compatibility and interchangeability requirements for AC power pin and contact tube accessories
CS IEC 62196-3:2022	Plugs socket-outlets, vehicle connectors and vehicle inlets – conductive charging of EVs – Part 3: Dimensional compatibility and interchangeability requirements for DC power and AC/DC pin and contact tube couplers
CS IEC 61851-1:2022	EV conductive charging system – Part 1: General requirements
CS IEC 17409:2022	Electrically propelled road vehicles – Conductive power transfer – Safety requirements
CS IEC 61851-21-1:2022	EV conductive charging system – Part 21-1: Electric vehicle on-board charger EMC requirements for conductive connection to AC/DC supply
CS IEC 61851-21-2:2022	EV conductive charging system – Part 21-2: Electric vehicle requirements for conductive connection to an AC/ DC supply – EMC requirements for off-board electric vehicle charging systems
CS IEC 61851-23:2022	EV conductive charging system – Part 23: DC electric vehicle charging station
CS IEC 61851 24:2022	EV conductive charging system – Part 24: Digital communication between a DC EV charging station and an electric vehicle for control of DC charging

Source: MISTI, 2022.

Table 18: Additional Standards Recommended for Adoption

Standard	Description
IEC 61851-1	Specifies the general requirements for EV charging systems, including the safety requirements for conductive charging. It is relevant for all types of EV charging infrastructure, including battery-swapping stations and e-bus charging stations.
ISO 17409	Provides guidelines for the design, installation, and operation of EV charging infrastructure, including conductive and wireless charging systems. It covers safety, reliability, and interoperability requirements.
ISO 6469	Provides requirements for the design and testing of on-board rechargeable energy storage systems for electric and hybrid electric road vehicles. It helps to ensure that rechargeable energy storage systems are designed and tested to meet appropriate performance and safety requirements and provide guidance for manufacturers and users of these systems.
IEC 61851-23	Specifies the safety requirements for DC fast-charging systems, which are relevant for fast-charging stations and E-bus charging stations.
IEC 62196-1 and IEC 62196-2	Specifies the requirements and tests for conductive charging systems, including connectors and communication protocols. They are relevant for home charging and fast-charging EV stations.
IEC 61851-24	Specifies the requirements and tests for communication between EVs and wireless charging systems. It is relevant for wireless charging systems, including those powered by solar photovoltaic and battery storage systems.
ISO 15-118	Vehicle-to-Grid Communication Interface — Part 2: Network and application protocol requirements

Box 4. EV Champion Best Practice – India

In India, the government has made the safety and interoperability of the country's EV charging network a priority, helping to facilitate the electric mobility uptake.

The government has established the Bharat EV Charger DC-001 standard for EV charging, which ensures that all EV charging stations in the country are interoperable, enabling drivers to access any charging station regardless of the manufacturer or charging standard. This measure has mitigated the challenge of fragmentation in the charging network, which is a major potential barrier to the widespread EV adoption.

Moreover, the government has set up a policy think tank called National Institution for Transforming India (NITI Ayog) to accelerate EV adoption. This thinktank, in collaboration with the Automotive Research Association of India (ARAI), developed specific EV standards (including the Bhara standards) and a rigorous certification system for EV charging stations to guarantee their safety and reliability. All standards are written and accessible via a clear and straightforward EV charging infrastructure handbook for CPOs. Under the handbook's regulations, all charging stations in India must be certified by the government, ensuring EV drivers trust in the charging network and providing them with confidence that the charging stations adhere to strict safety and quality standards.

As Cambodia progresses further into large-scale infrastructure deployment for electric mobility, it has an important opportunity to ingrain inter-operability, safety, and quality standards at the foundation of all developments. Resources such as the NITI Handbook for CPOs are significant assets to ensuring that when electric mobility infrastructure projects are approved, they are upheld and supported by rigorous planning and certification procedures (NITI 2021). Replicating these resources in the Cambodian context may guide and facilitate a cooperative, well-structured domestic charging network.

Priority 3: Clarify How CPOs Can Use the Electricity Law to Legally Establish Charging Stations

Among the 8 licenses proposed by EAC to allow private distributors to sell energy, the most suitable is the sub-distribution license. While this license allows for a reasonable return on investment of around 10 percent, it may not be suited to charging operators with multiple locations across several distribution licensees as it requires licensing and agreements with each distribution licensee.

The CPOs have indicated that they lack clarity on how to apply the subcontract license to their business model. The RGC could publish a guidance note explaining how the subcontract license would enable CPOs to resell electricity at public charging stations legally.

The key area where further information is needed is guidance on how to calculate the cost base of the CPO, so that tariffs can be set to cover these costs and provide a reasonable return on investment.

In the longer term, it may be beneficial to create a dedicated new type of license to suit EV charging. This update can include regulating tariff setting, which is mostly comprised of three elements:

- Costs (capital, electricity, maintenance and operations, hardware replacement);
- Profit;
- Taxes.

It is important for CPOs to generate enough revenue and profit while delivering an affordable service to the population that enables the shift to EV charging. This can be achieved through better guidance and regulation from MME and EAC on tariff setting. The EAC has existing tariff regulations that are led by the following commitment:

> EAC will wish to determine that each Licensee's costs are as low as is consistent with reliable and efficient operation and with maintaining its long-term financial viability. EAC may determine acceptable cost levels by reference to cost levels of comparable utilities elsewhere, indexes of relative efficiency, or to reasonably achievable levels of productivity improvement (EAC, 2007).

Under this commitment, the EAC general methodology for evaluating the reasonable cost for electricity **generation** is to examine the main components of costs including:

- Generation administrative and general costs,
- Generation fuel costs,
- Generation reasonable profit,
- Other generation operation and maintenance costs,
- Generation asset depreciation,
- Cost of generation loans

For determining the reasonable costs of electricity **distribution**, the general methodology is to consider:

- Distribution administrative and general costs,
- Power purchase costs,
- Distribution reasonable profit,
- Other distribution operation and maintenance costs,
- Distribution asset depreciation,
- Cost of distribution loans.

Beyond EAC work to ensure reasonable licensing costs, the government can intervene to ensure that the tariff does not exceed a certain threshold using electricity costs and taxes. This will help to ensure that EV charging remains affordable for the population while also allowing CPOs to generate enough revenue and profit to maintain and expand the charging infrastructure.

Key action needed from the RGC:

- In the short term, release guidance on how to use the subcontract license to make CPOs confident to enter the market .
- Ensure affordability of prices through tariff setting as part of the updated license.
- In the long term, consider a new license dedicated to EV charging to be released.

Box 5. EV Champion Best Practice – Thailand: Streamlining Processes to Remove Barriers to Entry to the Market for CPOs to Deploy EV Charging Infrastructure

In 2015, Thailand released its EV roadmap with the ambition to become a leader in the ASEAN region and a target of 1.2 million EVs on the road by 2036. The Ministry of Energy first launched a three-year pilot to subsidize EV charging stations to kick-start the transition with 150 chargers. This subsidy was open to all public or private stakeholders while simultaneously creating a competitive environment.

The National Energy Policy Commission (an inter-ministerial group) set up a time-of-use rate for the general public charging at home and CPOs. The time-of-use rate was meant to encourage charging during off-peak hours and weekends.

Finally, recognizing the need to provide a regulatory framework for CPOs, the existing licensing system has been adapted to accommodate CPOs. Specific requirements for CPOs were added to the original license provided by the Energy Regulatory Commission (equivalent to EAC), reducing at the same time the documents and steps needed to streamline the process, regulation, and standards CPOs must comply with (Thananusak and others 2020).

In order to facilitate the adoption of EV charging infrastructure in Cambodia, it may be beneficial to consider implementing a process similar to that of Thailand. This would involve streamlining the current regulatory framework to remove entry barriers to the market rather than creating new licenses and legislation that could result in lengthy delays. To achieve this, adapting the existing subcontract license to enable CPOs to offer EV charging services across multiple locations could be a more efficient approach in the short term. By minimizing regulatory burdens and maximizing efficiency, this approach could expedite the adoption of EV charging infrastructure in Cambodia while also providing long-term benefits.

Priority 4: Ensuring Clear Governance across Ministries for Implementation of E-Mobility Transition

E-Mobility Transition is a cross-cutting policy area that requires the establishment of a comprehensive regulatory framework and the involvement of many different stakeholders to be effectively implemented. The RGC is moving in that direction with roles given to each ministry through NEEP and the constitution of the inter-ministerial Working Group led by MPWT. However, clarity in terms of actions for each ministry regarding E-Mobility implementation specifically is not as straightforward, although crucial for the EV uptake.

This roadmap will help to resolve this challenge by providing a clear allocation of leadership for each of the regulatory and policy changes needed over the coming years. The existing Technical Working Group can oversee progress on each of these changes and enable cross-ministerial collaboration to overcome challenges.

Box 6: EV Champion Best Practice – Asian EV Champions

Across the different EV champions in Asia, the best approaches to deploying charging infrastructure and increasing the number of EVs have all been characterized by the following:

- Delivering a long-term-plan on EV penetration targets and charge points.
- Reflecting targets among the different ministries involved and undertaking cross-ministerial work.
- Creating governmental policy and regulatory interventions and incentives for CPOs to catalyze the infrastructure provision in a legal and safe manner.
- Fostering competition to augment state activity in energy provision.
- Providing clarity in licensing and tariff systems for CPOs.

The successful deployment of EVs and charging infrastructure in Asia requires a comprehensive, collaborative approach that involves clear targets, cross-ministerial work, government policies and incentives, competition, and regulatory interventions.

Cambodia has started its E-Mobility Transition journey, marked with the Inter-Ministerial Technical Working Group mandated by RGC and led by MPWT. This roadmap and the technical interventions aim to develop a conducive environment for the wider adoption and acceleration of EVs in Cambodia.

5.3 Medium- and Long-Term Regulatory Measures

Building on the Market Interventions and Priority Regulatory Measures, this section looks beyond 2030 and up to 2050, outlining further measures needed to enable a transition to E-Mobility Transition in Cambodia. These measures are sorted into three groups – (a) Increase EV supply, (b) drive up EV demand, and (c) provide required charging and power supply.

Measure 1: Increase EV Supply

The development of an enabling environment within Cambodia uncovers challenges associated with the shift from early adopters to mass-scale adoption. Understanding the supply of electric vehicles is at the core of building out the supporting ecosystem.

Cambodia’s high reliance on used vehicles, coupled with the limited global supply of used EVs, presents a challenge to this supply. Building on the Market Interventions 1, 2 and 3 (Section 5.1) and the Priority Regulatory Measure 1 (Section 5.2), the measures outlined in this section will make it easier for EVs to be imported and for Cambodia to play an increasing role in the wider ASEAN supply chain for EVs.

Ensure the available incentives are understood by importers and consumers and consider the competitive- ness of 2W incentives.	Lead: MEF *Support: GDT*

Context:

Primary research and stakeholder engagement suggest that car buyers are unaware of the import tariff reductions available for EVs. Importers of all types of vehicles also report confusion around their entitlement to reduced import tariffs.

Incentives are most effective where they have targeted "marginal consumers" – those purchasing a vehicle considering electric and non-electric options. In Cambodia, a significant proportion of these consumers are likely to purchase 2Ws.

Currently, E-2Ws receive a 5% discount in specific tax, whereas E-4Ws receive a 40% discount in specific tax. While E-2Ws are now cost-competitive with ICE equivalents on a TCO basis, this disparity fits with the evidence. Nevertheless, high upfront costs remain a barrier to consumers.

- Increase awareness via a communication campaign (physical and digital) at the destination of EV importers and car dealers to be aware of tax reductions and fiscal incentives.
- Monitoring incentives to ensure they are effective in delivering expected outcomes.

Create the conditions for Cambodia to play a leading role in the EV supply chain across the ASEAN region	Lead: CDC *Support: MISTI*

Context:

Cambodia has the opportunity to nurture the domestic industry with manufacturers and key automotive actors present in the country. Elements to support this are the production and/or assembly of simple vehicle components, end-of-life waste management (short-term) and the manufacturing of small vehicles, primarily 2Ws (long-term).

The current lack of a well-structured domestic supply chain does not allow for the realization of these opportunities and their potential for economic growth and sectoral development.

Given a large number of used vehicles and high import rates from Japan and Korea, structuring the supply chain must account for the current market landscape while progressing toward a value chain fit for the future (more complex components for export).

Cambodia could use its strategic position near EV hubs (Thailand and Vietnam) to create favorable trade agreements for the export of vehicle components.

- Establish a well-structured domestic supply chain, including battery end-of-life disposal and recycling, focusing on small components.
- Nurture relationships with nearby EV champions and economic partners (Thailand and Vietnam) for exports of small components.
- Encourage foreign direct investment by offering streamlined administrative processes and a favorable fiscal environment.
- Educational and professional development initiatives focusing on EV technology to train future engineers, mechanics as well as project managers and policy makers.
- Start manufacturing small 2Ws.
- Build the retrofitting opportunity, particularly for buses and heavy-duty vehicles.

Measure 2: Drive-up EV Demand

The adoption of EVs is first and foremost dependent on behavior change – drivers must perceive that an EV is the most suited option for their needs based on a diverse range of factors, including cost, reliability, consumer preferences, and environmental considerations. The regulatory measures proposed in this section will enable drivers and firms in Cambodia to identify how they could benefit from EV adoption.

Develop financing options to offset the high upfront costs of E-4Ws.	Lead: MEF *Support: -*

Context:

Globally, the automotive finance industry is continuing to grapple with the challenges associated with making loans against and leasing EVs. The relatively high up-front costs of EVs lead to monthly payments, which can deter consumers, even given the lower ongoing fueling and maintenance costs.

The Cambodian automotive and leasing finance industry has undertaken considerable development over the past 10 years. There are now 16 leasing companies registered with the National Bank of Cambodia.

In order to drive greater consumer uptake of electric vehicles, this industry should be supported to offer loans and lease agreements on improved terms for electric vehicles. They should also be encouraged to explore innovative new models of financing.

- Encourage leasing companies to explore innovative new financing models, particularly in the 4W market, where all-in leasing arrangements can be used to cover the cost of vehicle maintenance and battery insurance.
- Work with the National Bank of Cambodia and other stakeholders to develop guidelines for the automotive and leasing finance industry on offering loans and leases for EVs, including best practices for risk assessment and loan pricing.
- Promote consumer awareness of the financing options available for EVs, including through public campaigns and partnerships with the automotive and leasing finance industry as seen in the Market Interventions 2 and 5.

Create direct links between the E-Mobility Transition and the wider sustainable transport network in Cambodia, including public transport	Lead: MPWT *Support: MLMUPC*

Context:

The long-term challenge to E-Mobility Transition is to ensure that it fits with wider plans for sustainable transport in Cambodia.

The LTS4CN sets a target for a 30% modal share of public transport in urban areas by 2050. If this target is met with electric buses and coaches, it will likely play a significant role in achieving the country's long-term plans to reduce GHG emissions and reduce total urban VKM by approximately 30 billion km by 2050.

The shift to electric mobility also offers the opportunity to rethink traditional methods for personal travel, logistics, and public transport. An E-mobility steer will address the need for charging infrastructure, investment, and financing options from the outset. It can also provide entry points for modal transport, last-mile logistic options and shared transport schemes based on zero-emission vehicles such as the go2 electric bikes.

- Develop a comprehensive sustainable public transport strategy integrating E-mobility and required charging infrastructure.
- Ensure a holistic approach to clean public transportation, including maritime passenger transport, with the E-boat opportunity.

Ensure that the electricity supply needed to power electric mobility is accessible to people in rural locations	Lead: MME *Support: EDC/ EAC*

Context:

To ensure the successful adoption of electric vehicles in rural areas, it is imperative to ensure an adequate supply of vehicles that meet the specific needs of rural consumers, including electric pick-up trucks. In addition, it is crucial to plan for the availability of charging infrastructure in rural locations to enable journeys to be completed in Cambodia's interior. For instance, vehicles using the Oradav border crossing into Vietnam would require access to charging facilities along Highway 78.

The RGC should encourage charge point operators to make their infrastructure accessible to people with disabilities by considering the connectors and cables used for charging. As an emerging area of development, it is worth noting that the UK recently produced guidance to enhance the user experience for all.

Furthermore, in line with developing charge points as community assets, RGC should also consider linking local energy regeneration initiatives to rural charging infrastructure development. This would enhance the resiliency of rural locations while supporting the government's transition toward a low-carbon economy.

- Develop a particular focus on rural charging as part of the long-term national EV charging development plan.
- Ensure equity of tariffs across urban and rural, using procurement recognizing the likely lower demand for EV charging in rural areas.
- Assess the community charging opportunity.

Measure 3: Provide Required Charging and Power Supply

Vehicles are only as clean as their power supply. Shifting to E-mobility can be an efficient way to drastically decrease tailpipe carbon emissions linked to road transport. However, overall emissions will only be decreased if the growing electricity demand is met by renewable and efficient energy generation, as investigated by the PDP generation expansion development plan.

Powering EVs with electricity that has been produced by fossil fuel can even have a higher GHG mission impact than their ICE counterpart for less energy-efficient vehicles such as E-2Ws. This section identifies key regulatory measures to deliver the charging elements of electric mobility in Cambodia building on the Market Intervention 7 (Section 5.1) and Priority Regulatory Measure 2 and 3 (Section 5.2).

Understand and develop a plan for battery-swapping facilities	Lead: MME Support: EDC

Context:

Battery swapping is already driving a significant uptake of electric mobility in the 2W and 3W segments. It comes with a number of benefits, namely that it concentrates energy demand in a specific location that can have a strengthened low-voltage or even high-voltage connection.

The battery-swapping model also simplifies consumer financing arrangements as it enables them to sign up for "all-inclusive" subscriptions rather than having to purchase a vehicle outright.

MME should engage with key private sector players in this market to deliver power to required locations and ensure they can resell energy legally and support their wider development.

Battery swapping can have its limitations, with private consumers often preferring to purchase their own second battery to ensure control. It is likely that commercial activities will continue in this area.

- Identify developing sites for battery-swapping stations in key cities as part of the long-term national EV charging development plan.
- Engage with key private sector players in this market to deliver power to required locations and ensure they can resell energy legally and support their wider development.

Ensure batteries can be safely and sustainably disposed.	**Lead: MOE** ***Support*: -**

Context:

Batteries are fundamental to E-mobility. In a Cambodian context, where a large part of the fleet is captured by motorcycles with batteries that last, on average, 3 to 5 years, battery disposal and recycling may become an increasingly difficult problem if not addressed quickly. An issue that is being navigated in different ways globally.

For instance, Norway now has operational EV battery recycling facilities. Other countries simply mandate that batteries must be disposed of safely in managed landfill facilities, while Singapore is moving toward the establishment of a recycling facility.

- In the near term, ensure that there are regulations in place for EV batteries to be disposed of safely alongside other hazardous waste containing lithium.
- In the longer term, create partnerships with recycling partners in the region as the market develops.
- Introduced additional legislation that covers extended producer responsibility and can incentivize more sustainable choices. This can include using second-hand batteries as part of the storage solution.

Ensure the development of an inter-city and national EV network charging infrastructure to offset range anxiety and provide a user experience comparable to ICEs.	**Lead: MME/ MPWT** ***Support*: EDC**

Context:

At present, the vast majority of EV charging in Cambodia happens at home or at battery-swapping stations operated by firms such as ONiON (3Ws) and Oyika (2Ws).

A key gap in provision is EV charging along major national routes and within urban areas. This makes it difficult for users without the opportunity to charge at home or make inter-city journeys.

Range anxiety is cited as a consistent barrier to EV adoption. While the average vehicle travels 44 km per day in Cambodia,[a] the range of even the cheapest E-4Ws on the market is generally now above 100 km. With battery swapping, almost all E-2Ws can also serve this need.

Building on the outcome of the first EV charging infrastructure at rest stops as explained in the Market Intervention 7, it will then be necessary to continue the deployment of infrastructure for a robust national EV charging network.

- Introducing EV charging at several strategic sites such as identified in Chapter 2.
- Ensure the good design and inclusivity of the new charging station as described in the guidance in Chapter 2.
- Undertake PPPs and/or work with gas stations to convert some of their infrastructure to support the uptake of EVs.

a Based on a return journey to work or school, source: Cambodia Business Survey

Identify opportunities for off-peak tariffs to support renewable energy	Lead: MME *Support*: EAC

Context:

Alongside the deployment of EVs, having a reliable charging infrastructure is essential to provide the population with all the benefits that EVs can provide. As the demand for electricity tends to fall overnight, countries across the globe have created specific cheaper night tariffs. This can help to:

- Decrease the total cost of ownership for EVs' compared to their ICE counterpart,
- Limit possible grid constraints by balancing the charging load.

Using technologies such as energy storage and smart metering can also help reduce the overall power demand required and can accelerate the reduction in grid emission factors. As observed in the TCO analysis for light-duty trucks, as they consume more and more fuel than savings would happen over time, and electricity is expected to be cheaper. As they may still be using a lot of energy, renewables for light-duty vehicles and heavy-duty vehicles are a great opportunity to decrease overall emissions.

- Introduce a smart metering plan to allow for smart charging.
- Use renewables such as solar photovoltaic canopies in charging hubs with battery storage to decrease costs.

5.4 Recommended Action Plan

The E-Mobility Transition Action Plan encompasses all key interventions, recommendations, and policies for each E-mobility dimension, which include EV supply, demand, and charging infrastructure. The following tables summarize these actions, with ministerial lead and timelines for each phase:

- Short term (2024-2026)
- Medium term (2027-2040)
- Long term (up to 2050)

The Action Plan provides a roadmap to accelerate the transition toward the electrification of road transport in Cambodia, leveraging its potential for economic, social, and environmental benefits. The proposed actions aim to establish a solid foundation for E-Mobility Transition and promote its adoption throughout the country.

Table 19: Increase EV Supply

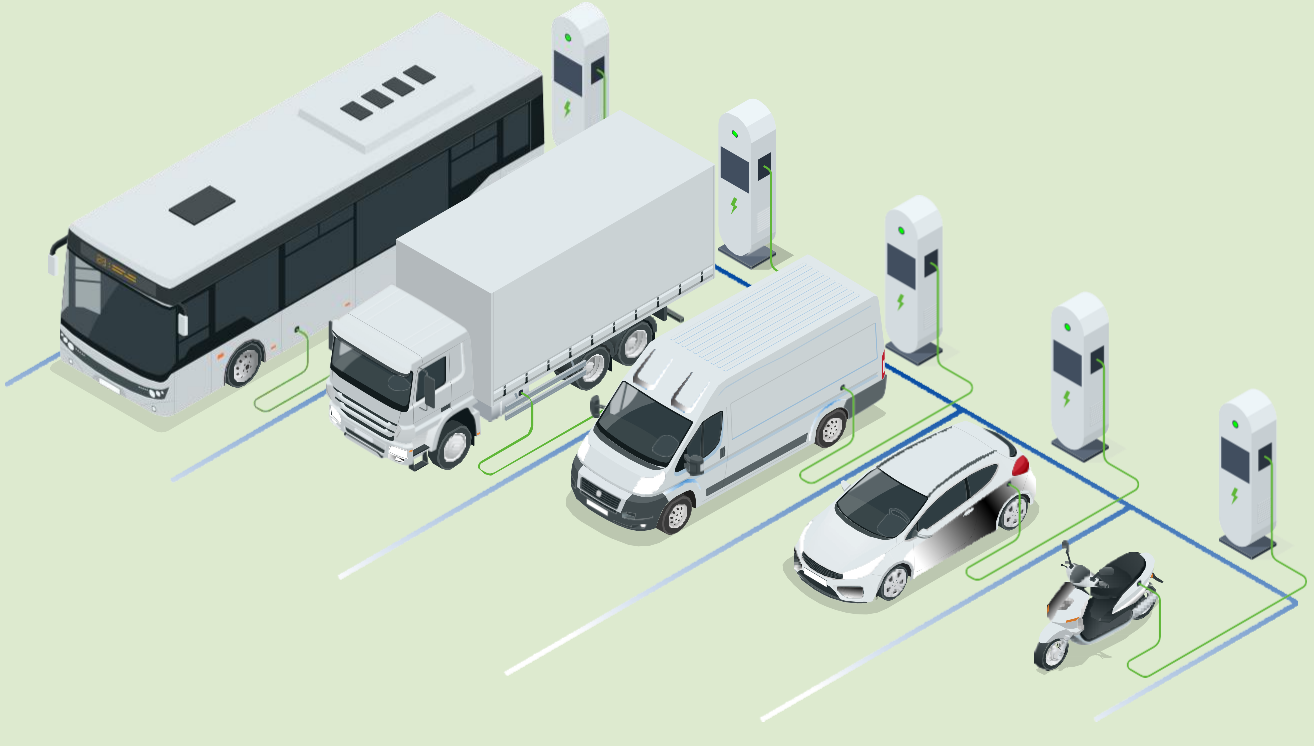
E-Mobility dimension	Policy – Intervention – Recommendation	Lead / *Support*	Timeline
Data	Create a data platform to monitor trends and manage the transition.	MPWT	Short erm
Increase EV Supply	Introduce incentives and de-risked financing for E-2Ws.	MEF / *GDT*	Short term
Increase EV Supply	Implement a scrappage scheme for 3Ws.	MEF / *MPWT*	Short term
Increase EV Supply	Release governmental EV targets to reach by 2030 and 2050.	RGC	Short term
Increase EV Supply	Establish a well-structured domestic supply chain, including battery end-of-life disposal and recycling, focusing on small components.	MPWT	Medium term
Increase EV Supply	Encourage foreign direct investment by offering streamlined administrative processes and a favorable fiscal environment.	MEF / *GDT*	Medium term
Increase EV Supply	Provide educational and professional development initiatives focusing on EV technology to train future engineers, mechanics as well as project managers and policy makers.	MOEYS / *MLVT*	Medium term
Increase EV Supply	Start manufacturing small 2Ws.	MISTI	Long term
Increase EV Supply	Build the retrofitting opportunity, particularly for buses and heavy-duty vehicle.	MISTI / *MPWT*	Long term

Table 20: Drive Up EV Demand

E-Mobility Dimension	Policy – Intervention – Recommendation	Lead / *Support*	Timeline
Drive up EV Demand	Monitor incentives to ensure they are effective in delivering expected outcomes.	MEF / *GDT*	Overall
Drive up EV Demand	Release guidance on how to use the sub-distribution license to make CPOs confident to enter the market.	EAC	Short term
Drive up EV Demand	Ensure affordability of prices through tariff setting as part of the updated license.	EAC	Short term
Drive up EV Demand	Introduce disincentives for new ICE-2W purchases.	MEF / *GDT*	Short term
Drive up EV Demand	Start a major public information campaign to debunk EV myths and promote its benefits.	Public/private	Short term
Drive up EV Demand	Establish a representative industry group to consult with the government and take part in communication campaign for an optimal outreach.	MPWT / *MME*	Short term
Drive up EV Demand	Explore the feasibility to convert government fleets to EVs.	MME / *MPWT*	Short term
Drive up EV Demand	Collaborate with original equipment manufacturers and financiers to provide financing solutions and insurance schemes to make EVs affordable and protect batteries. (See Market Intervention 2, Section 5.2).		Short term
Drive up EV Demand	Promote consumer awareness of the financing options available for EVs, with the automotive and leasing finance industry.	MPWT / *GDT*	Short term
Drive up EV Demand	Increase awareness for EV importers and car dealers of tax reductions and fiscal incentives.	CDC	Short term
Drive up EV Demand	Work with the National Bank of Cambodia and other stakeholders to develop guidelines for the automotive and leasing finance industry on offering loans and leases for EVs.	MEF	Medium term
Drive up EV Demand	Encourage leasing companies to explore innovative new financing models, particularly in the 4W market, where all-in leasing arrangements can be used to cover the cost vehicle maintenance and battery insurance.	MEF	Medium term
Drive up EV Demand	Introduced additional legislation that covers extended producer responsibility and can incentivize more sustainable choices. This can include using second-hand batteries as part of the storage solution.	MEF	Medium term
Drive up EV Demand	Develop a comprehensive sustainable public transport strategy integrating E-mobility and required charging infrastructure.	MPWT / *MLMUPC*	Long term
Drive up EV Demand	Ensure a holistic approach to clean public transportation, including maritime passenger transport, with the E-boat opportunity.	MPWT / *MLMUPC*	Long term

Table 21: Charging and Power Supply

E-Mobility Dimension	Policy – Intervention – Recommendation	Lead / *Support*	Timeline
Charging & Power Supply	Provide charging infrastructure at express way rest stops.	MME	Short term
Charging & Power Supply	Publish the Technical Standards of The Kingdom of Cambodia for Electrical Wiring and Safety for Buildings and Households (MME 2015) with an added section on EV charging for property developers to ensure all new housing developments answer safety norms.	MME	Short term
Charging & Power Supply	Provide a clear route for CPOs to provide battery-swapping stations and EDC to strengthen their access to the grid and ensure grid capacity at planned locations.	MME / *EDC*	Short term
Charging & Power Supply	Ensure the three main connection standards (CCS, CHAdeMO, GB/T) are included in ISC standards and available on the market.	ISC / *MISTI*	Short term
Charging & Power Supply	Set standards for interoperability and simple payment for all suppliers.	ISC / *MISTI*	Short term
Charging & Power Supply	Update standards repository with relevant IEC and ISO standards and continuously keep track of the evolution of standards in the industry.	ISC / *MISTI*	Short term
Charging & Power Supply	Create a long-term EV charging deployment plan.	MME / *MPWT*	Short term
Charging & Power Supply	Engage with key private sector players in this market to deliver power to required locations and review if they can resell energy legally under the Law of Electricity and support their wider development.	MME / *EDC*	Short term
Charging & Power Supply	Undertake electrical housing assessment to ensure people can safely charge at home.	MME	Short to medium term
Charging & Power Supply	Include best design and EV charging accessibility best practices in procurement for PPP.	MME	Short to medium term
Charging & Power Supply	Issue guidance on sub-distribution license applicable to EV charging and determining tariff for EV charging	EAC	Short to medium term
Charging & Power Supply	Identify developing sites for battery-swapping stations in key cities as part of the long-term national EV charging development plan.	MME / *EDC*	Medium term
Charging & Power Supply	Ensure that there are regulations in place for EV batteries to be disposed of safely alongside other hazardous waste containing lithium.	MOE	Medium term
Charging & Power Supply	Introduce EV charging at several strategic sites identified.	MME / *EDC*	Medium term
Charging & Power Supply	Ensure the good design and inclusivity of the new charging station.	MME / *EDC*	Medium term
Charging & Power Supply	Undertake PPPs and/or work with petroleum stations to convert some of their infrastructure into EV charging.	MME / *EDC*	Medium term
Charging & Power Supply	Assess the community-charging opportunity.	MME / *EDC*	Long term
Charging & Power Supply	Create partnerships with recycling partners in the region as the market develops.	MOE	Long term
Charging & Power Supply	Introduce a smart metering plan to allow for smart charging.	MME / *EDC*	Long term
Charging & Power Supply	Use renewables such as solar photovoltaic canopies in charging hubs with battery storage, to decrease costs.	MME / *EDC*	Long term



Bibliography

Asem Connect Vietnam. 2019. “Automobile Industry Development Plan of Vietnam.” Accessed at: http://asemconnectvietnam.gov.vn/default.aspx ?ZID1=14&ID8=15474&ID1=2.

ADB (Asian Development Bank). 2018. “Cambodia: Energy Sector Assessment, Strategy and Roadmap.”

ADB (Asian Development Bank). 2019. “Cambodia Transport Sector Assessment, Strategy, and Road Map.”

Automotive Research Association of India. 2017. “Automotive Industry Standard: AIS138 part 1 and 2.”

Bangkok Post. 2022. “Chinese EV makers eye Southeast Asia as Competition Escalates.” Accessed at: https://www.bangkokpost.com/auto/news/2439209/chinese-ev-makers-such-as-great-wall-motor-and-byd-eye-southeast-asian-markets-as-competition-escalates-at-home.

Boonsanong, S., Charoonchitsathian, C. “Electricity Regulation in Thailand: Overview.” n.d. Practical Law. 2020. Accessed at: https://uk.practicallaw.thomsonreuters.com/1-628-5906?transitionType=Default&contextData=(sc.Default)&firstPage=true.

BSI (British Standards Institute). 2022. PAS 1899:2022 Electric vehicles – Accessible charging – Specification. Office for Zero Emission Vehicles, and Motability.

Centre for Public Impact. “The Rise of Electric Vehicles in Norway.” Accessed at: https://www.centreforpublicimpact.org/case-study/electric-cars-norway.

Cheng, E. 2023. “Upstart Chinese electric car brand delivered more cars than Nio in 2022.” CNBC. Accessed at: https://www.cnbc.com/2023/01/04/upstart-chinese-electric-car-brand-delivered-more-cars-than-nio-in-2022.html.

Clean Air Asia. 2019. “An Assessment of Regulatory and Fiscal Policies for Road Transport Vehicles in Cambodia.”

Climate Watch Data. 2023. “Historical GHG Emissions.” Accessed at: https://www.climatewatchdata.org/ghg-emissions?breakBy=sector&chartType=area&end_ year=2019&regions=KHM&sectors=building%2Celectricity-heat%2Cfugitive-emissions%2Cmanufacturing-construction%2Cother-fuel-combustion%2Ctransportation&source=Climate%20 Watch&start_year=1990.

Conrad, J. 2022. “China Is Racing to Electrify Its Future.” Wired. Accessed at: https://www.wired.com/story/china-ev-infrastructure-charging/.

Conzade, J., A. Cornet, P. Hertzke, R. Hensley, R. Heuss, T. Möller, P. Schaufuss, S. Schenk, A. Tschiesner, and K. von Laufenberg. 2021. "Why the Automotive Future Is Electric." McKinsey & Company. Accessed at: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/why-the-automotive-future-is-electric.

Dutta, B., and H.B. Hwang. 2021. "Consumers Purchase Intentions of Green Electric Vehicles: The Influence of Consumers Technological and Environmental Considerations."

EAC (Electricity Authority of Cambodia). 2023. Energy Tariff and Electrification Rate. https://agep.aseanenergy.org/country-profiles/cambodia/cambodia-energy-sector/#1524896697001-ab31a2e1-3ebc

EAC. 2007. "Regulations on General Principles for Regulating Electricity Tariffs in the Kingdom of Cambodia." Accessed at: https://eac.gov.kh/site/viewfile? param=legal_doc%2Fenglish%2Fregulation%2FRegulations-On-General-Principles-For-Regulating-Electricity-Tariffs.en.pdf&lang=en.

Energy Saving Trust. 2021. "Lessons learned from the Go Ultra Low Cities scheme." https://energysavingtrust.org.uk/lessons-learned-from-the-go-ultra-low-cities-scheme/.

Ge, A. 2018. "Electric Vehicle Regulation and Law in China | CMS Expert Guides." Cms.law. Accessed at: https://cms.law/en/int/expert-guides/cms-expert-guide-to-electric-vehicles/china.

GGGI (Global Green Growth Institute). 2021. "Promoting Green Mobility Through Electric Motorbikes in Cambodia."

GTC-K (Green Technology Center, Korea). 2019 "Climate Technology Deployment Roadmap for the E-mobility ecosystem in Cambodia." Green Climate Fund. Accessed at: https://www.greenclimate. fund/sites/default/files/ document/cambodia-gtc-khm-rs-007.pdf.

Grab. 2018. "Grab Clocks 2 Billion Rides – Nine Months After Reaching Its First." https://www.grab.com/ph/blog/news/grab-clocks-2-billion-rides-nine-months-after-reaching-its-first/

India Times. 2021. "Vehicle scrappage policy: Details, benefits, rules and more." Accessed at: https://timesofindia.indiatimes.com/business/india-business/vehicle-scrappage-policy-details-benefits-rules-and-more/articleshow/85309762.cms

ICCT (International Council for Clean Transport). 2017. "Zero-emission vehicle deployment: ASEAN Markets."

IEA (International Energy Agency). 2021. "Trends and developments in electric vehicle markets." Accessed at: https://www.iea.org/reports/global-ev-outlook-2021/trends-and-developments-in-electric-vehicle-markets.

IEA 2022. "Cambodia Country Profile." Accessed at: https://www.iea.org/ countries/cambodia.

IEA. 2022. "Global EV Data Explorer – Data Tools." Accessed at: https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer.

IEA. 2022. "Trucks and Buses Tracking Report."

ILO (International Labour Organisation). 2002. "Rural Transporters: A survery of transport business in rural Cambodia", January 2002.

JICA (Japanese International Cooperation Agency). 2013. "Preliminary Data Collection Survey for Expressway Development in The Kingdom of Cambodia, Final Report." https://openjicareport.jica.go.jp/pdf/12153250_02.pdf.

JICA. 2016. Preparatory Survey Report on the Project for Improvement of Transportation Capacity of Public Bus in Phom Penh. https://openjicareport.jica.go.jp/pdf/12267720.pdf.

Le, H., F. Posada, and Z. Yang. 2022. "Electric Two-Wheeler Market Growth in Vietnam: An Overview. Briefing. ICCT." Issue Briefing.

Leith, C. 2023. "Challenges facing the Siem Reap tuk-tuk workforce in a changing tourism environment." In Proceedings of the 2nd International Conference on Tourism Research (ICTR 2019), edited by C. Sousa, I. Vaz de Freitas, and J. Marques, 166-172. Reading: Academic Conferences and Publishing International Limited, 2019. Accessed April 28, 2023.

MISTI (Ministry of Industry, Science, Technology & Innovation). 2022. "PRAKAS on Cambodia's Nine (9) Standards for Vehicle Products." No. 173 MISTI/2022.

MISTI. 2022. "Vehicle Production Standards."

MME (Ministry of Mines and Energy). 2022. "Power Development Masterplan 2022-2040." Kingdom of Cambodia. 2022.

MME. 2015. "Technical Standards of the Kingdom of Cambodia for Electrical Witing and Safety for Buildings and Households." Final Draft. 2015.

Ministry of Rural Development. 2002. "Rural Transporters: A Survey of Transport Business in Rural Cambodia." https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_policy/---invest/documents/projectdocumentation/wcms_asist_8399.pdf

Mol, C. J. Dabell, and others. 2022. "Interoperability of e-mobility services- User-centric charging infrastructure." Task 39, HEV TCP, IEA. Accessed at: https://ieahev.org/wp-content/uploads/2022/07/IEA-TCP-HEV-Task39-Final-Report-ExCo55.pdf.

MPWT (Ministry of Public Works and Transport). 2023. "Summary Vehicle Data 2022."

MPWT. 2022. "Vehicle registrations per year and per type of vehicle."

MPWT. 2021. "Summary Vehicle Data – number of registrations by type."

MotorCycles Data. 2023. "Electric Motorcycles Market - Data & Facts." Accessed at: https://www.motorcyclesdata.com/2023/01/12/electric-motorcycles-market/#:~:text=In%202022%20the%20electric%202.

National Bank of Cambodia. 2017. "Prakas on Interest Rate Ceiling on Loan." Unofficial Translation. https://www.nbc.gov.kh/download_files/legislation/prakas_eng/Prakas-on-Interest-Rate-Cap-Eng.pdf.

NITI (National Institution for Transforming India). 2021. "Handbook Of Electric Vehicle Charging Infrastructure Implementation."

NIS (National Institute for Statistics). 2019. "People and Building Statistics-urban-rural."

Office of the State Council. 2015. "Guiding Opinions of the General Office of the State Council on Accelerating the Construction of Electric Vehicle Charging Infrastructure." Accessed at: http://www.gov.cn/zhengce/content/2015-10/09/content_10214.html.

OCE (Observatory of Economic Complexity. 2020. https://oec.world/en/profile/bilateral-product/cars/reporter/khm

Pontes, J. 2023. "22% of New Car Sales in China Were 100% Electric in 2022!" CleanTechnica. Accessed at: https://cleantechnica.com/2023/02/01/plugin-electric-vehicles-get-30- share-of-auto-market-in-another-record-month-in-china/.

PR Newswire. 2023. "Electric Three Wheeler Market Size to Grow USD 1.5 Billion by 2031 Growing at a CAGR of 7%." Accessed at: https://www.prnewswire.com/news-releases/

electric-three-wheeler-market-size-to-grow-usd-1-5-billion-by-2031-growing-at-a-cagr-of-7--valuates-reports-301720300.html.

PwC (Price Waterhouse Cooper). 2023. “Demand Projection Model-S Curve Approach.” Draft for the World Bank. March 2023.

Raksmey, H. 2022. “Gone the way of the cyclo? Khmer tuk-tuk not finished yet, say drivers.” The Phnom Penh Post. June 2022. Accessed at: https://www.phnompenhpost.com/national-post-depth/gone-way-cyclo-khmer-tuk-tuk-not-finished-yet-say-drivers.

RGC (Royal Government of Cambodia). 2022a. “National Energy Efficiency Policy 2022-2030.”

RGC. 2022b. “Cambodia Automotive and Electronics Sector Development Roadmap.”

Sharma, A., and R. Gupta. 2020. “Bharat DC001 Charging Standard Based EV Fast Charger.” IECON 2020 The 46th Annual Conference of the IEEE Industrial Electronics Society. Accessed at: https://doi.org/10.1109/iecon43393.2020.9254949.

Siddhant, W. and M. Sonia. 2022. “Used Cars Market by Vehicle Type (Hatchback, Sedan, SUV), by Propulsion (ICE, Electric and Hybrid), by Distribution Channel (Franchised Dealer, Independent Dealer, Peer-to-peer): Global Opportunity Analysis and Industry Forecast, 2021-203.”

Thananusak, T., P. Punnakitikashem, S. Tanthasith, and B. Kongarchapatara. 2020. “The Development of Electric Vehicle Charging Stations in Thailand: Policies, Players, and Key Issues (2015–2020).” World Electric Vehicle Journal 12(1):2. 2020. Accessed at: https://doi.org/10.3390/wevj12010002.

General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia. 2020. “Cambodia’s Updated Nationally Determined Contribution.”

General Secretariat of the National Council for Sustainable Development. 2021. “Long-Term Strategy for Carbon Neutrality.”

The Phnom Penh Post. 2023. “Groundbreaking announced for Phnom Penh-Bavet Expressway.” Accessed April 28, 2023. https://phnompenhpost.com/national/ground-breaking-announced-phnom-penh-bavet-expressway.

The Phnom Penh Post. 2022. Gone the way of the cyclo? Khmer tuk-tuk not finished yet, say drivers. https://www.phnompenhpost.com/national-post-depth/gone-way-cyclo-khmer-tuk-tuk-not-finished-yet-say-drivers#:~:text=He%20estimated%20that%20there%20were,transport%20and%20the%20occasional%20tourist.

UK BEIS (UK Department of Business, Energy, and Industrial Strategy). 2022. “UK Government GHG Conversion Factors for Company Reporting.” https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fgovernment%2Fuploads%2Fsystem%2Fuploads%2Fattachment_data%2Ffile%2F1083855%2Fghg-conversion-factors-2022-full-set.xls&wdOrigin=BROWSELINK

UK Department for Transport. 2020. Average new car and light goods vehible (LGV) fuel consumption. Great Britain, 1997-2020. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fgovernment%2Fuploads%2Fsystem%2Fuploads%2Fattachment_data%2Ffile%2F1040512%2Fenv0103.ods&wdOrigin=BROWSELINK

US Department of Energy. 2022. “EV Charging at Home.”

UNDP (United Nations Development Program). 2022. “Review of Roadmap for the Development of a Network of Electric Vehicle Charging Stations in Cambodia (Draft).” MPWT.

UNESCAP (United Nations Economic and Social Commission for Asia and the Pacific). 2023. "National Policy Framework for Electric Mobility Development in Cambodia." https://www.unescap.org/kp/2023/national-policy-framework-electric-mobility-development-cambodia

United Nations Framework Convention on Climate Change. 2019. "National GHG Inventory Report."

Valuates Reports. 2023. "Electric Three Wheeler Market Size to Grow USD 1.5 Billion by 2031 Growing at a CAGR of 7%." Accessed at: https://www.prnewswire.com/news-releases/electric-three-wheeler-market-size-to-grow-usd-1-5-billion-by-2031-growing-at-a-cagr-of-7--valuates-reports-301720300.html

Vietnam Briefing. 2023. "E-Mobility Conference Sheds Light on Vietnam's EV Market Development." Last modified January 18, 2023. https://www.vietnam-briefing.com/news/e-mobility-conference-sheds-light-on-vietnams-ev-market-development.html/.

Wang, L., X. Xue, Z. Zhao, and Z. Wang. 2018. "The Impacts of Transportation Infrastructure on Sustainable Development: Emerging Trends and Challenges." International Journal of Environmental Research and Public Health 15(6).

World Bank. 2018. "Urban Population (% Total Population) – Cambodia." https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?end=2021&locations=KH&start=1960&view=chart

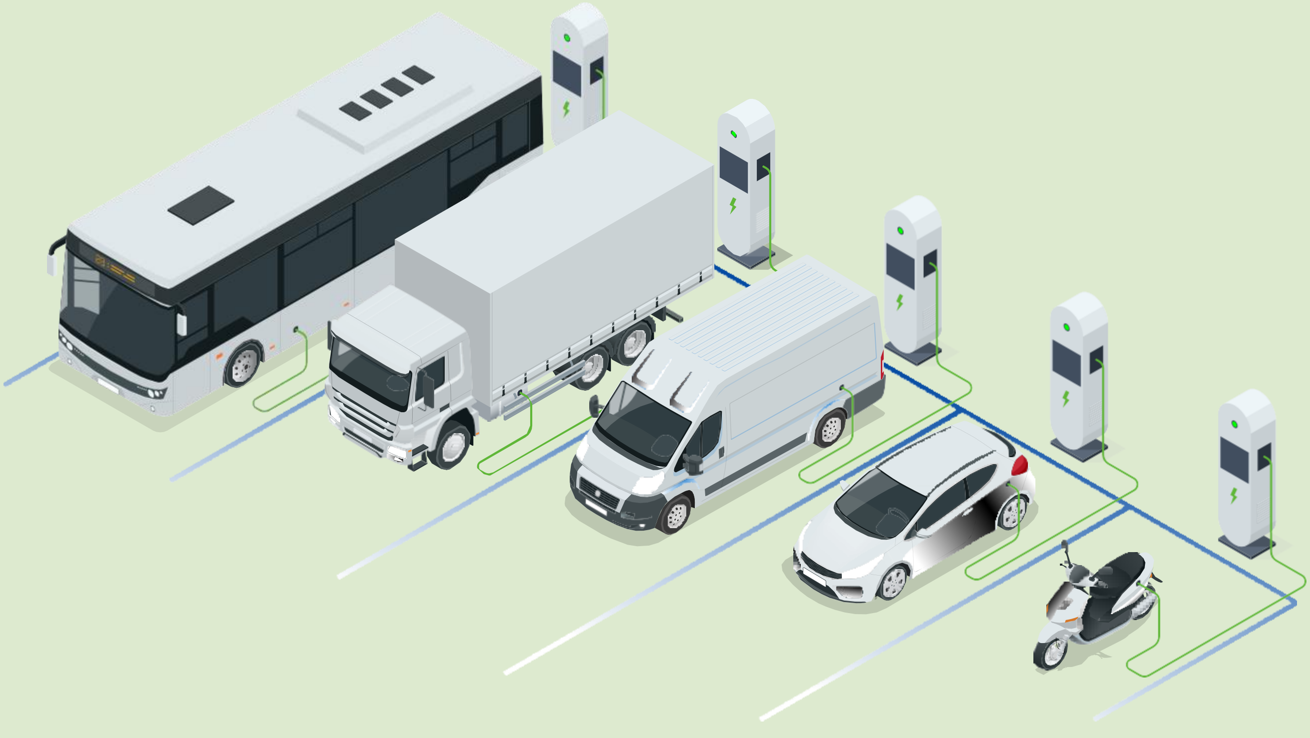
World Bank. 2019a. "Population, Total - Cambodia | Data." Accessed at: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=KH.

World Bank, 2019b. "Strengthening Vietnam's Trucking Sector", 2019

World Bank. 2022. "The Economics of EVs for Passenger Transportation: Country at a Glance – Passenger Electric Mobility in Cambodia."

World Bank. 2023. "GDP (Current US$) - Cambodia | Data."Data.worldbank.org. Accessed at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?end=2021&locations=KH&start=2000.

Yang, T. 2020. "Understanding Commuting Patterns and Changes: Counterfactual Analysis in a Planning Support Framework." Environment and Planning B: Urban Analytics and City Science 47(8). 2020.



Appendices

Appendix A — Modeling Methodology

The modeled scenarios were based on data from sources of primary data collected in Cambodia. Where reliable data was not available, informed assumptions were made. This Appendix lists the data used in the method along with the source it was taken from as a supplement to Chapter 2. Source documents can be found in the Reference List at the end of the document.

Vehicle Distribution Assumptions

Assumptions regarding ownership and distribution were applied for the various vehicle types currently prevalent in the Cambodian market. The sources for these assumptions were various official reports, local news articles, and assumptions informed by stakeholder engagement. These sources and assumptions have been listed in Table A.1.

Table A.1: Assumptions regarding vehicle distribution

Assumption	Value assumed (%)	Source
Motorcycles		
Urban private 2Ws	61	NIS, 2019.
Rural private 2Ws	39	
Urban commercial 2Ws	80	Grab, 2018.
Rural commercial 2Ws	20	
Urban commercial 3Ws	100	The Phnom Penh Post, 2022.
Rural commercial 3Ws	0	
Light Vehicles		
Urban private 4Ws	61	National Institute for Statistics, 2019.
Rural private 4Ws	39	
Urban commercial minivans	80	Urban Foresight, 2023
Rural commercial minivans	20	
Commercial inter-city minibus	100	
Heavy Vehicles		
Urban Bus	1.5	JICA, 2016.
Inner-city – Bus/Coach	98.5	
Trucks	100	Urban Foresight. 2023. Assumed 100% of trucks are heavy duty

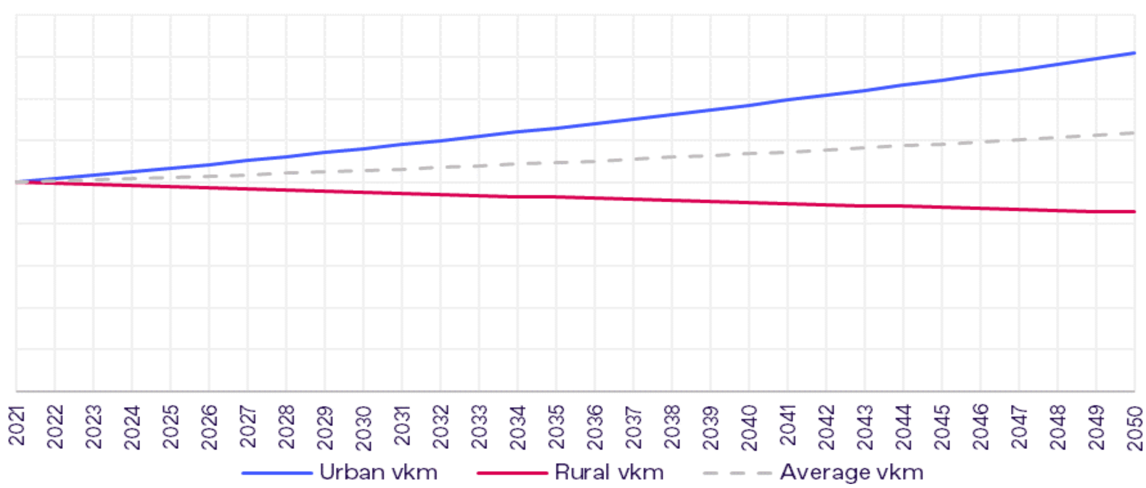
Vehicle Activity Assumptions

A rise in the average distance traveled is expected in urban areas as towns and cities experience continued expansion. This growth is expected to increase the annual mileage of vehicles in urban areas (World Bank 2022). Conversely, it is predicted that rural areas will experience a reduction in the average distance traveled as the distances between urban and rural centers shrink (Yang 2020). These rates are depicted in Figure AI.1.

- Urbanization growth has been assumed to set to increase at a constant average rate of 1.67 percent per annum (World Bank 2018).
- Rural-associated VKMs are estimated to decrease at an average rate of -0.53 percent per annum. (World Bank 2018).

Baseline vehicle activity assumptions are shown in Table A.2.

Figure A.1: Projection of Urban and Rural VKM from 2021-2050



Source: World Bank 2022; and Yang 2020.

Table A.2: Vehicle activity assumptions

Vehicle segment	2022 baseline assumption (km)	Source
Motorcycles		
Urban private 2Ws	7,627	World Bank, 2022.
Rural private 2Ws	10,901	Rural mileage is assumed to be 50% higher than urban areas, following trends in European national travel surveys.
Urban commercial 2Ws	20,000	Urban commercial mileage is assumed same as rural.
Rural commercial 2Ws	20,000	Ministry of Rural Development, 2002.
Urban commercial 3Ws	31,000	Local engagement in Cambodia with Nham 24 and ONiON, February 2023.
Light Vehicles		
Urban private 4Ws	15,224	World Bank, 2022.
Rural private 4Ws	15,224	World Bank, 2022.
Urban commercial minivans	15,000	Assumed the same as rural. Although the distance traveled per trip is on average higher for urban vehicles, the frequency of trips is higher for rural vehicles.

Vehicle segment	2022 baseline assumption (km)	Source
Rural commercial minivans	15,000	Average VKM based on local engagement in Cambodia, February 2023.
Commercial inter-city minibus	48,092	World Bank, 2022.
Heavy Vehicles		
Urban Bus	47,000	Local engagement with a Phnom Penh bus operator, February 2023.
Inter-city coach/bus	105,000	
Trucks	55,000	

Baseline Power Train Share Assumptions

Table A.3: Powertrain type as a share of total vehicle segment

Vehicle Segment	2022 Baseline Assumption (%)					Source
	Diesel	Electric	Gasoline	Hybrid	LPG	
Motorcycles						
2Ws	N/A	0.10	99.9	N/A	N/A	MPWT, 2021.
3Ws	2.2	0.33	33.2	N/A	64.3	
Light Vehicles						
Private 4Ws	4.2	0.3	58.1	37.2	0.2	MPWT, 2021.
Mini van	86.39	0.33	13.27	N/A	N/A	
Pick-up	71.24	0.02	28.74	N/A	N/A	
Inter-city minibus	86.39	0.33	13.27	N/A	N/A	
Heavy Vehicles						
Urban Bus	86.4	0.3	13.3	N/A	N/A	MPWT, 2021.

Powertrain Energy Efficiency

As technology advances, powertrains are expected to get more efficient. An increase in both ICE and EV efficiency was predicted as part of a market analysis. The increase in fuel efficiency was forecasted at a constant linear rate over time with the following assumptions based on the research undertaken:

- The EV efficiency rate is predicted to increase by 1.84 percent per year.
- The ICE efficiency rate is predicted to increase by 0.46 percent per year.

Table A.4: Baseline assumptions: Powertrain Energy Efficiency

Vehicle segment	2022 Baseline assumption					Source
	Diesel (l/km)	Electric (kWh/km)	Gasoline (l/km)	Hybrid (l/km)	LPG (l/km)	
Motorcycles						
2Ws	N/A	0.20	0.015	N/A	N/A	Market assessment via Khmer24.com
3Ws	0.02	0.60	0.27	N/A	0.03	
Light Vehicles						
Private 4Ws	0.54	0.18	0.05	0.04	0.12	Market assessment via Spritmonitor.de
Mini-van	0.06	0.22	0.046	N/A	N/A	UK Department for Transport. 2020.
Pick-up	0.09	0.30	0.098	N/A	N/A	Market assessment via Spritmonitor.de
Inter-city minibus	0.07	0.30	0.09	0.03	0.03	Market assessment via CarDekho, Red Kite and Hyundai
Heavy Vehicles						
Urban bus	0.45	1.18	0.25	N/A	N/A	Engagement with Phnom Penn bus operator
Inter-City Coach	0.34	0.64	0.25	N/A	N/A	Engagement with Royal Group Cambodia
Truck	0.33	1.45	0.33	N/A	N/A	ADB, 2019.

GHG Emission Factors

An emissions baseline was calculated using the associated emissions ($kgCO_2e$) per kilometer traveled. The emission factors taken from UK BEIS are an average emissions factor by vehicle segment and drivetrain type for a vehicle registered over the 16-year period 2005-2021. The emission factor used for Urban buses was calculated by ADB using data from COPERT. The emission factors for each segment are listed in Table A.5.

Table A.5: Baseline assumptions - GHG Emission Factors ($kgCO_2e/km$ or $kgCO_2e/kWh$)

Vehicle segment	2022 Baseline assumption					Source
	Diesel	Electric	Gasoline	Hybrid	LPG	
Motorcycles						
2Ws	N/A	0.53	0.077	N/A	N/A	UK BEIS. 2022.
3Ws	0.129	0.53	0.129	N/A	0.102	
Light Vehicles						
Private 4Ws	0.212	0.53	0.219	0.151	0.221	UK BEIS. 2022.
Mini van	0.291	0.53	0.272	N/A	0.291	
Pick-up	0.253	0.53	0.271	N/A	N/A	
Inter-city minibus	0.267	0.53	0.286	N/A	0.291	
Heavy Vehicles						
Urban bus	0.533	0.53	0.533	N/A	N/A	ADB, 2019
Inter-city coach	0.533	0.53	0.533	N/A	N/A	UNESCAP, 2023.
Truck	1.020	0.53	1.0995	N/A	N/A	UK BEIS, 2022.

Charging Infrastructure Requirements

The infrastructure requirements analysis estimates the level of infrastructure, investment, and power impact on the grid (kVA) and the required level of supporting infrastructure. The infrastructure requirements analysis estimates the level of infrastructure, investment and power impact on the grid (kVA) and the required level of supporting infrastructure.

Energy per charging category

The assessment of charging share by vehicle segment type is assumed to stay constant until 2050, representing an average share and split of how EV owners are likely to charge their vehicles

Table A.6: Share of total charging

Vehicle segment	Charging Assumption (%)				
	Home	Destination	"Top-Up"	Battery Swap	Depot
Private 2Ws	80	-	-	20	-
Commercial 2Ws	-	-	-	50	50
3Ws	-	-	-	100	-
Private 4Ws & Pick-Ups	80	14	6	-	-
Minivan	-	-	10	-	90
Inter-City Minibus	-	-	-	-	100
Urban Bus	-	-	-	-	100
Inter-City Coach	-	-	-	-	100
Truck	-	-	-	-	100

Number of chargers

Charging speed and utilization were used to determine the level of charging infrastructure that may be required to support EV uptake for each segment in Cambodia. The approach to calculating the number of chargers was bespoke for each charging category to ensure that market trends were accurately reflected.

Home Charging

The level of home charging infrastructure has been forecasted at a provincial level based on the number of private vehicles (motorcycles and cars) per residence. Therefore, the level of home charging demand assumes that if a property owns multiple vehicles, only one home charging point will be required.

The rates of private motorcycles and cars per property utilized the forecasted growth of the individual vehicle segments, split by province, assuming the 2019 vehicle split and the number of residences per province taken from the National Institute for Statistics (NIS 2019).

Table A.7: Private Motorcycles and Cars per Residence per Residence

Province	Private Motorcycles per Residence	Private Cars per Residence
1 Banteay Meanchey	1.507	0.211
2 Battambang	1.545	0.224
3 Kampong Cham	1.577	0.162
4 Kampong Chhnang	1.422	0.118
5 Kampong Speu	1.657	0.211
6 Kampong Thom	1.506	0.147
7 Kampot	1.551	0.182
8 Kandal	1.844	0.245
9 Koh Kong	1.662	0.208
10 Kracheh	1.562	0.172
11 Mondul Kiri	1.942	0.272
12 Phnom Penh	2.817	0.871
13 Preah Vihear	1.369	0.160
14 Prey Veng	1.538	0.124
15 Pursat	1.387	0.137
16 Ratanak Kiri	1.741	0.170
17 Siem Reap	1.731	0.228
18 Preah Sihanouk	1.856	0.424
19 Stung Treng	1.426	0.144
20 Svay Rieng	1.731	0.132
21 Takeo	1.703	0.169
22 Otdar Meanchey	1.505	0.188
23 Kep	1.822	0.249
24 Pailin	1.593	0.300
25 Tboung Khmum	2.031	0.205

Public (Destination & Top-Up) & Depot Charging

The estimated quantity of public EV charging, both fast destination and rapid “top-up” charging infrastructure, and depot charging was established by dividing the total annual required energy (kWh) for each vehicle segment by the average annual charger utilization (hours) and power drawn (kW).

Table A.8: Assumed Charging Technologies for each Segment

Vehicle segment	Destination			"Top up"			Depot		
	Private 4Ws	Pick-ups	Mini-vans	Private 4Ws	Pick-ups	Mini-vans	Commercial 3Ws	Mini-vans	Bus, intercity and trucks
Power rating (kW)	10	10	N/A	50	50	50	2.3	7	50
Utilization rate (%)	20%	20%	N/A	5%	5%	5%	-	35%	80%
Utilization rate (hrs)	4.8	4.8	N/A	1.2	1.2	1.2	8.0	8.5	19.2
Annual utilization per unit	17,520	17,520	N/A	21,900	21,900	21,900	6,716	21,716	350,400

Battery Swapping

To assess the potential demand for battery swapping in Cambodia, the key assumptions from the UNDP study were utilized. It was assumed 6 batteries were available per swapping station and a ratio of one swapping station for every 185 electric vehicles was assessed.

Impact on Grid

Total kVA capacity refers to the maximum amount of power (in kilovolt-amperes) that an electrical system or equipment can deliver or handle at any given time. It is a measure of the capacity or capability of the system or equipment to handle electrical loads. This capacity is determined by the Domestic Network Operators (DNO) and total capacity is determined by looking at the capacity available at each substation in a region.

The total grid capacity (kVA) was estimated by multiplying the total number of chargers (by type) with the associated kVA capacity required for each charger. The figures for the calculation are depicted in Table A.9.

Table A.9: Apparent power (kVAs) required by charger speed

Charger Speed (kW)	kVA required
7kW	7.5kVA
22kW	44kVA
50kW	75kVA
51kW+	187.5kVA

Source: Urban Foresight, 2023.

These figures were used to calculate the provincial kVA demands, which were then used to calculate the total kVA capacity.

Although the PDP provided insights on the HV connections (>1,000kVA), information about the LV connections (<1,000kVA) was not provided with the plan. Since EV infrastructure requires LV connections, it was not possible to determine the capacity available and network reinforcements required at a provincial level for installing EV charging infrastructure as part of this roadmap.

Appendix B – 2030 Detailed Provincial Results

Total Vehicles

Using Census and population data from the National Institute for Statistics, provincial motorization rates were calculated for the total number of vehicles. These numbers were used to determine the provincial energy demand and charging infrastructure required at a more granular level.

It should be noted that heavy vehicles and inter-city vehicles have not been modeled at a provincial level due to the nature of operation of such vehicles. It is assumed that a majority of the charging will take place at depots given the market trends in the European Nations.

Table B.1: Forecasted total vehicles by 2030

Province	Private 2Ws	Commercial 2Ws	Commercial 3Ws	Cars	Pick-Ups	Minivans
1 Banteay Meanchey	329,172	53,586	7,811	40,487	9,737	4,499
2 Battambang	402,168	65,469	9,544	51,224	12,319	5,692
3 Kampong Cham	396,675	64,575	9,413	35,703	8,587	3,967
4 Kampong Chhnang	215,972	35,158	5,125	15,710	3,778	1,746
5 Kampong Speu	390,920	63,638	9,277	43,606	10,487	4,845
6 Kampong Thom	274,367	44,664	6,511	23,434	5,636	2,604
7 Kampot	261,340	42,544	6,202	26,973	6,487	2,997
8 Kandal	581,597	94,679	13,802	67,928	16,337	7,548
9 Koh Kong	49,659	8,084	1,178	5,468	1,315	608
10 Kracheh	148,590	24,189	3,526	14,348	3,451	1,594
11 Mondul Kiri	41,663	6,782	989	5,129	1,234	570
12 Phnom Penh	1,326,083	215,874	31,469	360,046	86,592	40,005
13 Preah Vihear	87,105	14,180	2,067	8,916	2,144	991
14 Prey Veng	473,698	77,114	11,241	33,641	8,091	3,738
15 Pursat	167,931	27,338	3,985	14,514	3,491	1,613
16 Ratanak Kiri	100,689	16,391	2,389	8,606	2,070	956
17 Siem Reap	426,067	69,360	10,111	49,255	11,846	5,473
18 Preah Sihanouk	97,823	15,925	2,321	19,608	4,716	2,179
19 Stung Treng	62,256	10,135	1,477	5,523	1,328	614
20 Svay Rieng	268,069	43,639	6,361	17,965	4,321	1,996
21 Takeo	416,687	67,833	9,888	36,407	8,756	4,045
22 Otdar Meanchey	98,907	16,101	2,347	10,856	2,611	1,206
23 Kep	18,012	2,932	427	2,159	519	240
24 Pailin	30,788	5,012	731	5,099	1,226	567
25 Tboung Khmum	361,995	58,929	8,590	32,148	7,732	3,572

Electric Vehicles

Electric vehicles were projected using the SPT scenario stated in the LTS4CN and the provincial motorization rates, in a similar way to that mentioned in this report. These projections were used to determine the number and different types of chargers required in each province.

Table B.2: Forecasted Electric Vehicles by 2030

Province	Private 2Ws	Commercial 2Ws	Commercial 3Ws	Cars	Pick-Ups	Minivans
1 Banteay Meanchey	36,120	5,880	858	2,079	250	167
2 Battambang	44,130	7,184	1,048	2,630	316	211
3 Kampong Cham	43,527	7,086	1,034	1,833	220	147
4 Kampong Chhnang	23,698	3,858	563	807	97	65
5 Kampong Speu	42,895	6,983	1,019	2,239	269	180
6 Kampong Thom	30,106	4,901	715	1,203	144	97
7 Kampot	28,677	4,668	681	1,385	166	111
8 Kandal	63,818	10,389	1,515	3,488	419	280
9 Koh Kong	5,449	887	129	281	34	23
10 Kracheh	16,305	2,654	387	737	88	59
11 Mondul Kiri	4,572	744	109	263	32	21
12 Phnom Penh	145,510	23,688	3,455	18,489	2,219	1,483
13 Preah Vihear	9,558	1,556	227	458	55	37
14 Prey Veng	51,979	8,462	1,234	1,727	207	139
15 Pursat	18,427	3,000	438	745	89	60
16 Ratanak Kiri	11,049	1,799	262	442	53	35
17 Siem Reap	46,752	7,611	1,110	2,529	304	203
18 Preah Sihanouk	10,734	1,747	255	1,007	121	81
19 Stung Treng	6,831	1,112	162	284	34	23
20 Svay Rieng	29,415	4,788	698	923	111	74
21 Takeo	45,723	7,443	1,086	1,870	224	150
22 Otdar Meanchey	10,853	1,767	258	557	67	45
23 Kep	1,977	322	47	111	13	9
24 Pailin	3,378	550	80	262	31	21
25 Tbourg Khmum	39,722	6,466	943	1,651	198	132

Charging Infrastructure

The EV charging requirements assessment followed a similar approach undertaken for the United States and the United Kingdom (ICCT 2020).

Home Charging (2030)

As home charging usually occurs overnight, the infrastructure required for these types of chargers would have speeds varying from 3-7 kW. Certain 2Ws come equipped with removable battery packs which can be charged indoors.

Table. B.3: Forecasted number of home chargers by 2030

Province	Private 2Ws	Cars	Pick-Ups
1 Banteay Meanchey	14,987	8,074	969
2 Battambang	17,864	9,625	1,155
3 Kampong Cham	17,260	9,298	1,116
4 Kampong Chhnang	10,421	5,617	674
5 Kampong Speu	16,188	8,722	1,047
6 Kampong Thom	12,504	6,734	809
7 Kampot	11,563	6,231	748
8 Kandal	21,645	11,661	1,400
9 Koh Kong	2,051	1,107	133
10 Kracheh	6,527	3,517	422
11 Mondul Kiri	1,473	792	95
12 Phnom Penh	32,309	17,408	2,089
13 Preah Vihear	4,366	2,354	282
14 Prey Veng	21,134	11,382	1,367
15 Pursat	8,308	4,477	537
16 Ratanak Kiri	3,969	2,140	257
17 Siem Reap	16,889	9,098	1,092
18 Preah Sihanouk	3,618	1,950	234
19 Stung Treng	2,997	1,615	194
20 Svay Rieng	10,630	5,730	687
21 Takeo	16,795	9,049	1,086
22 Otdar Meanchey	4,510	2,427	292
23 Kep	679	366	44
24 Pailin	1,326	714	86
25 Tboung Khmum	12,235	6,591	791

Depot Charging (2030)

Commercial fleets and heavy vehicles used for inter-city transport are charged in depots. While heavy vehicles such as buses and trucks might require faster direct current chargers (50+kW), 2Ws can be provisioned for using AC chargers (3kW).

Table B.4: Forecasted number of depot chargers by 2030

Province	Commercial 2Ws	Minivans
1 Banteay Meanchey	159	50
2 Battambang	195	63
3 Kampong Cham	192	44
4 Kampong Chhnang	104	19
5 Kampong Speu	189	54
6 Kampong Thom	133	29
7 Kampot	126	33
8 Kandal	281	84
9 Koh Kong	24	7
10 Kracheh	72	18
11 Mondul Kiri	20	6
12 Phnom Penh	642	444
13 Preah Vihear	42	11
14 Prey Veng	229	42
15 Pursat	81	18
16 Ratanak Kiri	49	11
17 Siem Reap	206	61
18 Preah Sihanouk	47	24
19 Stung Treng	30	7
20 Svay Rieng	130	22
21 Takeo	202	45
22 Otdar Meanchey	48	13
23 Kep	9	3
24 Pailin	15	6
25 Tboung Khmum	175	40

Away from home chargers (2030)

Away from home or destination chargers are used in public locations where an EV user might stay for a few hours. For cars and pick-ups, these are typically AC chargers with speeds of around 7kW.

Table B.5: Forecasted away from home charging units by 2030

Province	Cars	Pick-Ups	Total
1 Banteay Meanchey	64	13	77
2 Battambang	81	17	98
3 Kampong Cham	57	12	69
4 Kampong Chhnang	25	5	30
5 Kampong Speu	69	15	84
6 Kampong Thom	37	8	45
7 Kampot	43	9	52
8 Kandal	108	23	131
9 Koh Kong	9	2	11
10 Kracheh	23	5	28
11 Mondul Kiri	8	2	10
12 Phnom Penh	570	120	690
13 Preah Vihear	14	3	17
14 Prey Veng	53	11	64
15 Pursat	23	5	28
16 Ratanak Kiri	14	3	17
17 Siem Reap	78	16	94
18 Preah Sihanouk	31	7	38
19 Stung Treng	9	2	11
20 Svay Rieng	28	6	34
21 Takeo	58	12	70
22 Otdar Meanchey	17	4	21
23 Kep	3	1	4
24 Pailin	8	2	10
25 Tboung Khmum	51	11	62

Fast charging (2030)

Direct current fast charging (50kW+) is usually provided at major road networks and locations where the dwell time might not exceed 30 minutes to an hour. It is essential to provide these kind of chargers as they provide for long-distance and inter-city travel without any concerns regarding range anxiety of EVs.

Table B.6. Forecasted fast chargers by 2030

Province	Cars	Pick-Ups	Minivans	Total
1 Banteay Meanchey	22	5	6	33
2 Battambang	28	6	7	41
3 Kampong Cham	19	4	5	28
4 Kampong Chhnang	9	2	2	13
5 Kampong Speu	24	5	6	35
6 Kampong Thom	13	3	3	19
7 Kampot	15	3	4	22
8 Kandal	37	8	9	54
9 Koh Kong	3	1	1	5
10 Kracheh	8	2	2	12
11 Mondul Kiri	3	1	1	5
12 Phnom Penh	195	41	49	285
13 Preah Vihear	5	1	1	7
14 Prey Veng	18	4	5	27
15 Pursat	8	2	2	12
16 Ratanak Kiri	5	1	1	7
17 Siem Reap	27	6	7	40
18 Preah Sihanouk	11	2	3	16
19 Stung Treng	3	1	1	5
20 Svay Rieng	10	2	2	14
21 Takeo	20	4	5	29
22 Otdar Meanchey	6	1	1	8
23 Kep	1	-	-	1
24 Pailin	3	1	1	5
25 Tboung Khmum	17	4	4	25

Battery-Swapping Stations (2030)

Due to standardization of batteries in the segment, battery-swapping stations are currently used for two and 3Ws in Cambodia. EV users of such vehicles can switch their depleted battery packs for fully charged ones for a fee.

Table B.7: Forecasted battery-swapping stations by 2030

Province	Private 2Ws	Commercial 2Ws	Commercial 3Ws	Total
1 Banteay Meanchey	3	16	5	24
2 Battambang	4	19	6	29
3 Kampong Cham	4	19	6	29
4 Kampong Chhnang	2	10	3	15
5 Kampong Speu	3	19	5	27
6 Kampong Thom	2	13	4	19
7 Kampot	2	13	4	19
8 Kandal	5	28	8	41
9 Koh Kong	-	2	1	3
10 Kracheh	1	7	2	10
11 Mondul Kiri	-	2	1	3
12 Phnom Penh	12	64	19	95
13 Preah Vihear	1	4	1	6
14 Prey Veng	4	23	7	34
15 Pursat	2	8	2	12
16 Ratanak Kiri	1	5	1	7
17 Siem Reap	4	21	6	31
18 Preah Sihanouk	1	5	1	7
19 Stung Treng	1	3	1	5
20 Svay Rieng	2	13	4	19
21 Takeo	4	20	6	30
22 Otdar Meanchey	1	5	1	7
23 Kep	-	1	-	1
24 Pailin	-	1	-	1
25 Tboung Khmum	3	17	5	25

Total Charging Units (2030)

Given the charging units forecasted in the tables above, total charging units per province were calculated in Table B.8.

Table B.8: Forecasted number of total chargers by 2030

Province	Home charging – Private 2Ws	Depot charging – Commercial 2Ws	Home charging – Private 4Ws	Away from home charging – All 4Ws	Fast charging – All 4WS	Depot charging - Minivans	Battery-swapping stations – All vehicles
1 Banteay Meanchey	14,987	159	9,043	77	33	50	24
2 Battambang	17,864	195	10,780	98	41	63	29
3 Kampong Cham	17,260	192	10,414	69	28	44	29
4 Kampong Chhnang	10,421	104	6,291	30	13	19	15
5 Kampong Speu	16,188	189	9,769	84	35	54	27
6 Kampong Thom	12,504	133	7,543	45	19	29	19
7 Kampot	11,563	126	6,979	52	22	33	19
8 Kandal	21,645	281	13,061	131	54	84	41
9 Koh Kong	2,051	24	1,240	11	5	7	3
10 Kracheh	6,527	72	3,939	28	12	18	10
11 Mondul Kiri	1,473	20	887	10	5	6	3
12 Phnom Penh	32,309	642	19,497	690	285	444	95
13 Preah Vihear	4,366	42	2,636	17	7	11	6
14 Prey Veng	21,134	229	12,749	64	27	42	34
15 Pursat	8,308	81	5,014	28	12	18	12
16 Ratanak Kiri	3,969	49	2,397	17	7	11	7
17 Siem Reap	16,889	206	10,190	94	40	61	31
18 Preah Sihanouk	3,618	47	2,184	38	16	24	7
19 Stung Treng	2,997	30	1,809	11	5	7	5
20 Svay Rieng	10,630	130	6,417	34	14	22	19
21 Takeo	16,795	202	10,135	70	29	45	30
22 Otdar Meanchey	4,510	48	2,719	21	8	13	7
23 Kep	679	9	410	4	1	3	1
24 Pailin	1,326	15	800	10	5	6	1
25 Tboung Khmum	12,235	175	7,382	62	25	40	25

Total Charging Cost

The estimated cost to deliver the level of charging infrastructure at a provincial level is outlined in Table B.9. This investment will be required from a mixture of consumers, private organizations and the public sector.

Table B.9: Total Charging Cost

Province	Home charging – Private 2Ws ($)	Depot charging – Commercial 2Ws ($)	Home charging – Private 4Ws ($)	Away from home charging – All 4Ws ($)	Fast charging – All 4Ws ($)	Depot charging – Minivans ($)	Bat-tery-swap-ping stations – All vehicles ($)
1 Banteay Meanchey	4,496,100	79,500	4,521,500	577,500	1,650,000	250,000	240,000
2 Battambang	5,359,200	97,500	5,390,000	735,000	2,050,000	315,000	290,000
3 Kampong Cham	5,178,000	96,000	5,207,000	517,500	1,400,000	220,000	290,000
4 Kampong Chhnang	3,126,300	52,000	3,145,500	225,000	650,000	95,000	150,000
5 Kampong Speu	4,856,400	94,500	4,884,500	630,000	1,750,000	270,000	270,000
6 Kampong Thom	3,751,200	66,500	3,771,500	337,500	950,000	145,000	190,000
7 Kampot	3,468,900	63,000	3,489,500	390,000	1,100,000	165,000	190,000
8 Kandal	6,493,500	140,500	6,530,500	982,500	2,700,000	420,000	410,000
9 Koh Kong	615,300	12,000	620,000	82,500	250,000	35,000	30,000
10 Kracheh	1,958,100	36,000	1,969,500	210,000	600,000	90,000	100,000
11 Mondul Kiri	441,900	10,000	443,500	75,000	250,000	30,000	30,000
12 Phnom Penh	9,692,700	321,000	9,748,500	5,175,000	14,250,000	2,220,000	950,000
13 Preah Vihear	1,309,800	21,000	1,318,000	127,500	350,000	55,000	60,000
14 Prey Veng	6,340,200	114,500	6,374,500	480,000	1,350,000	210,000	340,000
15 Pursat	2,492,400	40,500	2,507,000	210,000	600,000	90,000	120,000
16 Ratanak Kiri	1,190,700	24,500	1,198,500	127,500	350,000	55,000	70,000
17 Siem Reap	5,066,700	103,000	5,095,000	705,000	2,000,000	305,000	310,000
18 Preah Sihanouk	1,085,400	23,500	1,092,000	285,000	800,000	120,000	70,000
19 Stung Treng	899,100	15,000	904,500	82,500	250,000	35,000	50,000
20 Svay Rieng	3,189,000	65,000	3,208,500	255,000	700,000	110,000	190,000
21 Takeo	5,038,500	101,000	5,067,500	525,000	1,450,000	225,000	300,000
22 Otdar Meanchey	1,353,000	24,000	1,359,500	157,500	400,000	65,000	70,000
23 Kep	203,700	4,500	205,000	30,000	50,000	15,000	10,000
24 Pailin	397,800	7,500	400,000	75,000	250,000	30,000	10,000
25 Tboung Khmum	3,670,500	87,500	3,691,000	465,000	1,250,000	200,000	250,000

Energy Demand (2030)

Given the different types and number of chargers required at a provincial level, the total energy demand was calculated and presented in Table B.10.

Table B.10: Cumulative Total Energy demand by 2030 (GWh)

Province	Cumulative Total Energy Demand (GWh)
1 Banteay Meanchey	20
2 Battambang	25
3 Kampong Cham	21
4 Kampong Chhnang	10
5 Kampong Speu	23
6 Kampong Thom	14
7 Kampot	15
8 Kandal	34
9 Koh Kong	3
10 Kracheh	8
11 Mondul Kiri	3
12 Phnom Penh	134
13 Preah Vihear	5
14 Prey Veng	22
15 Pursat	9
16 Ratanak Kiri	5
17 Siem Reap	25
18 Preah Sihanouk	8
19 Stung Treng	3
20 Svay Rieng	12
21 Takeo	21
22 Otdar Meanchey	6
23 Kep	1
24 Pailin	2
25 Tboung Khmum	19

Appendix C – TCO Assumptions

Table C.1: Private 2Ws

Cost Category	Cost Items	Second-hand ICE	New ICE	New EV	References and Sources	Key Assumptions
Vehicle Details	Model	Honda Dream	Honda Dream	Sunra Robo-S	Market assessment via Khmer24.com Urban Foresight, 2023.	Honda Dream chosen due to high popularity in the Cambodian market. Sunra Robo-S was chosen as a suitable EV alternative.
	Total Years of Ownership	6 years			Urban Foresight, 2023.	-
	VKM	7,627			World Bank, 2022.	-
Purchasing Costs	Retail Price	$800	$2,400	$2,400	Market assessment via Khmer24.com Urban Foresight, 2023. GGGI, 2021.	These costs include the VAT, excise and customs duty. This includes a 6.3% reduction in E2W tax rates which takes the subsidised import tax rates provided by the government.
Operation Costs (per annum)	Repair & Mainte-nance	$120	$80	$50	GGGI, 2021.	$80 operating costs considered for ICE vehicles (GGGI 2021) $120 maintenance costs assumed for second- hand vehicles (through Urban Foresight market assessment)
	Total Battery Costs			$500		Urban Foresight assumption based on market review of battery life times.
	Road Tax	$0	$0	$0	GGGI, 2021.	Assumed motorcycles are exempt.
Fuel Costs	Gasoline price	$1.16/liter	$1.16/liter		Latest gasoline prices via globalpetrol-prices.com	N/A
	Electricity tariff			$0.17/ kWh	EAC, 2023.	N/A

Table C.2: Commercial 3Ws

Cost Category	Assumption	Second-hand ICE	New ICE	New EV	References and Sources	Key Assumptions
Vehicle Details	Model	TVS King Duramax	TVS King Duramax	ONiON T1	Local engagement with Virak Buntham Express and transport operators, as of February 2023	Due to its popularity and similar build/performance, an ONiON T1 was chosen as an EV alternative
	Ownership Period	6 years			Urban Foresight assumption, 2023	N/A
	VKM	31,000			Analysis based on engagement with local transport operators, Urban Foresight, 2023.	
Purchasing Costs	Retail Price	$500	$2,000	$5,000	$500 estimated by article in local publication, $2,000 obtained through local engagement and $5,000 is the price of an onion T1	These costs include the tax rates the VAT, customs and excise duties.
	Registration Fees	$0	$30.66	$30.66	MPWT, Vehicle registration (online), 2023	
Operation Costs (per annum)	Repair & Maintenance	$150	$120	$75	Urban Foresight, 2023. assumption of 1.5 times the cost of an ICE-2Ws.	Urban Foresight assumption, maintenance costs for second-hand vehicles assumed to be 1.25 times that of new ICE vehicles, and new EVs assumed to be 0.75 times that of new ICE vehicles.
	Total Battery Costs			N/A		Since a battery swap model is assumed, battery replacement would not be needed.
	Road Tax	$493.83	$493.83	$493.83	GDT Road Tax App	
Fuel Costs (per annum)	LPG price	$0.56/liter	$0.56/ liter		Latest LPG prices via globalpetrol-prices.com	
	Battery swapping			$3 per swap	VOD-Cambodia, ONiON tuk-tuk article, October 2022	

Table C.3: Private 4Ws

Cost Category	Assumption	Second-hand ICE	New ICE	New EV	References and Sources	Key Assumptions
Vehicle Details	Model	Kia Morning	Kia Morning	BYD E2		Kia Morning chosen due to high popularity in Cambodia; the E2 was chosen as it is in the same vehicle class
	Ownership Period	6 years				Urban Foresight Assumption, 2023
	VKM	15,224			World Bank, 2022.	
Purchasing Costs	Retail Price	$8,000	$15,000	$28,900	Market assessment using khmer24.com for second-hand vehicles and; Local stakeholder engagement with BYD.	These costs are assumed to include the VAT, excise and custom duty. This includes a 40% reduction in E4W tax rates which takes the subsidised excise duty rates provided by the government. (GDCE)
	Registration Fees	$0	$30.66	$30.66	MPWT, Vehicle registration (online), 2023	
Operation Costs (per annum)	Maintenance & Repair	$600	$480	$360	Based on data from on ILO, 2002.	Urban Foresight assumption, maintenance costs for second-hand vehicles assumed to be 1.25 times that of new ICE vehicles, and new EVs assumed to be 0.75 times that of new ICE vehicles.
	Total Battery Costs	N/A	N/A	N/A	N/A	Since the TCO has only been carried out for a period of 6yrs, we assume that the battery would not need to be replaced in the timeframe
	Road Tax	$97.99	$97.99	$97.99	Ministerial Document from the General Department of Customs and Taxes provided by the World Bank	
Fuel Costs (per annum)	Gasoline price	$1.16/liter	$1.16/liter		Latest gasoline prices via global-petrolprices.com	
	Electricity tariff			$0.17/kWh	EAC – Cambodia	

Table C.4: Urban Buses

Cost Category	Assumption	Second-hand ICE	New ICE	New EV	References and Sources	Key Assumptions
Vehicle Details	Model	Hyundai Universe	Hyundai Universe	Ankai 8.5m electric bus	Local engagement with Virak Buntham Express, as of February 2023	Ankai 8.5m electric bus, price from Vietnam, chosen as it was deemed to have similar performance and capacity
	Ownership Period	8 years				Urban Foresight Assumption, 2023. This was chosen based on market analysis carried out by Urban Foresight on battery performance for larger vehicles (buses and trucks).
	VKM per annum	47,000			Local engagement with Phnom Penh buses, as of February 2023	
Purchasing Costs	Retail Price	$45,000	$90,000	$343,644	Local engagement with Virak Buntham Express, as of February 2023	These costs include the tax rates the VAT, customs, and excise duties.
	Registration Fees	$0	$30.66	$30.66	MPWT, Vehicle registration (online), 2023	
Operation Costs (per annum)	Maintenance & Repair	$7,618.43	$6,094.74	$4,571.06	JICA, 2016.	Urban Foresight assumption, maintenance costs for second-hand vehicles assumed to be 1.25 times that of new ICE vehicles, and new EVs assumed to be 0.75 times that of new ICE vehicles.
	Total Battery Costs			N/A		Since the TCO has only been carried out for a period of 8 years, we assume that the battery would not need to be replaced in the timeframe
	Road Tax	$247.08	$247.08	$247.08	GDT Road Tax App	
Fuel Costs (per annum)	Diesel price	$1.04/liter	$1.04/ liter		Local engagement with Virak Buntham Express, as of February 2023	
	Electricity tariff			$0.17/ kWh	EAC – Cambodia	

Table C.5: Light Trucks

Cost Category	Cost Items	Second-hand ICE	New ICE	New EV	References and Sources	Key assumptions
Vehicle Details	Model	Hyundai mighty 3.5T	Hyundai mighty 3.5T	Iveco eDaily 3.5T	Local engagement with Virak Buntham Express, as of February 2023	Iveco eDaily truck quote given by Virak Buntham Express supplier.
	Total Years considered	8			Urban Foresight Assumption, 2023	This was chosen based on market analysis carried out by Urban Foresight on battery performance for larger vehicles (buses and trucks).
	VKM	55,000			Local engagement with Virak Buntham Express, as of February 2023	
Purchasing Costs	Retail Price	$20,000	$35,000	$70,000	Local engagement with Virak Buntham Express, as of February 2023	These costs include the tax rates the VAT, customs and excise duties.
	Registration Fees	$0	$30.66	$30.66	MPWT, Vehicle registration (online), 2023 MPWT, 2023.	
Operation Costs (per annum)	Maintenance & Repair	$2,848.10	$2,278.48	$1,708.86	World Bank, 2019b.	Urban Foresight assumption, maintenance costs for second-hand vehicles assumed to be 1.25 times that of new ICE vehicles, and new EVs assumed to be 0.75 times that of new ICE vehicles.
	Total Battery Costs			N/A		Since the TCO has only been carried out for a period of 8yrs, we assume that the battery would not need to be replaced in the timeframe
	Road Tax	$493.83	$493.83	$493.83	GDT Road Tax App	
Fuel Costs (per annum)	Diesel price	$1.04/liter	$1.04/ liter		Local engagement with Virak Buntham Express, as of February 2023	Wholesale diesel prices
	Electricity tariff			$0.17/ kWh	EAC – Cambodia	

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