# CITY ROADMAP FOR ELECTRIC TWO-WHEELER TAXIS IN BANGKOK, THAILAND

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## PROJECT PARTNERS

## ABOUT

TO PRESENT A ROADMAP TO UPSCALE ELECTRIC TWO-WHEELER TAXIS IN BANGKOK

## TITLE

City Roadmap for Electric Two-wheeler Taxis in Bangkok, Thailand

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## LAYOUT

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## PICTURES

All the pictures are provided by the SOL+ partners

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# Executive Summary

This report first gives an overview of Thailand's greenhouse gas (GHG) emission landscape, highlighting that the transport sector accounts for 34% of the country's GHG emissions. The current national climate change plan, and the updated Nationally Determined Contribution (NDC), indicate a target of a 20-30% reduction of GHG emission by 2030 from all sectors compared to the business-as-usual scenario in reference year 2005, in line with the Long-term Low Greenhouse Gas Emission Development Strategy (LT-LEDS) and the Thailand Carbon Neutrality 2050 and Net Zero 2065 targets. Furthermore, the report described the current effort at the city level in Bangkok following the Bangkok Master Plan on Climate Change, from the first version of 2007 until the more recent update to synergize with Thailand's national target and institutional arrangement for monitoring and evaluation.

A survey looking at urban mobility in Bangkok shows that the majority (60%) of commuters are in the age range of 20-40 years old and travel mainly for work (74.6%). The fact that only about 30% of commuters in the City Business District and 24% of urban households have no vehicle, and 30% of suburban households have both a car and motorcycle prompts for the need to switch to e-mobility. Especially electric 2-wheelers should be prioritized, as this is a commonly used mode of transport (4.31 million 2-wheelers registered for use in Bangkok in 2023) and electric 2-wheelers are already cost competitive today with 21,415 registered for use in Bangkok in 2023. The national roadmap on electric vehicles (EV), has a 30@30 target to achieve 30% EV production by 2030 that is targeted especially on the electric 2-wheelers sector.

Various policy initiatives, such as an emphasis on EV charging infrastructure, standards and an EV subsidy scheme (EV3.0 & EV3.5) have effectively resulted in high growth of EV car sales in the past few years. Ongoing demonstration projects to use electric 2-wheelers as taxis are highlighted with projection of $CO_2$ reduction, which are later tracked via scientific sensor installed in electric 2-wheelers for monitoring the energy consumption according to Thailand's framework on Measuring, Reporting, Verifying (MRV). In addition, total cost of ownership (TCO) has been undertaken to assess financial viability for ICE-to-e2w switch over, as well as design sustainable financial scheme with participating private sectors in demonstration projects to avoid governmental subsidy for future expansion. Among many options, the leasing scheme to own e2w asset at the end of the leasing period with a fee for battery swapping subscription is found to be the most attractive to riders as it reduces the upfront cost while avoiding the need for a significant rider behavior change with unlimited battery swapping subscription fee.

Furthermore, there is an update of the national battery swapping standard TISI3316-2564 (Electric Mopeds and Motorcycles–Removable Rechargeable Electric Energy Storage System) via the Thailand battery swapping platform, which aims to efficiently utilize governmental budget on battery swapping infrastructure expansion by promoting compatibility across different swapping platforms

Further institutional, regulatory, financial, and standardization arrangements are the key to advance the electric 2-wheelers roadmap. To realize this, a roadmap is proposed for consideration by the city of Bangkok. It includes the following five steps:

1. **Assess Willingness to Pay and Subsidy Needs:**

    - Determine the willingness to pay for electric two-wheelers (e2ws) and the necessity for an initial subsidy scheme.
    - Analyse the total cost of ownership (TCO) for both internal combustion engine (ICE) 2-wheelers and e2ws.
    - Propose a potential subsidy scheme to the government or potential donors to encourage the initial demand-driven push for electrifying the 2-wheeler fleet.

2. **Engage Stakeholders:**

    - Collaborate with stakeholders in the 2-wheeler value chain to identify barriers to switching to electric vehicles.
    - Convince riders to transition from ICE 2-wheelers to e2ws, possibly by organizing test drives for potential riders.

3. **Implement Demonstration Projects:**

    - Launch demonstration projects targeting riders interested in switching to electric vehicles to create a pool of first customers.

4. **Conduct Comprehensive Assessments:**

    - Perform technical, financial, environmental, and social assessments of e2w usage and specific use cases for monitoring and evaluation purposes.

5. **Map Roles and Responsibilities:**

    - Define roles and responsibilities for the roadmap implementation when Bangkok designs and implements a policy framework to stimulate e2w adoption.
    - Ensure synchronization with existing plans such as the Bangkok Master Plan on Climate Change and the third Bangkok 20-Year Development Plan.

The timeline of this roadmaps is divided into 3 phases as follows:

- Demonstration (2024-2027): Implement various demonstration and pilot projects to highlight the feasibility and benefits of electric two-wheelers (e2ws).
- Scale-up (2027-2030): Introduce incentives and set up a regulatory framework focused on e2ws to stimulate demand and encourage wider adoption.

- Mainstream (2030 onwards): Position electric vehicles (EVs) as the default choice due to their superior performance and lower costs, making them the standard choice for new vehicle purchases.

The roadmap highlights 5 focus areas for the development of the e2w roadmap, focusing on:

- Urban planning: Develop action plans that support the integration of e2ws into the city's use of public spaces.
- Regulatory measures: Set up policies and regulations to facilitate a smooth transition from ICE 2-wheelers to e2ws.
- Economic and financial measures: Implement financial incentives and support systems to encourage the shift to e-mobility.
- Charging infrastructure: Develop comprehensive measures to ensure the availability and accessibility of charging stations.
- Partnerships and public awareness: Promote partnerships and raise public awareness about EVs, ensuring inclusiveness across various communities and backgrounds.

The next step for Bangkok's electric 2-wheelers roadmap is to focus on public-private partnerships, with the government acting as a facilitator to enable stakeholders to implement the rollout of e2ws and the necessary charging infrastructure.

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# List of Abbreviations

| | |
|---|---|
| 2w | Two-wheelers |
| ASI | Avoid-Shift-Improve |
| BAU | Business-as-usual |
| BEV | Battery Electric Vehicle |
| BMA | Bangkok Metropolitan Administration |
| BMR | Bangkok Metropolitan Region |
| BOI | Board of Investment |
| BUR | Biennial Updated Report |
| CBD | Central business district |
| $CH_4$ | Methane |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| dB | Decibel |
| e2w | Electric two-wheelers |
| e3w | Electric 3-wheelers |
| e2&3w | Electric 2&3 wheelers |
| ECT | Energy Consumption Tracker |
| EGAT | Electricity Generating Authority of Thailand |
| EPPO | Energy Policy and Planning Office |
| EV | Electric Vehicle |
| EVAT | Electric Vehicle Association of Thailand |
| FCEV | Fuel Cell Electric Vehicle |
| GDP | Gross domestic product |
| GHG | Greenhouse gas |
| GIZ | Deutsche Gesellschaft für Internationale Zusammenarbeit |
| HEV | Hybrid Electric Vehicle |
| HFCs | Hydrofluorocarbons |
| HTS | Household travel survey |
| ICE | Internal combustion engine |
| IEC | International Electrotechnical Commission |
| IMF | International Monetary Fund |
| INDC | Intended Nationally Determined Contribution |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPs | Independent Power Producers |
| IPPU | Industrial Processes and Product Use |
| JICA | Japan International Cooperation Agency |
| LT-LEDS | Long-term Low Greenhouse Gas Emission Development Strategy |
| LULUCF | Land use, Land-Use Change, and Forestry |
| MEA | Metropolitan Electricity Authority |
| MNRE | Ministry of Natural Resources and Environment |

| | |
|---|---|
| MRV | Monitoring, Reporting, and Verification |
| MTEC | National Metal and Materials Technology Center |
| $N_2O$ | Nitrous oxide |
| NAMA | Nationally Appropriate Mitigation Actions |
| NDC | Nationally Determined Contribution |
| $NO_2$ | Nitrogen dioxide |
| NSTDA | National Science and Technology Development Agency |
| $O_3$ | Ozone |
| OTP | Office of Transport and Traffic Policy and Planning |
| PCD | Pollution Control Department |
| PEA | Provincial Electricity Authority |
| PFCs | Perfluorocarbons |
| PHEV | Plug-in Hybrid Electric Vehicle |
| PM | Particulate matter |
| $PM_{2.5}$ | Particulate matter of size less than 2.5 micron |
| $PM_{10}$ | Particulate matter of size less than 10 micron |
| PPP | Purchasing power parity |
| SECAP | Sustainable Energy and Climate Action Plan |
| $SF_6$ | Perfluorocarbons |
| $SO_2$ | Sulphur dioxide |
| SPPs | Small Power Producers |
| SUMP | Sustainable Urban Mobility Plan |
| TCO | Total cost of ownership |
| TDS | Travel demand survey |
| TISI | Thailand Industrial Standards Institute |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VSPP | Very Small Power Producers |
| WHO | World Health Organization |
| ZEV | Zero-emission vehicle |
| ZEZ | Zero-emission zone |

| | |
|---|---|
| **Purpose** | To present a roadmap to upscale electric two-wheeler taxis in Bangkok |
| **Coordination** | UNEP<br>Wuppertal Institute |
| **Contributors** | Nuwong Chollacoop (ENTEC)<br>Peerawat Saisirirat (ENTEC) |
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| **Disclaimer** | The views expressed in this publication are the sole responsibility of the authors named and do not necessarily reflect the views of the European Commission. |

# 1. Background – Where are we now?

## 1.1. Urban mobility context in selected city

Thailand[1], with a population of 66.09 million[2] (2022), is located at the heart of the ASEAN Economic Community, a 10-nation Southeast Asian Common market of 671.7 million consumers. Second to Indonesia, Thailand ranks as the second largest economy in Southeast Asia. IMF data shows that Thailand's GDP per capita, based on purchasing power parity (PPP), was estimated to be US$23,708 in 2024.

Thailand's pollution is mainly a result of a rapidly increasing population, industrial activities, and a growing economy. Thailand[3] keeps track of six main types of GHG emissions, namely carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_20$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$), for reporting according to the UNFCCC. In December 20224, the national greenhouse gas (GHG) emissions reported in the fourth Biennial Updated Report (BUR) of Thailand was made per 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

In 2019, the total GHG emissions in Thailand (excluding those from Land use, Land-Use Change, and Forestry, LULUCF) were 372,716.86 GgCO2eq and net GHG emission were 280,728.34 GgCO2eq (including those from LULUCF). The energy sector was the largest contributor to Thailand's GHG emission, accounting for 69.96% of total GHG emissions in 2016, while emission from the Agriculture, IPPU, and Waste sectors accounted for 15.23%, 10.28%, and 4.53%, respectively. The LULUCF sector contributed to a net removal of 91,988.52 GgCO2eq, showing a trend of increased net removals. In the global perspective, Thailand's GHG emissions represent less than 1% of global emissions and are lower than the world average. Figure 1 shows the trend of GHG emissions from 2000 – 2019.

Real-time monitoring of CO2 emissions by sectors[5], namely power generation, industry and transport, is provided by Energy Policy and Planning Office (EPPO), where transport is accounted for 34% of total $CO_2$ emission during the first quarter of 2024.

As of 2023, the vehicle fleet in Thailand, consists of 11.8 million cars, 7.1 million pickup trucks, 1.2 million heavy-duty trucks, 0.13 million buses, 22.7 million two-wheelers and 0.02 million three-wheelers, where 43% of cars, 21% of pickup trucks, 13% of heavy-duty trucks, 27% of buses, 19% of two-wheelers and 49% of three-wheelers are registered in Bangkok 6. In terms of e-mobility landscape, in 2023, Thailand registered 21,927 electric motorcycles, a significant rise from 7,314 in 2022 and 1,840 in 2021. As of 2023, 1.1% of cars, 26.7% of buses, 0.5% of two-wheelers and 8.1% of three-wheelers are electric.

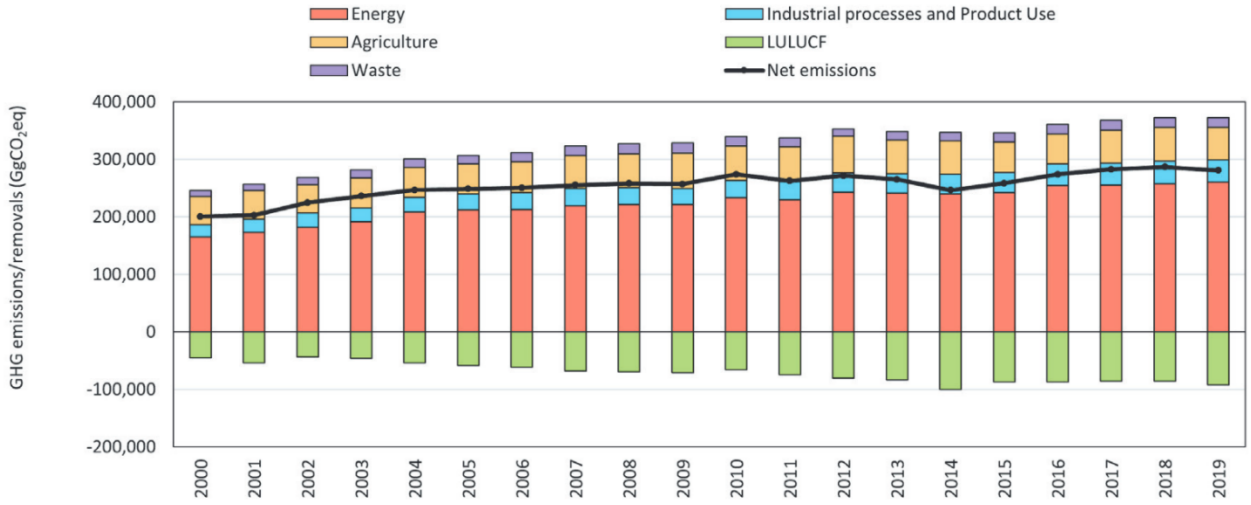



*Figure 1: National GHG emissions/removals by sector: 2000 – 2019*

In terms of air pollution in Thailand, the five major contributors are sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), carbon monoxide (CO), ozone ($O_3$), and particulate matter (PM). $PM_{10}$ is generated by building and road construction while $SO_2$ mainly comes from industrial activities. Air pollution in Thailand can be attributed to two main sources: 1) meteorological factors during the dry season, and 2) point source pollution. To address this problem, Royal Thai Government has formulated the 20-Year Master Plan on Air Quality Management (2018 – 2037) to establish standards for atmospheric air quality and emissions from specific sources of origin and develop a national air quality reporting system to improve air quality. In addition, the $PM_{2.5}$ level has become a major air quality problem for Thailand, where the road transport sector is the major source of $PM_{2.5}$ for the urban area. As a result, 2021 National Agenda on "Particulate Matter Pollution" was announced[7].

As for noise pollution in Thailand, the Pollution Control Department (PCD) has monitored this[8]. The World Health Organization (WHO) recommends that noise exposure levels should not exceed 70 dB over a 24-hour period, and 85 dB over a 1-hour period to avoid hearing impairment[9]. It was found that numerous roads in Bangkok have noise level exceeding the WHO limit (6 from 13 measuring stations), and around 37.25% of this is caused by traffic[10].

Thailand has achieved an exceptionally high level of electricity access, maintaining a 99% penetration rate since 2009 and reaching 100% in 2020, according to the World Bank[11]. Thailand's electricity system is regulated by the government under an enhanced single-buyer model with state electricity enterprises being sole buyers from power producers, both government (EGAT) and privates (IPPs/SPPs/VSPPs), and distributors (PEA/MEA) through national grid, as shown in Figure 2[12]. The role of private power producers (IPPs/SPPs/VSPPs) is to strengthen supply of electricity with renewable energy portfolio. In terms of mix, electricity is produced from 58% natural gas, 14% coal, 10% renewable, 3% hydro with the remaining 15% imported.

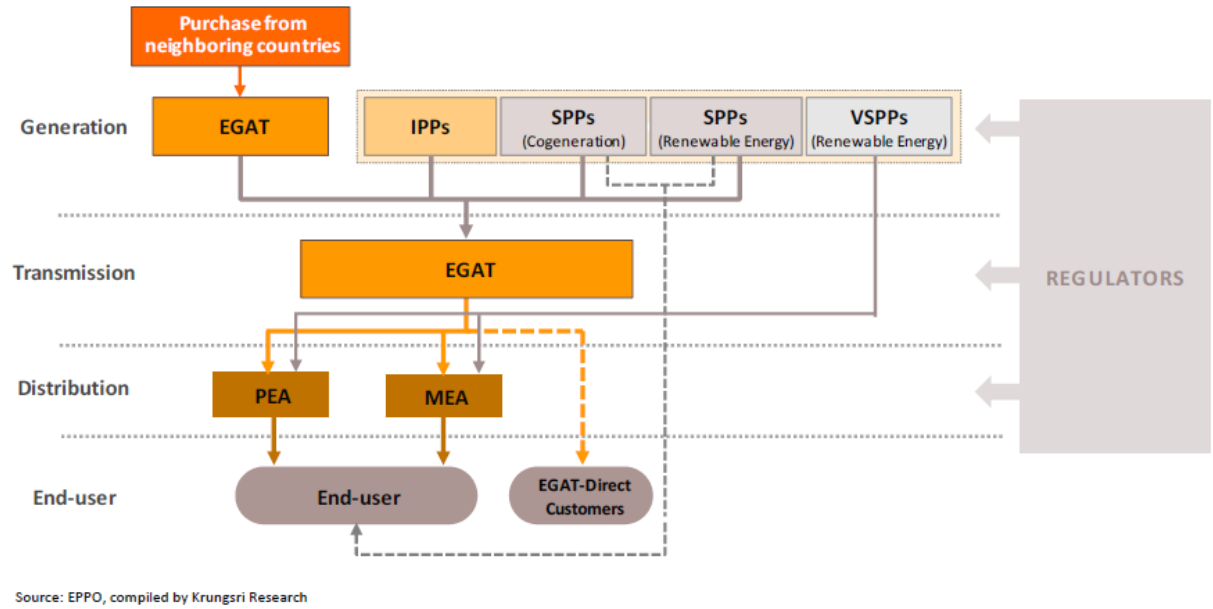



*Figure 2: Thailand Electricity System*

Within latitude range of 5° 37' to 20° 27' north and a longitude range of 97° 22' to 105° 37' east for Thailand topography, Bangkok is located at 13° 45' north and 100° 31' east with relatively flat topography at the floodplain of Chao Praya River. With little variation in land elevation, thermal variability in Bangkok is affected by urban heat island with seasonality and river proximity to typical tropical weather of 30-35°C. Rain, with often leads to flood, must be considered for city transport and e-mobility planning and design.

The 2018 Travel Demand Survey (TDS) by the Office of Transport and Traffic Policy and Planning [13] reveals key insights about Bangkokians, as shown in Figure 3. A significant proportion live in urban areas, particularly the central business district (CBD). Despite high vehicle ownership rates, many urban residents, especially in the CBD, do not own private vehicles, suggesting a high usage of public transportation or ride-hailing services possibly due to their convenience and lower costs.

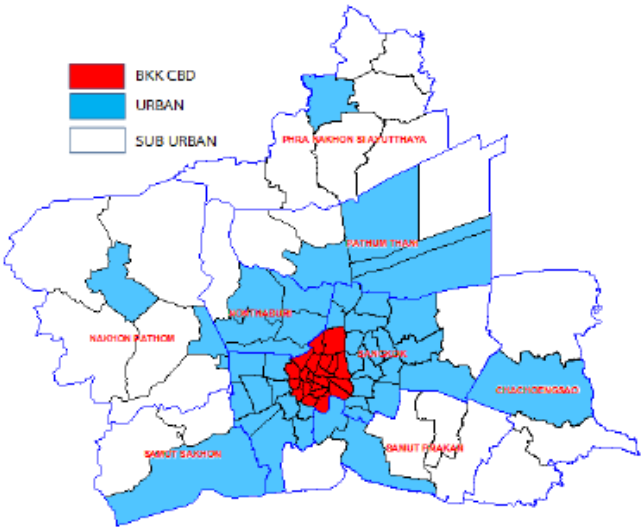
In contrast, suburban residents are more likely to own a car and/or a motorcycle, likely due to less accessible public transportation and the necessity of personal vehicles for longer distances. The demographic is largely young, with over 60% aged 20-40.

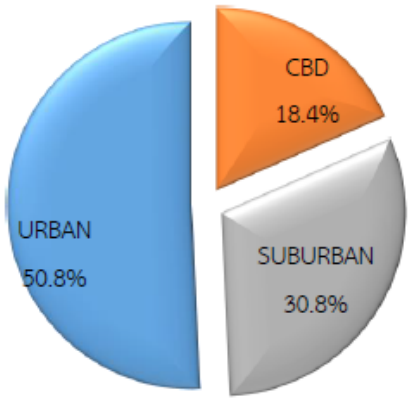
Many respondents come from small households with 2-3 family members, influencing their transportation preferences towards economical and convenient modes. The primary reason for travel is commuting to work and another significant portion being for study and private errands.

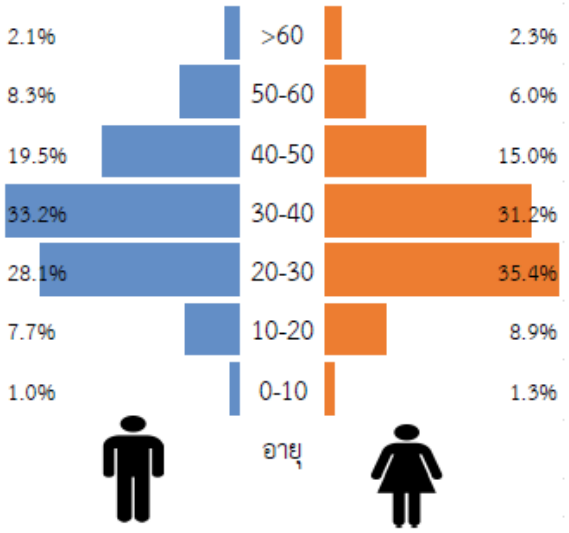
Most of the travel is by private car, but a significant number also use motorcycles and public transportation, indicating a reliance on both private and public solutions with many trips being multi-modal. Bangkokians show diverse transportation habits, with a strong reliance on convenient commuting options in urban areas and a need for personal vehicles in suburban regions. The young and active

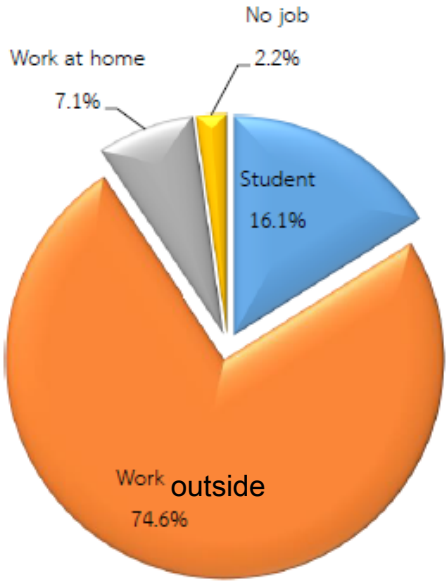
demographic seems open to adopting new transportation technologies if they are convenient, reliable, and accessible.

Overall, the data indicates a strong potential for electric two-wheelers to play a significant role in Bangkok's transportation landscape. They offer a flexible, economical, and efficient mode of transport that complements the city's public transport and aligns well with the needs and preferences of Bangkok residents.

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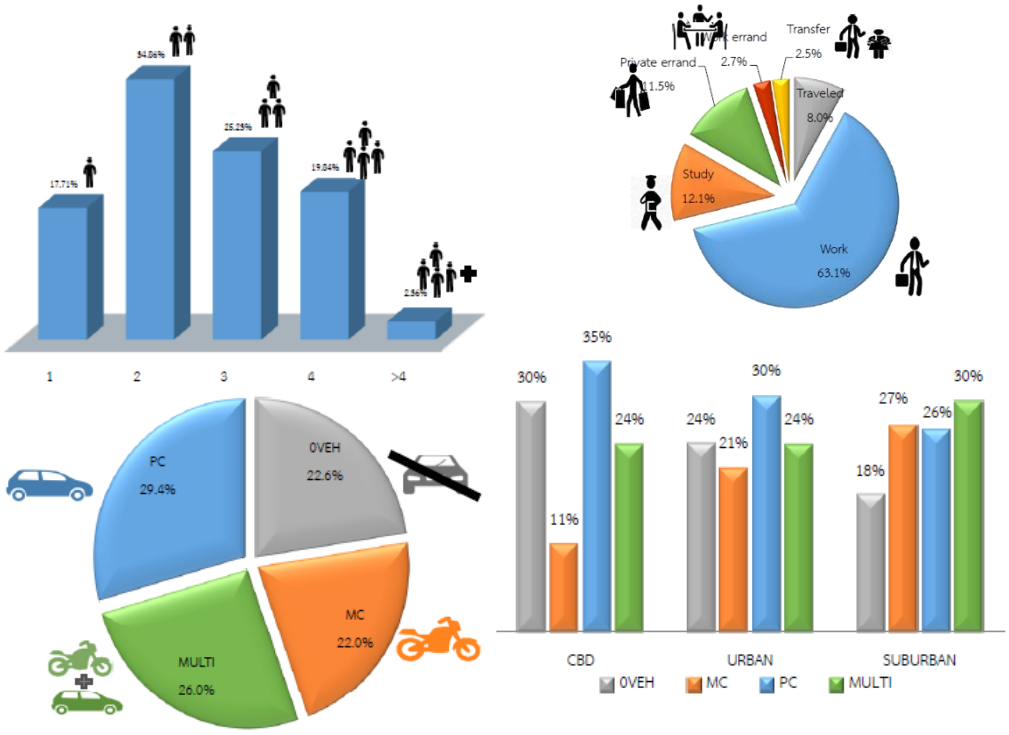


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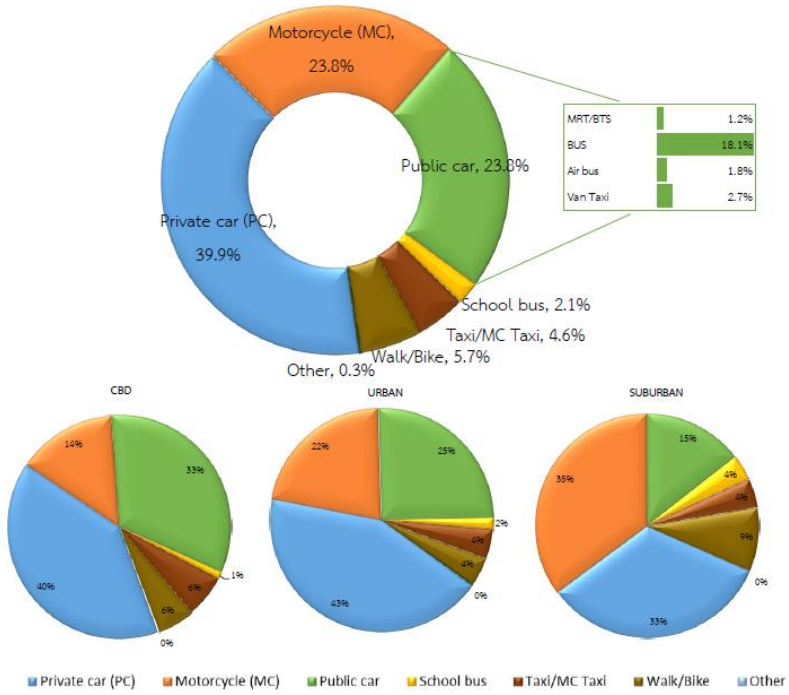



(c)

*Figure 3: Transport Demand Survey in Bangkok and vicinity with household (a) coverage, (b) characteristics and (c) travel modes*
*Source: Travel Demand Survey by the Office of Transport and Traffic Policy and Planning (2018)*

In terms of the national context, Thailand has been actively involved in climate change policy planning through a series of Sustainable Energy and Climate Action Plans, including NAMA [14] (Nationally Appropriate Mitigation Actions) aiming to reduce GHG emissions by 7-20% below projections for 2020 from 2005 reference year, which was upgraded in 2008 following the INDC [15] (Intended Nationally Determined Contribution) and NDC [16] (Nationally Determined Contribution) aiming to reduce GHG emissions by 20-25% by 2030 from 2005, the Climate Change Master Plan[17] (2015-2050), and the updated NDC[18] and LT-LEDS[19,20] (Long-term Low Greenhouse Gas Emission Development Strategy) which has set the target of reaching carbon neutrality by 2050 and net zero by 2065, as well as 30-40% GHG reduction target by 2030.

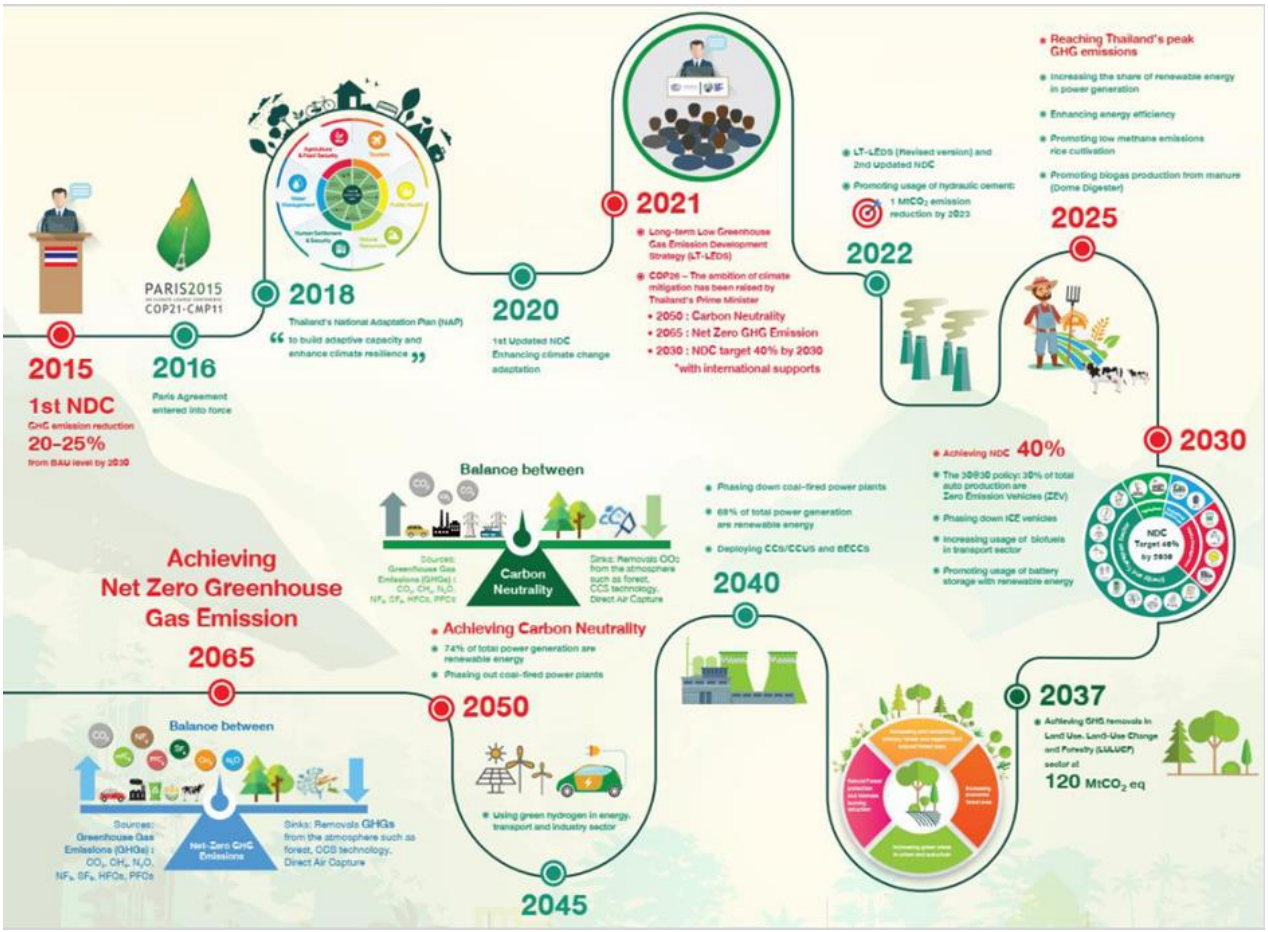
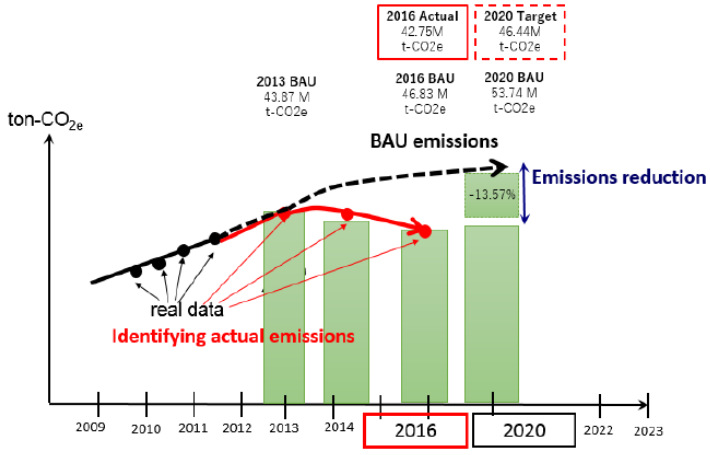
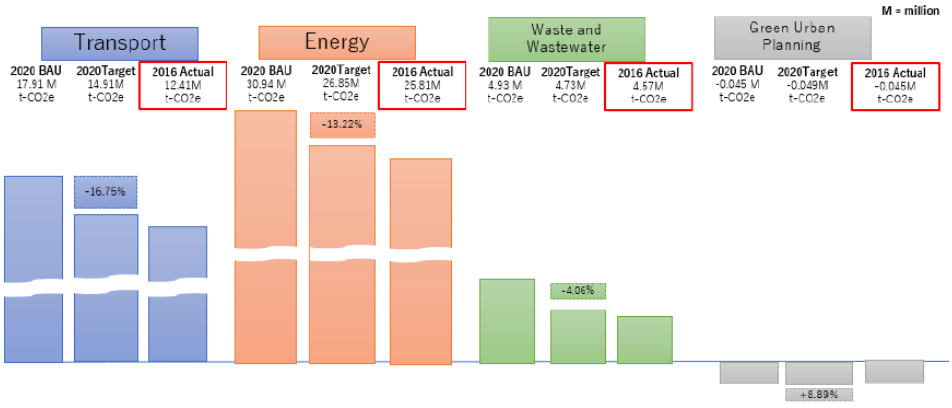


*Figure 4: Thailand Climate Change Planning (Source: Climate Change Master Plan 2015-2050)*

At the city level, the Bangkok Master Plan on Climate Change was originally for 2007-2012[21,22] with an aim to reduce at least 15% of total GHG emission in 2012. The master plan was updated for 2013-2023[23,24] with assistance from JICA[25] (Japan International Cooperation Agency) aiming to reduce GHG emission by 13.57% in the year 2020, as shown in Figure 5(a). In synergy with the national target in 2030 and carbon neutrality by 2050, Bangkok Master Plan on Climate Change: 2021-203026 has set a target of 19% reduction in 2030 and net zero by 2050, as shown in Figure 5(b). Note that institutional arrangement to

implement Bangkok Master Plan on Climate Change consists of 5 members, which are (1) a steering committee, (2) a working group, (3) a task forces, (4) the BMA secretariat, and (5) other partners, with are responsible for the monitoring and evaluating scheme shown in Figure 6.

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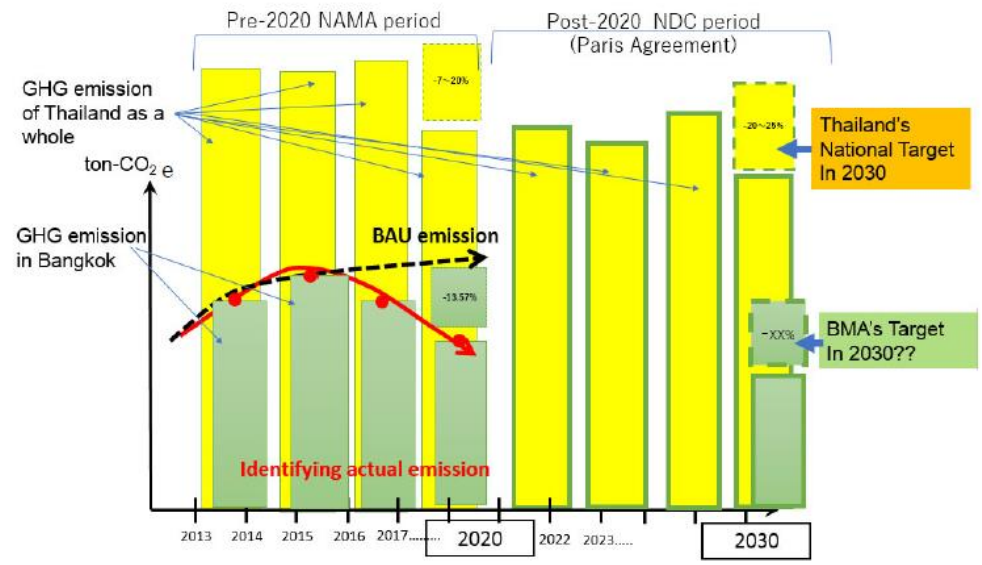


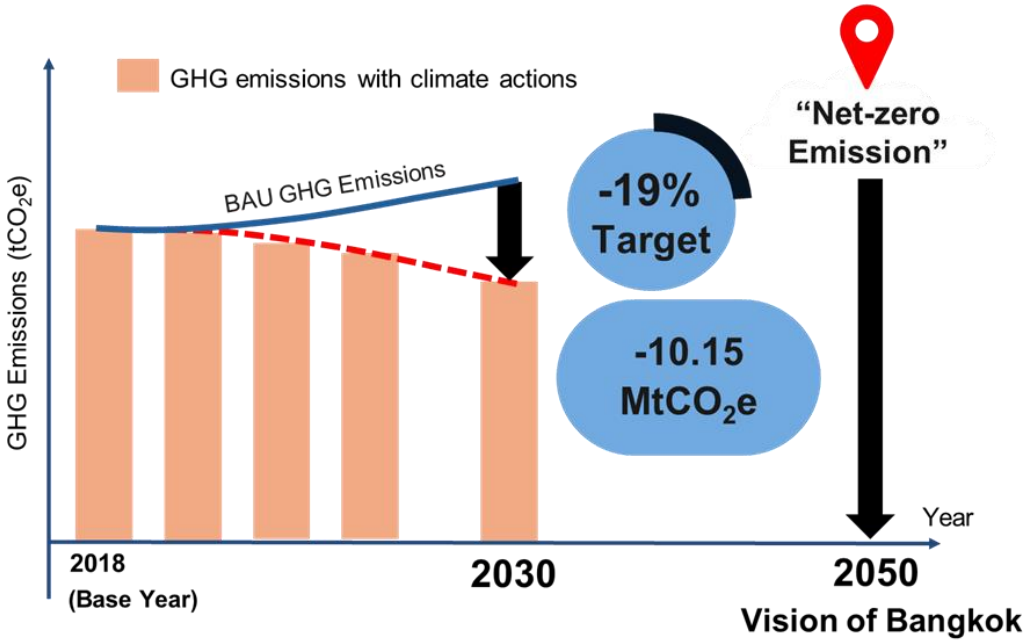


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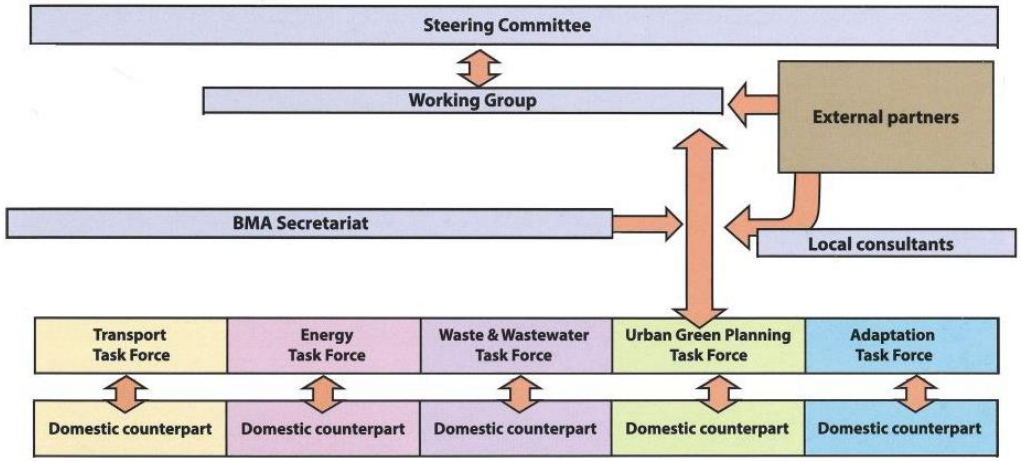
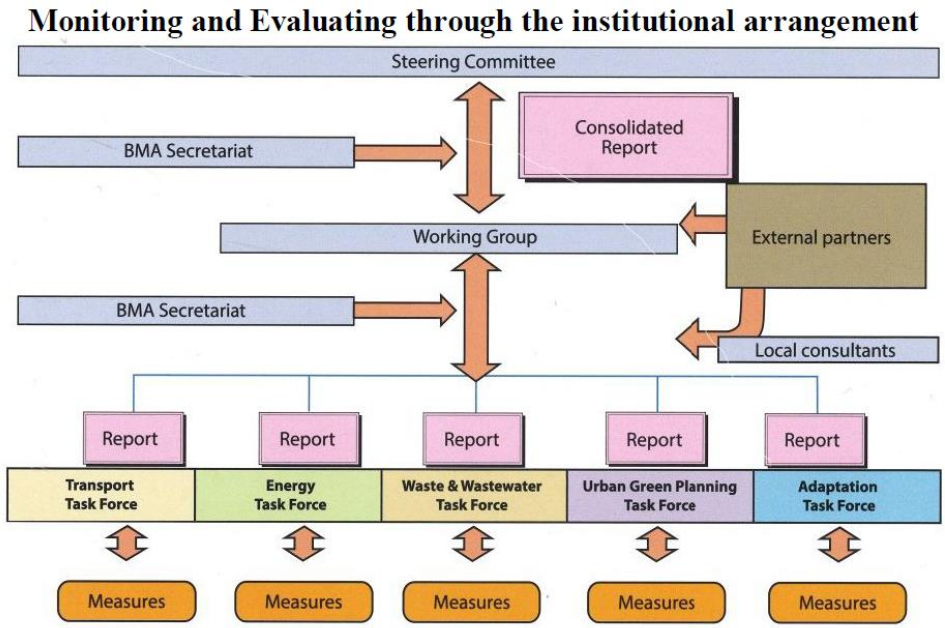
*Figure 5: Bangkok GHG emission reduction in (a) 2016 by sectors with (b) new target for 2030 and 2050*



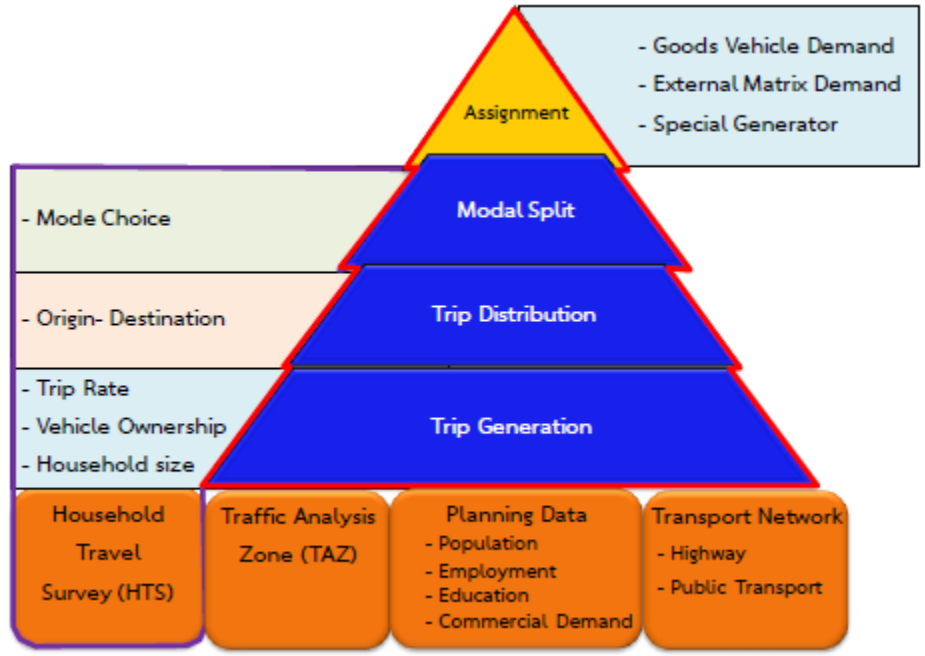

(a)




(b)

*Figure 6: (a) Institutional arrangement and (b) monitoring & evaluating for Bangkok Mater Plan on Climate Change*

To project the transport demand within Bangkok and vicinity until 2042, an extended Bangkok Urban Model (eBUM) model with structure shown in Figure 7(a) is used with survey data[13] to project the number of trips for different transport modes shown in Figure 7(b). This has been used by the Ministry of Transport to investigate the potential effect of certain transport measures.

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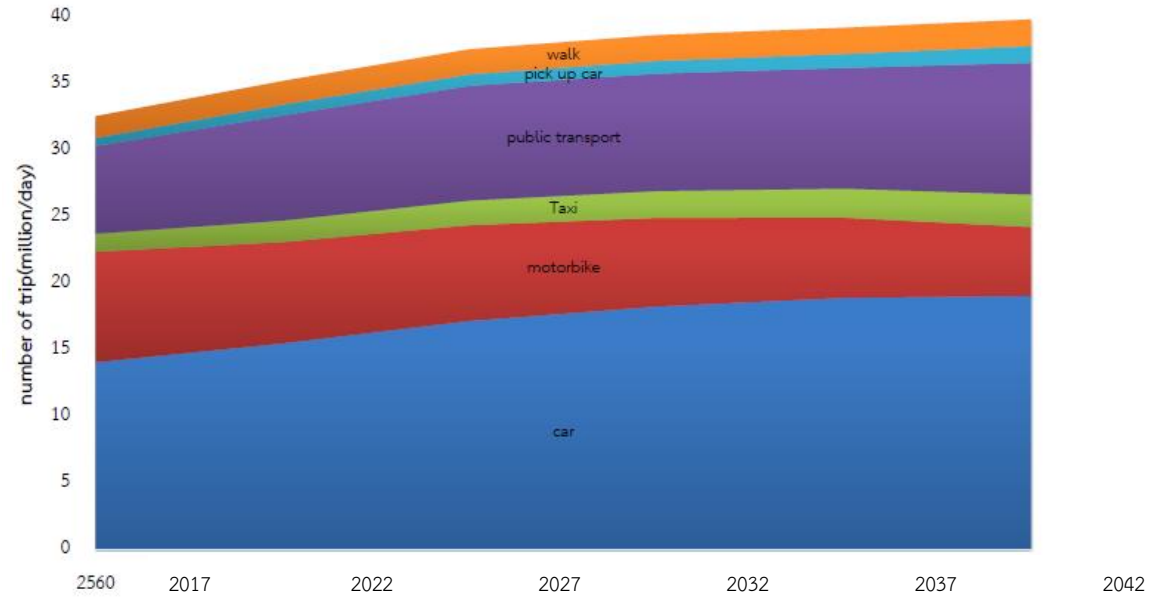
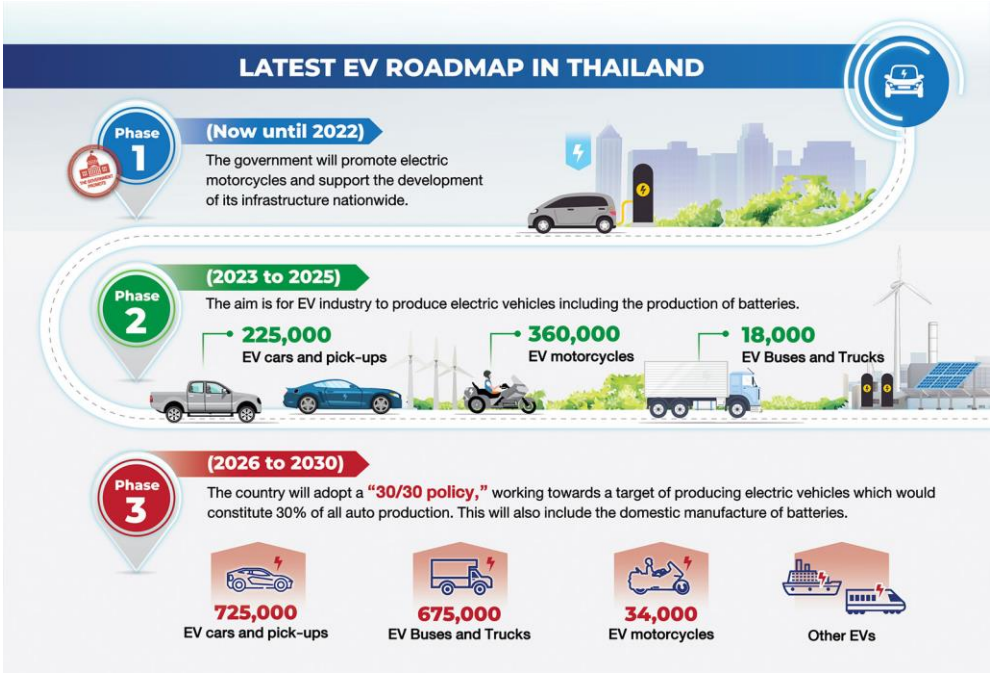



(b)

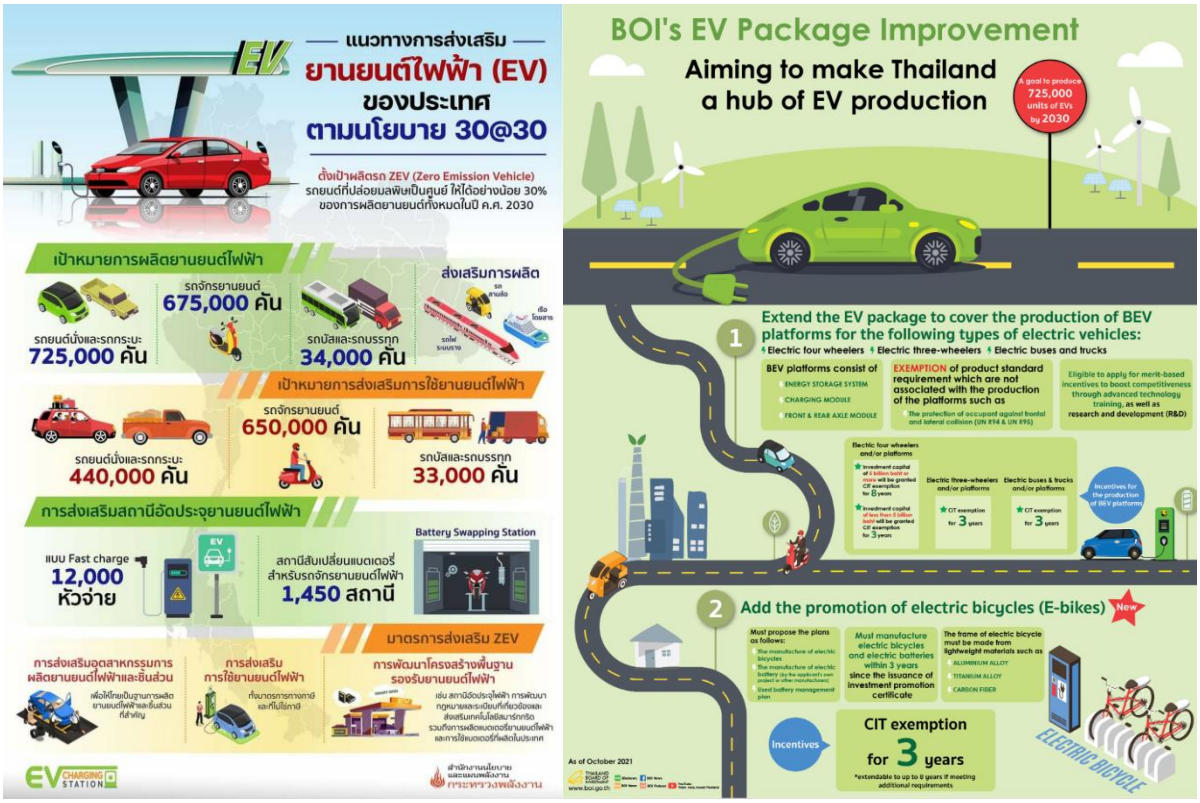
*Figure 7: (a) Extended Bangkok Urban Model (eBUM) model structure with (b) projection on number of trips*

## 1.2. Current Policy Framework and Market Readiness for deployment of e-mobility

This chapter will focus on the national-level policy framework as there is no city-level e-mobility policies in Thailand. The current national policy framework for the deployment of e-mobility is derived from the National Electric Vehicle Policy Committee's vision to become a global hub for the supply and production of EVs and automotive parts. It has published the 2021-2035 roadmap aiming for a target of 30% zero-emission vehicle (ZEV) production by 2030, often called 30@30, and a target of 100% ZEV sales by 2035, as shown in Figure 8[27,28,29] and Table 1[30,31]. ZEVs include Battery Electric Vehicle (BEV) or Fuel Cell Electric Vehicle (FCEV) excluding Hybrid Electric Vehicle (HEV) and Plug-in Hybrid Electric Vehicle (PHEV). Specifically on electric two-wheelers (e2w), Thailand aims to achieve 675 ,000 e2w production (or 30% of all two-wheelers) and 650,000 e2w sale (or 40% of all two-wheelers) by 2030 under 30@30 policy target. In addition, 8,000 e2w charging stations and 1,450 e2w battery swapping stations are targeted to have been installed by 2030. In terms of three wheelers (tuktuks), Thailand aims for the local production to be at 100% EVs by 2030 (2,200 units).




(a)




(b) (c)

*Figure 8: Latest (a) EV roadmap in Thailand with (b) 30@30 target and (c) investment incentive from Board of Investment*

*Table 1: Thailand (a) EV targets for all types of vehicles and (b) charging infrastructure*

| Target | Type of Vehicles | Estimated number of ZEV per Year | | |
|---|---|---|---|---|
| | | 2025 | 2030 | 2035 |
| Usage | Passenger cars / Pick up trucks | 225,000 (30%) | 440,000 (50%) | 1,154,000 (100%) |
| | Motorcycles (units) | 360,000 (20%) | 650,000 (40%) | 1,800,000 (100%) |
| | Buses | 18,000 (20%) | 33,000 (35%) | 83,000 (100%) |
| | Tuk Tuks | 500 (85%) | 2,200 (100%) | 2,800 (100%) |
| | Ships | 130 (12%) | 480 (35%) | 1,800 (100%) |
| | Rail system | 620 (70%) | 850 (85%) | 1,170 (100%) |
| Production | Passenger cars / Pick up trucks | 225,000 (10%) | 725,000 (30%) | 1,350,000 (50%) |
| | Motorcycles (units) | 360,000 (20%) | 675,000 (30%) | 1,850,000 (70%) |
| | Buses | 18,000 (35%) | 34,000 (50%) | 84,000 (85%) |
| | Tuk Tuks | 500 (85%) | 2,200 (100%) | 2,800 (100%) |
| | Ships | 130 (12%) | 480 (35%) | 1,800 (100%) |
| | Rail system | 620 (100%) | 850 (100%) | 1,170 (100%) |

(a)

| Passenger Cars and Pick Up Trucks | | |
|---|---|---|
| Year | Accumulated targets of ZEV cars (million units) | DC Quick charger targets |
| 2025 | 0.4 | 2,200-4,400 |
| 2030 | 2.0 | 12,000 |
| 2035 | 6.4 | 36,500 |

| Electric motorcycles | | | | |
|---|---|---|---|---|
| Year | Accumulated targets of electric motorcycles (million units) | Charger targets | Estimated 2% electric motorcycle taxi | Charger targets |
| 2025 | 0.6 | 1,600 | 12,000 | 260 |
| 2030 | 3.3 | 8,000 | 65,000 | 1,450 |
| 2035 | 8.8 | 20,000 | 176,000 | 4,000 |

(b)

Regarding standards related to electric vehicles (EVs), the Thailand Industrial Standards Institute (TISI) has adopted the International Electrotechnical Commission (IEC) charging socket standards for electric buses and passenger cars. Additionally, TISI has developed its own standard for battery swapping, as illustrated in Figure 9. TISI has been continuously adopting and issuing numerous standards relevant to EVs.

Thailand Industrial Standards Institute

| Vehicles | AC Charger | DC Charger | Vehicles |
|---|---|---|---|
| Electric Bus | IEC 62196-2 Configuration Type 2 | IEC 62196-3 Configuration FF<br>**Rated Current:** Up to 200 A<br>**Rated Voltage:** ≥ 500 V DC<br>**Communication Protocol:** PLC | Electric Bus |
| Electric Passenger Car | **Phase:** Single / Three<br>**Rated Current:** 70A (Single phase) / 63A (Three phase)<br>**Rated Voltage:** 480 V<br>**Capacity:** Up to 22 kW (Mode 2)<br>Up to 43 kW (maximum) | System A: CHAdeMO (Japan); System B: GB/T (PRC); System C: COMBO1 (US), COMBO2 (DE)<br>Connector<br>Vehicle Inlet<br>Communication Protocol: CAN / PLC | Electric Passenger Car |

(a)

**Voltage range**

- voltage 48 V [ranging 48 V - 52V]
- voltage 60 V [ranging 60 V - 66V]
- voltage 72 V [ranging 72 V - 72V]

**Size by voltage**

❑ **Voltage 48 V and 60 V**

| Size | L | H | W |
|---|---|---|---|
| mm | 160 | 180 | 300 |

❑ **Voltage 72 V**

| Size | L | H | W |
|---|---|---|---|
| mm | 180 | 220 | 300 |

**Note:** Width [W] Length [L] Height [H]

+ -: electricity
1-9: signal communication

**Example of connector 1**

+ anode
- cathode
1 RS485A or CAN H
2 RS485B or CAN L
3 Not used [spare]
4 Not used [spare]
5 RS485B หรือ CAN L
6 RS485A หรือ CAN H

**Example of connector 2**

+ anode
- cathode
ground
1 CAN L
2 Not used [spare]
3 Not used [spare]
4 Not used [spare]
5 CAN H

**Example of connector 3**

+ anode
- cathode
ground
1 RS485A
2 CAN G
3 RS485A
4 5 6 grouond
7 RS485B
8 CAN L
9 RS485B

**Example of connector 4**

+ anode
- cathode
1 RS485A or CAN H
2 RS485B or CAN L
3 Not used [spare]
4 Not used [spare]

มาตรฐานผลิตภัณฑ์อุตสาหกรรม มอก. 3316-2564

(b)

Infrastructure : Electric vehicle and part standards

Electric passenger car standards

- Charging Socket : TISI 2749
- On-Board Charging System TISI 61851
- Wireless Charging System : TISI 61980
- Charging cables : TISI 3060
- In-car cable : TISI 3248
- High-performance Cable : TISI 3249
- Safety requirement for connection to external supply : TISI 2776
- Circuit Safety Break :TISI 3247
- In-Cable Protecting Device : TISI 2911
- Vehicle to grid communication interface : TBD
- Safety specifications (Electrical / Post crash) : TISI 3102
- Fuel cell safety specifications : TISI 3267
- Power Measuring : TISI 2331 / UNR 85
- E-Range Measuring, Consumption : TISI 2335 / UNR 101
- Electromagnetic compatibility (EMC) UNR10 : TBD
- Energy consumption and range : TISI 3265

Powertrain

- Motor : TISI 3032

Battery

- Battery (Non-Lithium) : TISI 61982
- Battery (Lithium-ion) cell : TISI 62660
- Battery (Lithium-ion) pack and system : TBD
- Battery Electric Vehicle Safety UNR 100 / TISI 3026

Note: = Voluntary Standard, = Compulsory Standard Source : OIE Revised from TAI and TISI as of October 2021

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Infrastructure : Electric vehicle and part standards

Electric motorcycle standards

- Electric Motorcycle category : TISI 3103
- Charging Socket : TISI 2749
- On-Board Charging System TISI 61851
- Wireless Charging System : TISI 61980
- In-car cable : TISI 3248
- High-performance Cable : TISI 3249
- Safety requirement for connection to external supply : TBD
- Circuit Safety Break :TISI 3247
- In-Cable Protecting Device : TISI 2911
- Energy consumption and range : TISI 3105
- Vehicle to grid communication interface : TBD
- Safety specifications (Electrical / Post crash) : TISI 3102
- Fuel cell safety specifications : TISI 3267
- Safety specifications for electric mopeds and motorcycles : TISI 3104

Powertrain

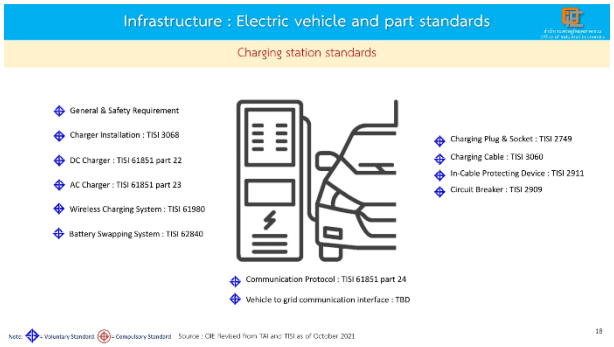
- Motor : TISI 3032
- Regenerative Braking : TBD

Battery

- Battery (Non-Lithium) : TISI 61982
- Battery (Lithium-ion) cell : TISI 62660
- Battery (Lithium-ion) pack and system : TBD
- Battery Electric Vehicle Safety UNR 136 / TISI 3026
- Battery Swapping System : TISI 62840

Note: = Voluntary Standard, = Compulsory Standard Source : OIE Revised from TAI and TISI as of October 2021

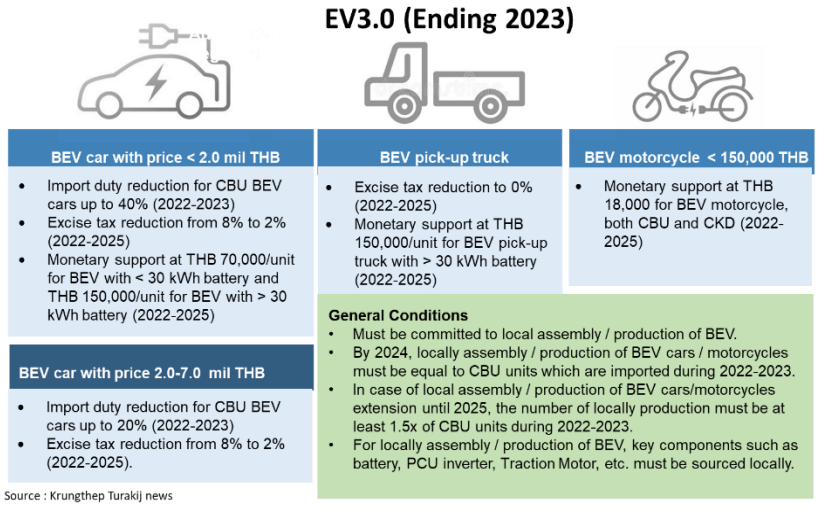
17



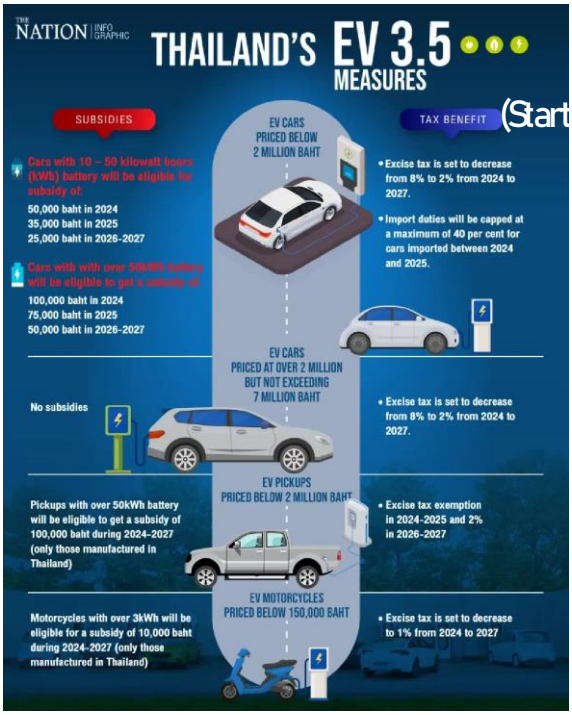

(c)

*Figure 9: EV standards for (a) bus & car socket and inlet, (b) swapping e2w battery and (c) others*

Financial incentives to stimulate demand for initial EV market uptake come in the form of direct subsidy of the EV upfront price. In this regard, the EV3.0 scheme ended in 2023 and is followed by the EV3.5 scheme starting in 2024, as shown in Figure 10[32]. For every EV purchased under this direct subsidy, EV manufacturers have to set up local assembly in Thailand. As a result, a sharp increase in BEV sales was witnessed (12% in sedan passenger vehicle sale) in 2023, which surpassed HEV sales, resulting in a larger BEV fleet than the PHEV fleet. Also, the number of public charging stations has been expanding to a total of 9693 by the end of 2023, as shown in Figure 11.

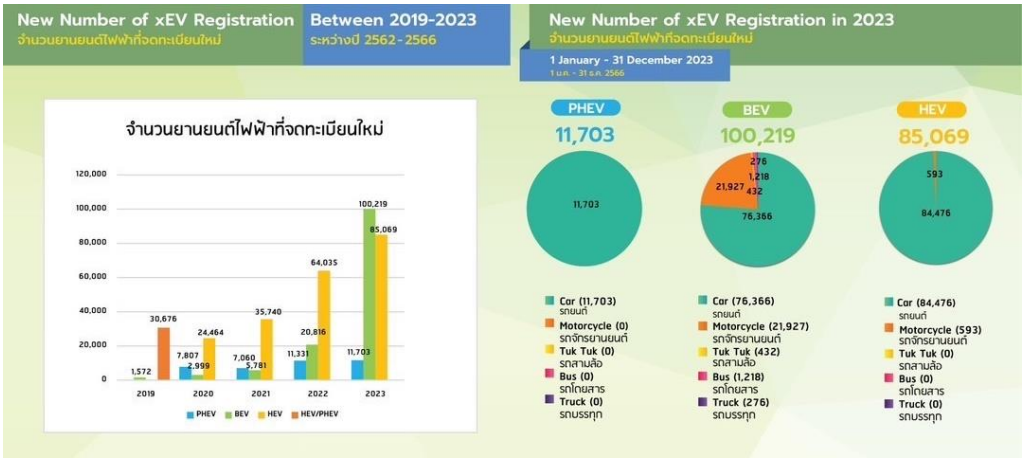



(a)



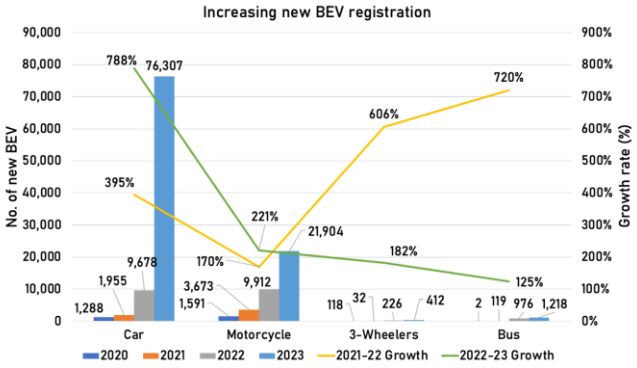

(b)

*Figure 10: EV incentive for demand side push (a) EV3.0 until 2023 and (b) EV3.5 after 2024*




(a)


(b)




(c)


(d)

*Figure 11: EV markets for (a) new EV registration, (b) accumulative EV registration with (c) % increase in each sector and (d) increasing number of public charging infrastructure*

## 1.3. Ongoing Electric two-wheeler projects

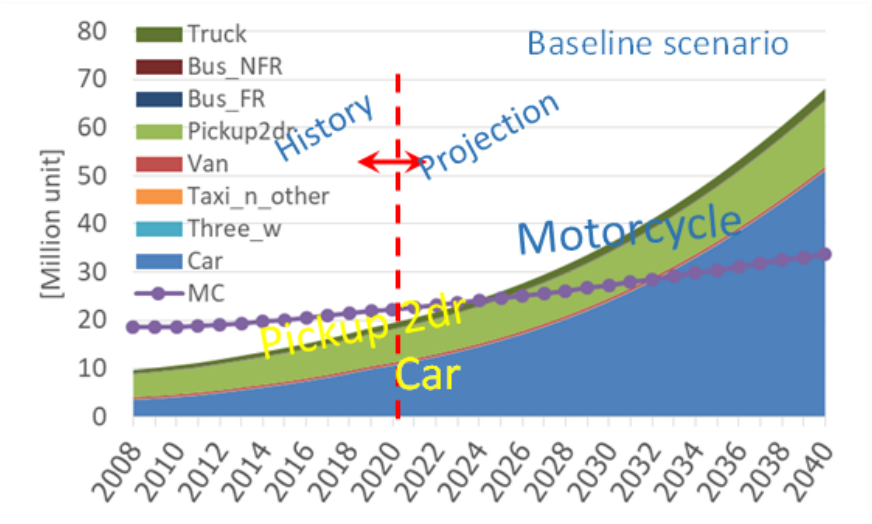
SOLUTIONSplus replication project (1st July 2023 - 31st May 2024), supported with seed funding, joined several on-going and upcoming projects on electric two-wheeler projects in Bangkok, yielding positive outcome by finding synergies with these projects.

**Mainstreaming Electric Mobility 2- and 3- wheelers in Thailand**

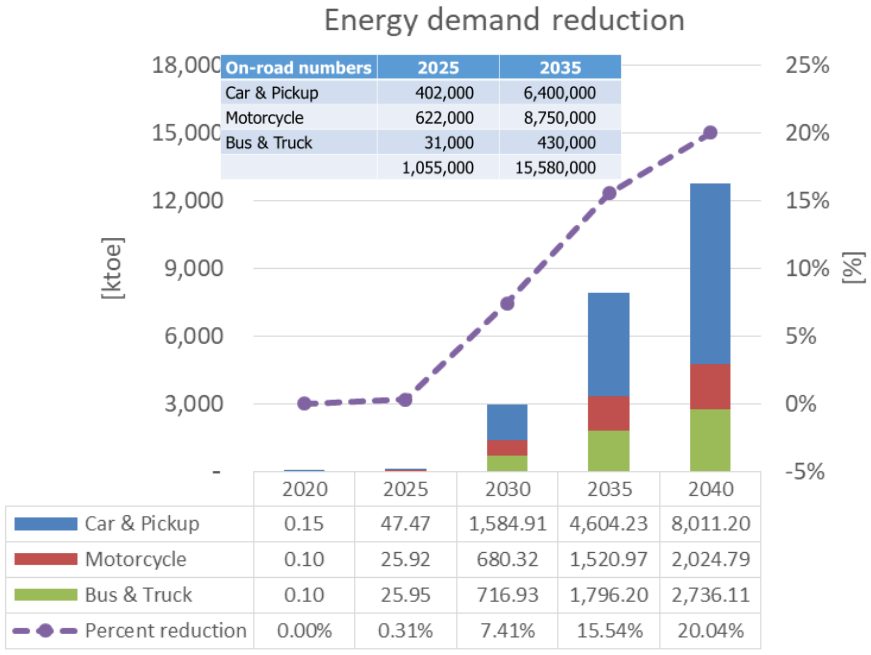
During 2020-2021, the UNEP (United Nations Environment Programme) project entitled "Mainstreaming Electric Mobility 2- and 3- wheelers in Thailand" had engaged the National Metal and Materials Technology Center (MTEC) under the National Science and Technology Development Agency (NSTDA) with the following objectives:

- ✓ To establish an advisory group to spearhead the development of policies to support the transition to electric mobility in Thailand focusing on electric 2&3 wheelers
- ✓ To support an assessment of the national baseline and business-as-usual scenarios to set the stage for uptake of electric 2&3 wheelers and electric mobility at large in Thailand
- ✓ To conduct relevant technical studies to support policy and standards development on electric 2&3 wheelers
- ✓ To assist with the design and launch of a demonstration pilot for electric 2&3 wheelers in Thailand

First, an advisory group on a national battery swapping standard under TISI has been formed at the national level, as well as a steering committee consisting of relevant EV stakeholders from government, academic and private sectors at the project level. Second, the national baseline and BAU (business-as-usual) scenarios have been assessed to include an update of e2&3w in Thailand. The vehicle ownership model, along with fuel economy and vehicle kilometers travelled for each vehicle type, was formulated and calibrated with historical data for projection of baseline and future e-mobility scenarios, as shown in Figure 12. This e-mobility uptake result has been presented at various national workshops, as shown in Figure 13[33,34]. Third, a national battery swapping standard for e2w, TISI3316-2564: Electric Mopeds and Motorcycles−Removable Rechargeable Electric Energy Storage System, has been drafted as shown in Figure 9(b). Fourthly, a demonstration project with EGAT e2w taxi was explored with a battery swapping system, where an electric circuit of an Energy Consumption Tracker (ECT) was custom designed for MRV (Monitoring, Reporting, and Verification) of the e2w taxi demonstration project[35], as shown in Figure 14.



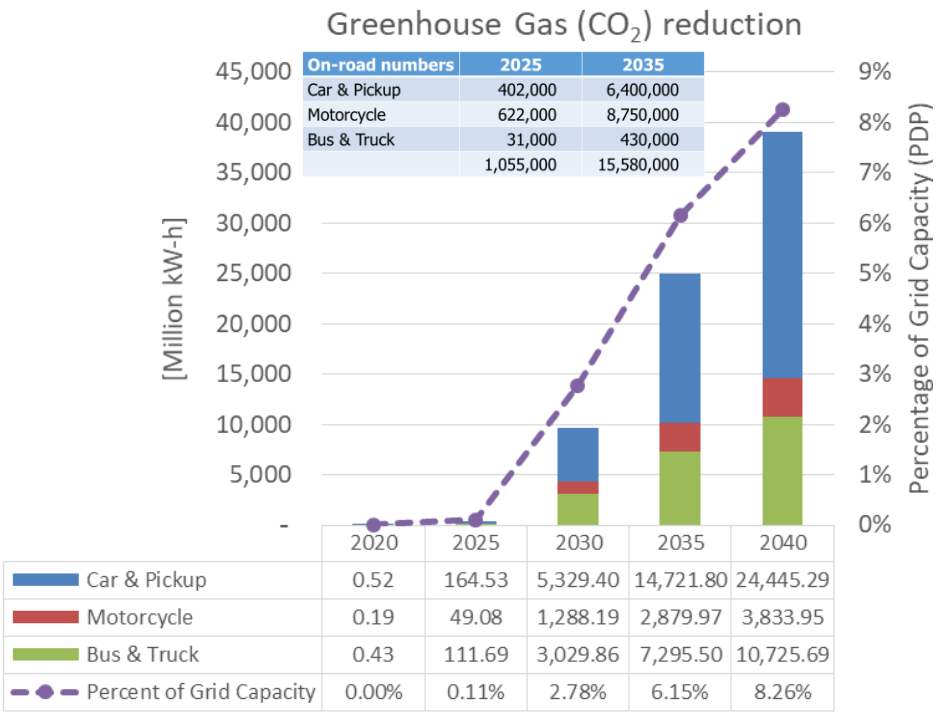

(a)




| On-road numbers | 2025 | 2035 |
|---|---|---|
| Car & Pickup | 402,000 | 6,400,000 |
| Motorcycle | 622,000 | 8,750,000 |
| Bus & Truck | 31,000 | 430,000 |
| | 1,055,000 | 15,580,000 |

| | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|
| Car & Pickup | 0.15 | 47.47 | 1,584.91 | 4,604.23 | 8,011.20 |
| Motorcycle | 0.10 | 25.92 | 680.32 | 1,520.97 | 2,024.79 |
| Bus & Truck | 0.10 | 25.95 | 716.93 | 1,796.20 | 2,736.11 |
| Percent reduction | 0.00% | 0.31% | 7.41% | 15.54% | 20.04% |

(b)



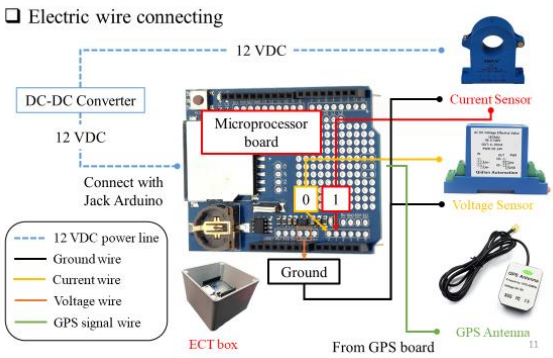

(c)

*Figure 12: (a) Thailand mobility baseline for projection of e-mobility scenario to investigate (b) energy demand reduction and (c) GHG reduction*


(a)


(b)

*Figure 13: National dissemination of e-mobility project: (a) 5th International Electric Vehicle Technology Conference and Exhibition (iEVTech 20220) on 25 September 2020, (b) Workshop on Mainstreaming Electricity Mobility in Thailand: Baseline and Alternative Energy Solution on 30 March 2021*



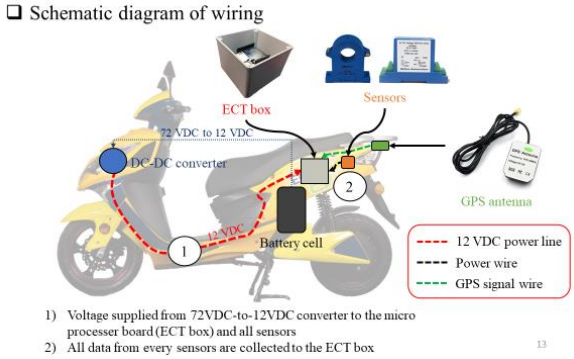



*Figure 14: Design ECT (Energy Consumption Tracker) with demonstration pilot for e2w taxi in Thailand*

**Supporting Scaling Up of Electric 2 and 3 Wheelers in Thailand**

As a follow up, the subsequent UNEP project entitled "Supporting Scaling Up of Electric 2 and 3 Wheelers in Thailand" was contracted to the National Energy Technology Center (ENTEC) with the following activities:

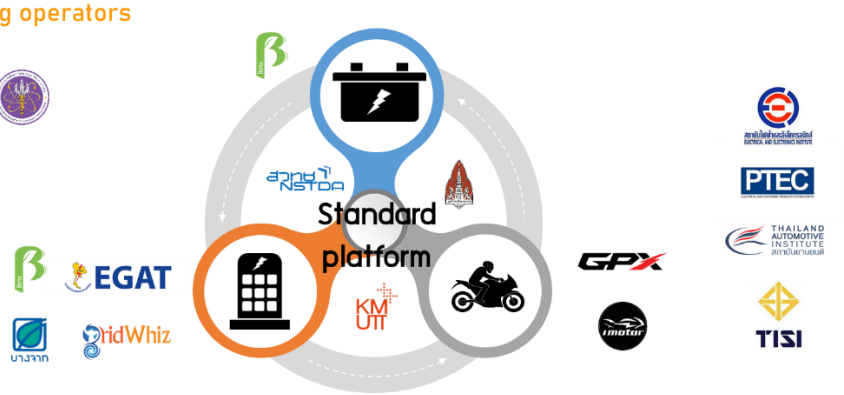
- ✓ Consolidate a report on electric 2&3 wheelers in Thailand and develop communications materials
- ✓ Support the demonstration project on electric 2-wheeler taxis in Bangkok with the Electricity Generating Authority of Thailand (EGAT)
- ✓ Integrate electric mobility projects, particularly 2&3 wheelers in Thailand's framework on Measuring, Reporting, Verifying (MRV) of climate change related projects

First, a report on e2&3w in Thailand was consolidated to synergize e-mobility effort from other projects, in particular the national project to update the national battery swapping standard TISI3316-2564: Electric Mopeds and Motorcycles−Removable Rechargeable Electric Energy Storage System, as shown in Figure 9(b). The Thailand battery swapping platform[36] was nationally granted to update TISI3316-2564 with a connector designed, fabricated and on-road tested for durability performance, as shown in Figure 15.

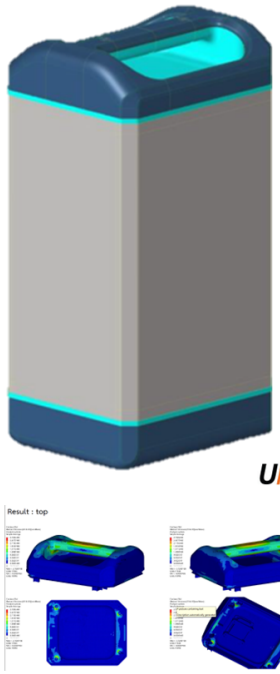
# Thailand Battery Swapping Platform

Project Period 2021 - 2023

- A collaborative project between research institute, universities, battery pack producer, E-motorcycle producers and charging service providers
- Target to create standardized battery packs which can be used in various motorcycle providers, and charging operators
- Funded by




http://www.batteryswapping.in.th



| Item | Specification |
|---|---|
| Overall system | |
| Dimension W x L x H (mm) | 145 x 180 x 340 |
| Total Weight | TBD |
| Storage temperature | 0-35℃ |
| Operating temperature | Charge: 0-45°C, Discharge: -20-60°C |
| 1. Battery packs | |
| total number of cell | 140 |
| number of cell in series | 20 |
| number of cell in parallel | 7 |
| Cell specifications | HDCNR18650-2600-3.6V 2.6Ah |
| Connection | 2 modules 7P10S in series (7P10S*2) |
| pack capacity (Ah) | 18.2 |
| pack nominal voltage (V) | 72 |
| pack minimum voltage (V) | 55 |
| pack maximum voltage (V) | 84 |
| pack Energy (kWh) | 1.31 |
| Normal discharging current (A) | 18.2A (1C) |
| max cont. discharge current (A) | 54.6A (3C) |
| max pulse discharge current (A), 20 seconds | 72A (@ 20-100% SOC), 120 A (@40-100%C) |
| Normal charging current (A) | 9.1A (C/2) |
| Max charging current (A) | 18.2A (1C) |
| total cells weight (kg) | 6.44 |
| 2. BMS | |
| Maximum continuous current | Discharge 150A / Charge 75A |
| Connections | 1 Centralized system |
| Cell balancing method | Passive |
| Cell balancing current | 30 +/-5 mA @ cell voltage >3.8V |
| Cell balancing guarantee voltage | $\Delta$ Vcell $\leq$ 50 mV |

*Figure 15: Thailand Battery Swapping Platform*

Second, a demonstration project on electric 2-wheeler taxis in Bangkok with the Electricity Generating Authority of Thailand (EGAT) was successfully implemented in the Bangkok-Nonthaburi border near EGAT headquarters. Figure 16 shows the output of fifty e2w taxis as a demonstration to serve as first and last mile connectivity for the e-mobility platform[37]. The accumulative distance of 759,394 km has been driven by these fifty e2w taxis with 32.24 Wh/km (one-fifth less energy consumption than gasoline two-wheelers) resulting in savings of 38.8 ton of $CO_2$ equivalent.

## Project implementation areas

50 Electric motorcycles were analyzed in this study

| Model | EGAT-ENGY (TAILG-Dragon) |
|---|---|
| Motor power | 3 kW (rated) |
| Top speed | 80 km/hr |
| Gross load | 150 kg |
| Dust resistance | IP67 |
| Battery specification | |
| Type | Lithium-ion (NMC) |
| Capacity | 3.6 kWh (1.8 kWh x 2) |
| Voltage | 72V |
| Weight | 9.8 kg/pack (x 2 packs) |

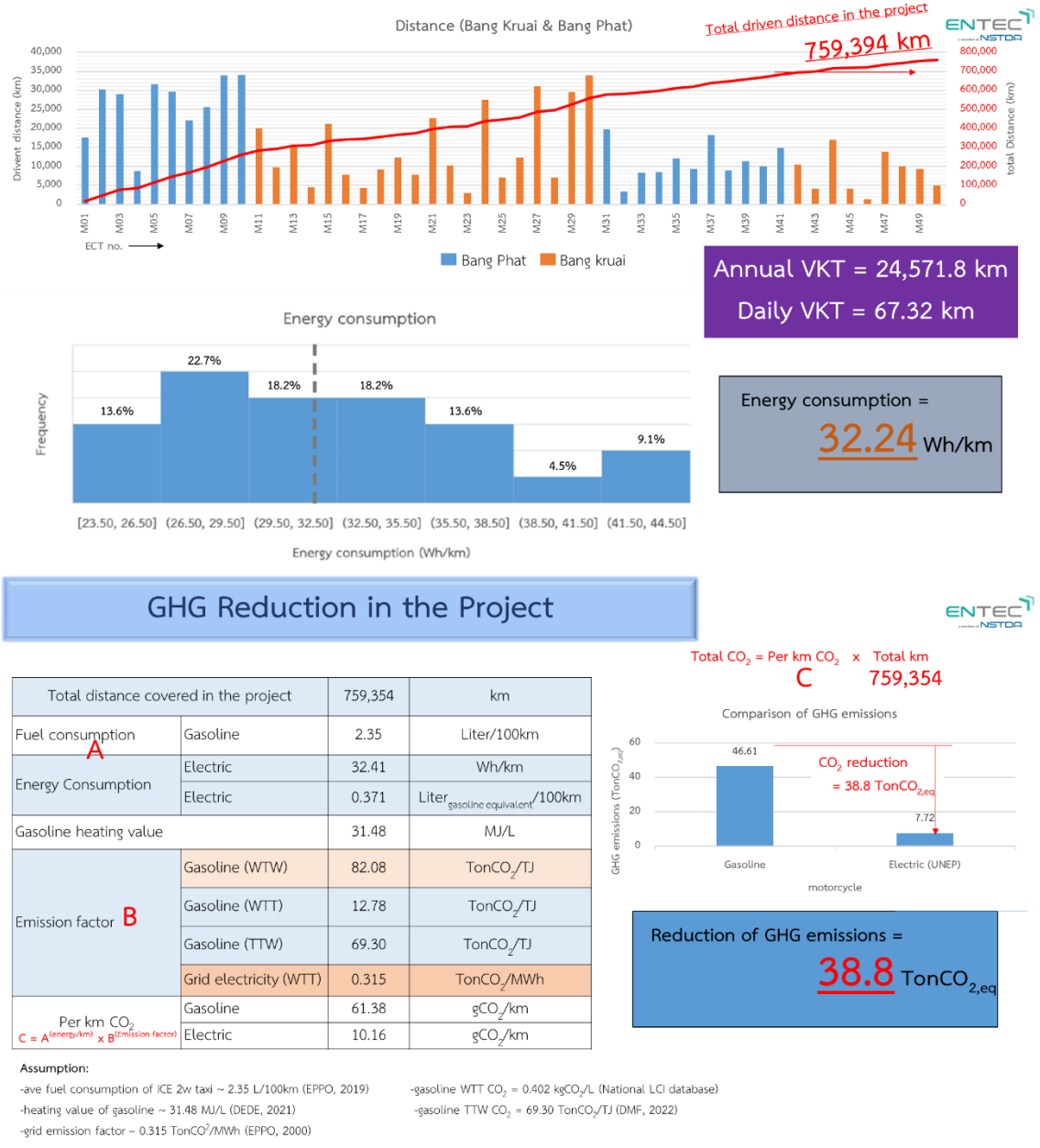

(a)

## Hand-over Ceremony of 50 Electric Motorcycles

23 June 2023
at EGAT Learning Center, Headquarters

https://www.entec.or.th/entec-news_50-electric-motorcycles/ , https://fb.watch/r0p6NOfKvr/


(b)




| Total distance covered in the project | | 759,354 | km |
|---|---|---|---|
| Fuel consumption A | Gasoline | 2.35 | Liter/100km |
| Energy Consumption | Electric | 32.41 | Wh/km |
| | Electric | 0.371 | $Liter_{gasoline\ equivalent}$/100km |
| Gasoline heating value | | 31.48 | MJ/L |
| Emission factor B | Gasoline (WTW) | 82.08 | $TonCO_2/TJ$ |
| | Gasoline (WTT) | 12.78 | $TonCO_2/TJ$ |
| | Gasoline (TTW) | 69.30 | $TonCO_2/TJ$ |
| | Grid electricity (WTT) | 0.315 | $TonCO_2/MWh$ |
| Per km $CO_2$ $C = A^{(energy/km)} \times B^{(Emission\ factor)}$ | Gasoline | 61.38 | $gCO_2/km$ |
| | Electric | 10.16 | $gCO_2/km$ |

Assumption:
-ave fuel consumption of ICE 2w taxi ~ 2.35 L/100km (EPPO, 2019)
-heating value of gasoline ~ 31.48 MJ/L (DEDE, 2021)
-grid emission factor – 0.315 $TonCO^2/MWh$ (EPPO, 2000)
-gasoline WTT $CO_2$ = 0.402 $kgCO_2/L$ (National LCI database)
-gasoline TTW $CO_2$ = 69.30 $TonCO_2/TJ$ (DMF, 2022)

(c)

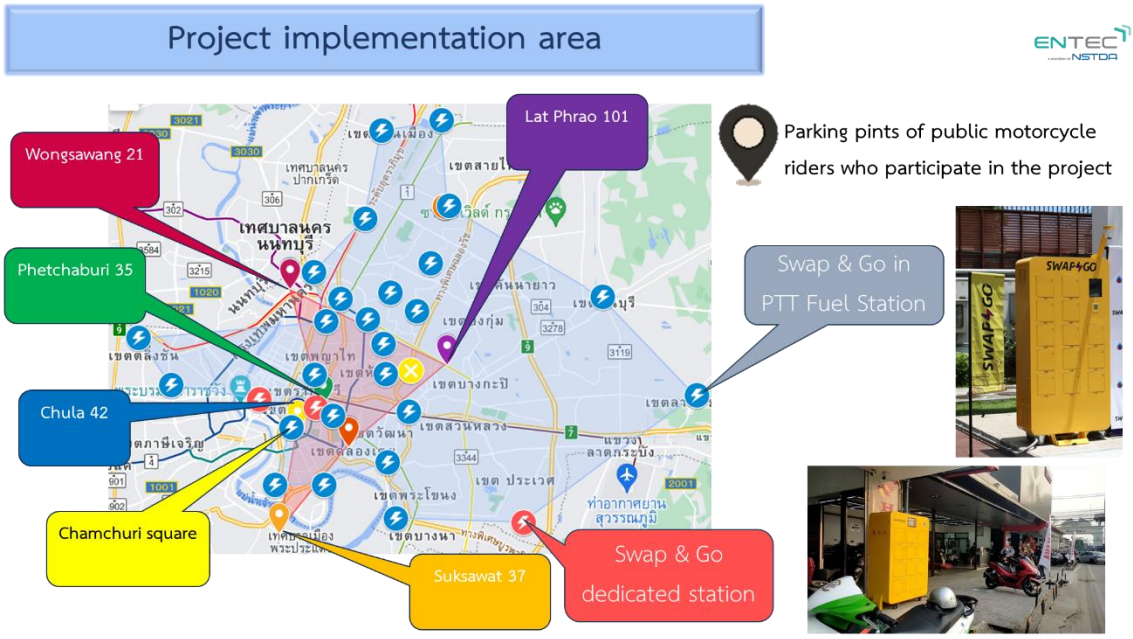
*Figure 16: Demonstration of e2w taxi with EGAT: (a) project implementation details, (b) hand-over ceremony of 50 e2w unit on 23 June 2023, (c) project closing ceremony with MRV result*

**Replicating Battery-Swappable Electric Motorcycle Taxis in Samyan District of Bangkok**

Another ongoing demonstration project from SOLUTIONSplus Replication project entitled, “Replicating Battery-Swappable Electric Motorcycle Taxis in Samyan District of Bangkok” was granted to ENTEC, NSTDA during 2023-2024 with activities to replicate the previous UNEP demonstration project on e2w taxi from Bangkok-Nonthaburi border to Samyan District centrally located in Bangkok. The aim was to determine a

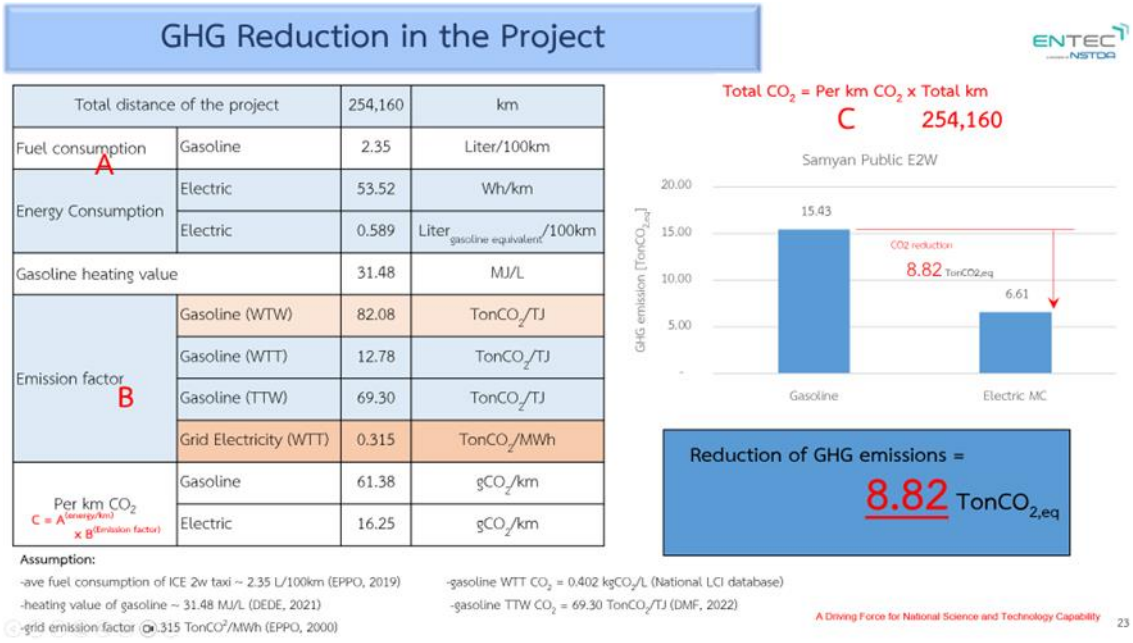
suitable financial scheme for thirty e2w taxi units with battery swapping involving local start-up companies, as well as to develop a training programme for drivers. An important lesson learned from the previous UNEP demonstration project was that once e2w riders have ownership of the swappable battery, riders tend to feel afraid of getting an inferior battery from others once swapped. This project then conducts Total Cost of Ownership (TCO) analysis through consultations with private sectors participating in the demonstration project to design a financial scheme to reduce capital costs of the battery from an e2w by offering a rental subscription fee for swappable batteries instead to reduce these concerns for the riders.

The project involves two local start-up companies, namely an e2w manufacturer and an e2w battery swapping company for design of a sustainable financial scheme in long term without relying on government subsidy for future expansion. The same local manufacturing company from the previous UNEP demonstration project joins this project with a swapping battery start-up investing in battery swapping machines in the region. Relevant data on battery swapping will be feedbacked to the National Battery Swapping System. Figure 17 shows the replication project details with ongoing MRV results[38].




(a)


(b)




(c)

*Figure 17: Replication of e2w taxi in Samyan District of Bangkok: (a) project implementation details, (b) kick-off event on 22 December 2023, (c) on-going MRV result*

# 2. Approach – Methodology

This roadmap aims to support the National EV Policy Committee Roadmap 30@30 for the two-wheelers sector, in particular for usage as first and last mile mobility in combination with other e-mobility modes, such as metro, electric bus and electric ferry. The roadmap targets in particular potential ICE (internal combustion engine) motorcycle riders, both personal and ride-hailing, which could switch to e2w.

The following steps are recommended for the development of the e2w roadmap:

1. Identify the willingness of motorcycle owners to pay for an e2w and identify the cost gap and the need for a potential subsidy scheme: the total cost of ownership (TCO) for ICE 2w and e2w should be understood to determine the user's perception of switching over from ICE to EV. In case there is a cost gap, a subsidy scheme could be proposed to the government or a potential donor to encourage an initial demand driven push for the electrification of the 2-wheeler fleet in Bangkok. Market and cost data for the TCO analysis must be surveyed from the most popular ICE 2w models and e2w models which are entering the 2w market. Relevant data includes for example the capital upfront cost, operation cost during usage from fuel/electricity, maintenance cost over the period of use and savage value at the end of vehicle's life, as schematically shown in Figure 18. This value given an insight into the minimum upfront cost offset for riders to feel indifferent to switching over from an ICE to an EV.

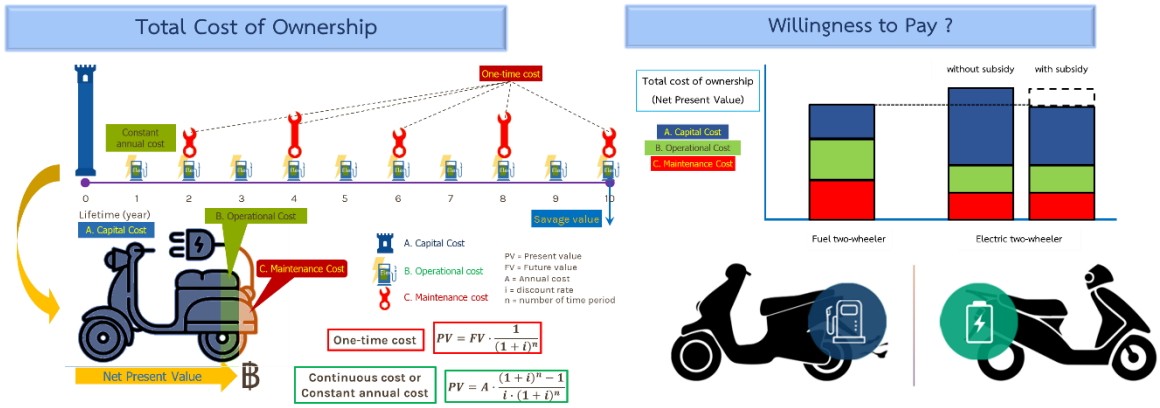



*Figure 18: Identifying willingness to pay or initial subsidy value through TCO analysis*

2. Organize a structured stakeholder dialogue with relevant stakeholders in the e2w value chain: to bring about the electrification of the 2-wheeler fleet in Bangkok city, stakeholders in the value chain were consulted on the barriers they face in switching to EVs and engaging them in the process. For example, it could be beneficial to organize test drives for taxi drivers and 2w shop owners to give them experience of e2w performance, especially for 2w taxi riders. This provides an excellent opportunity to get the stakeholders engaged and answer any question or concern. This has already successfully been done for demonstration projects mentioned in the previous chapter, as shown in Figure 19. In addition, discussion with industrial stakeholders from the e2w value chain, e.g. battery swapping operators, part

suppliers, 2w fleet operators, local authorities, is important to support and inform the policy making process for the e2w roadmap. E2w fleet operators like mail delivery[39], household electricity meter reading, city law enforcement, can also be engaged for e2w implementation or demonstration projects.


*Figure 19: Engaging relevant stakeholders in e2w value chain*

3. Launch a demonstration project: In the demonstration project mentioned in previous chapter, riders who wished to participate in the demonstration project, were asked to contribute to the cost and to contribute to technical/financial/environmental data collection. Failure to partake in the demonstration project monitoring/evaluation would result in reward forfeiting at the end. The benefit on the other hand for riders could be free ownership transfer or a heavily discounted price to buy the e2w. Figure 20 shows of picture of the launch of this demonstration project. in the results of the demonstration projects described in the previous chapter show that positive experiences from field-test riders are communicated to other potential riders enhancing the popularity to switch from ICE 2w to e2w.

*Figure 20: Launching demonstration project with commitment from riders before rewarding at the end*

4. Conduct technical, financial, environmental, and social assessments of e2w use cases: For the development of a policy framework and monitoring & evaluation purposes, assessments of e2w use cases can help understanding of the regulations and market rules needed to encourage the electrification of the 2w market, ensuring that is cost effective but also considerate of environmental and social aspects. Gender equality and other social aspects can be explored for inclusiveness in such a policy framework, for example in the case of women driver of e3w (electric 3-wheelers) in India.[40]

5. Mapping roles and responsibilities for roadmap implementation: it is important to identify the relevant actors and institutions which will design, operate, follow up and implement the e2w roadmap. This can follow the example of the organizational structure of the Bangkok Master Plan on Climate Change, as shown in Figure 6, establishing a steering committee, working group, task forces with secretariat from the local authority and other relevant stakeholders from the e2w value chain. These could include e2w manufacturers, e2w part suppliers, battery swapping operators, 2w fleet operators, financial institutions and insurance companies. Periodic meetings with all these actors and stakeholders are needed to ensure alignment and to shape policy recommendations to the city government.

# 3. The Roadmap

## 3.1 Vision

This e2w roadmap aims to achieve full electrification and carbon neutrality of the 2-wheeler fleet in Bangkok city. As Bangkok joins the international partnership initiative "C40 Cities Climate Leadership Group[41]", e-mobility is considered a priority to help address climate change issues by reducing GHG emissions in the transportation sector. In the transport section of the Bangkok Master Plan on Climate Change[22], there are 6 categories, namely:

- ✓ Category 1: Use of electric boats for public inland water transportation
- ✓ Category 2: public transport (support measures) focuses on feeder to attract people to use public transport, where this e2w roadmap can help to contribute to carbon neutral first and last mile connectivity to the metro network in the Bangkok Metropolitan Region (BMR).
- ✓ Category 3: measure on implementing a low emission zone for motor vehicles, where e2w could be included in this zero-emission zone (ZEZ).
- ✓ Category 4: non-motorized transport focusing on bicycle lanes and walkways.
- ✓ Category 5: traffic flow control focusing on adaptive traffic signal system control.
- ✓ Category 6: public awareness raising focusing on getting public engagement on various topics, such as the Bangkok Car Free Day, capacity building on sustainable transport in schools. This e2w roadmap can contribute with e2w focused campaigns such as during the "EVAT x EGAT Electric Motorcycle Conversion Contest for Business Opportunity", which has been held annually since 2022[42] [43].

Furthermore, the third Bangkok 20-Year Development Plan (2023-2027)[44] has already produced an EV master plan formulation in 2024, where this roadmap can provide additional value with the e2w aspect. Visioning exercises were undertaken with stakeholders and citizens to develop a shared understanding of the goal of this plan was once organized on 20-21 April 2019 during the 'Bangkok Foresight 2030' event[45], as shown in Figure 21. The foresight has gathered stakeholders to contribute to the future landscape of Bangkok with emphasis on e-mobility. This e2w roadmap aims to follow a similar vision.


*Figure 21: Bangkok Foresight 2030 experience during 19-20 April 2019 for stakeholders and citizen engagement*

## 3.2 Objectives

In alignment with the national EV target shown in Table 1, this e2w roadmap proposes to set a target of a 40% e2w sales share (new e2w registrations) in 2030 and 100% in 2035. In other words, Phasing out of ICE 2w sales in Bangkok by 2035.

In support of this the city could consider implementing a zero-emission zone for 2ws only allowing e2ws access to these areas (perhaps in combination with other vehicle segments), where inner and outer zones of Bangkok Metropolitan Region (BMR) can be considered for implementation in alignment with Bangkok Master Plan on Climate Change: 2021-2030, as shown in Figure 23.

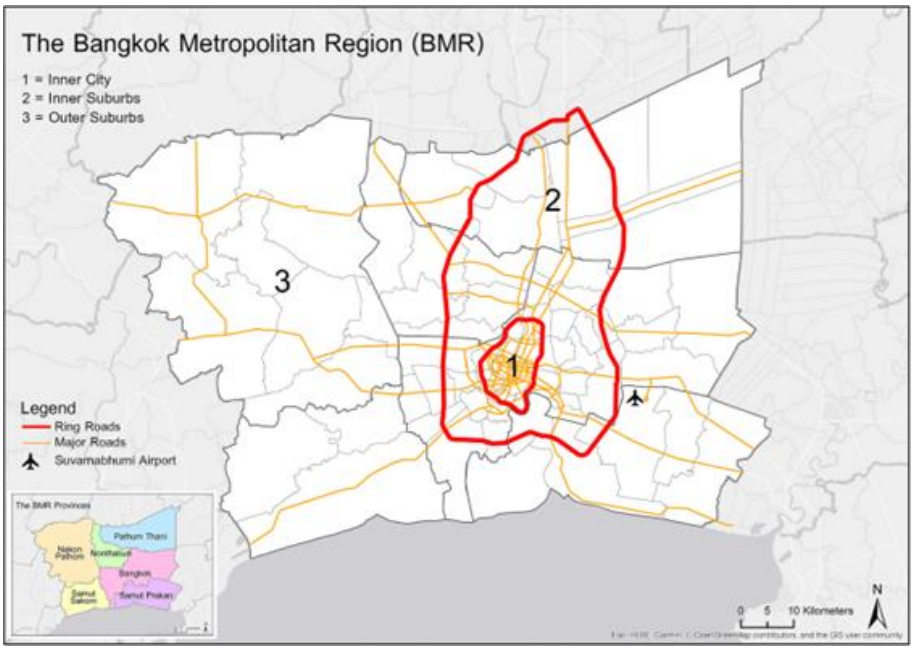



*Figure 22: Coverage by Bangkok Metropolitan Region (BMR)*

## 3.3 Timeline

The timeline of this e2w roadmap should follow the timeline of the national EV roadmap, which targets 100% EV sales by 2035, and the timeline of the Bangkok Master Plan on Climate Change, as shown in Table 2.

*Table 2: Timeline for e2w Bangkok City Roadmap*

| *Phase* | *Demonstration* | *Scale-Up* | *Mainstream* |
|---|---|---|---|
| *Timeline* | *2024-2027* | *2027-2030* | *2030 onwards* |
| *Target/ Focus area* | *implement various demonstration and pilot projects* | *Incentives and regulatory framework in place to stimulate demand* | *EVs are the default choice due to better performance and lower costs* |
| *Finance* | *Grants* | *Concessional loans* | *Commercial banks* |

| *Phase* | *Demonstration* | *Scale-Up* | *Mainstream* |
|---|---|---|---|
| *Responsible (refer to Figure 6)* | *City level task force* | *City level working group* | *City level committee* |
| *Actions* | - *Identify suitable area for a pilot for a ZEZ for e-2w along the metro network to serve as first & last mile connectivity*<br>- *Implement (shared) motorcycle pilots*<br>- *Develop business models from various pilot/demonstration projects*<br>- *Provide technical capacity building and awareness raising*<br>- *Conduct periodic stakeholder dialogue sessions with participants in the demonstration project and other private sector and public sector stakeholders for streamlining the needed policy framework.* | - *Step-by-step mandate government procurement of 2w for shared system*<br>- *Announce and prepare implementation of the ZEZ, based on lessons learned from the pilot phase.*<br>- *Continued structured stakeholder dialogue sessions*<br>- *Step-by-step EV charging master plan implementation*<br>- *Provision of subsidies and financial incentives where relevant to support the investment of EVs and charging infrastructure*<br>- *Launch public awareness campaigns, e.g. e2w day, e2w conversion competition for wider uptake*<br>- | - *Full operation of the ZEZ*<br>- *Initiate e2w battery recycling implementation with regional co-operation*<br>- *Full roll out of public charging and battery swapping stations*<br>- |

# 4. Implementation plan

To transition effectively to electric two-wheelers (e2ws) in Bangkok, a comprehensive and detailed implementation plan is required. This plan addresses various aspects such as urban planning, regulatory measures, economic and financial incentives, charging infrastructure, and public-private partnerships. The implementation is phased to ensure a smooth transition and effective integration into the city's existing transportation system, aligning with the outlined timeline: Demonstration Phase (2024-2027), Scale-Up Phase (2027-2030), and Mainstream Phase (2030 onwards).

The following focus areas could be considered as priorities for the development of the e2w roadmap for the city of Bangkok.

## Focus area 1: Urban Planning

The integration of e2ws into Bangkok's urban landscape necessitates a strategic zoning plan. This plan should identify specific locations for e2w hubs and Zero Emission Zones (ZEZs), set timelines for their development, and outline the expected benefits. By aligning these initiatives with ongoing urban development projects, the city can maximize synergies and minimize disruptions. Public spaces should be optimized for charging infrastructure, ensuring that these facilities are accessible, visible, and convenient for users.

Urban planning efforts must coordinate with broader urban development initiatives. Collaboration with urban planners and developers is essential to integrate e2w infrastructure into both new and existing urban developments. Updating building codes to include requirements for e2w charging points and battery swapping stations, particularly in large commercial buildings, is critical. Furthermore, designing e2w infrastructure to be resilient to local climate conditions, such as heavy rains and potential flooding, will ensure long-term sustainability and reliability.

Public spaces need to be strategically allocated for e2w taxi hubs and battery swapping stations, particularly in high-traffic locations. Ensuring that these hubs are conveniently located near public transportation nodes will facilitate seamless intermodal travel, encouraging more commuters to adopt e2ws.

To support the e2w roadmap, the following recommendations could be considered for urban planning and the use of public space:

- ✓ e2w taxi hub: allow expansion or addition of authorized e2w taxi to swap battery at busy location to attract 2w taxi rider to consider switching from ICE 2w to e2w
- ✓ Zero emission zone (ZEZ): appoint which areas will be made a ZEZ for e2ws and integrate this in the urban planning procedures.
- ✓ Integrated charging infrastructure requirements in the local building code: integrate e2w charging point/battery swapping into existing building code regulation for large commercial buildings.

## Focus Area 2: Regulatory measures

Effective regulatory measures can significantly accelerate the adoption of e2ws. Introducing financial incentives for early adopters, such as tax rebates, reduced registration fees, and exclusive access to certain areas, will encourage more people to switch to electric two-wheelers. Additionally, implementing preferential policies that give an advantage to companies and services using e2ws in government contracts and procurement processes will further promote their adoption.

Developing standardized policies and guidelines for e2w adoption and usage is crucial to ensure consistency across different parts of the city. Establishing clear safety and compliance standards for e2ws and related infrastructure, including charging stations and battery swapping facilities, will also be necessary.

A mechanism for regular review and updating of policies should be implemented to adapt to new insights and changing conditions. Engaging stakeholders in the policy review process will ensure that regulations remain relevant and effective, addressing any emerging challenges or opportunities.

The city of Bangkok could consider the following regulatory measures to support the e2w roadmap:

- ✓ Figure 9Subcontract preference on use of e2w: give a preferential score to companies that use e2w in the government contract/procurement bidding process
- ✓ Mandate utilities (electricity and water) meters reading by e2w: slowly regulating utilities meters reading officers to use e2w
- ✓ Scope 3 emission accounting: start scope 3 emission inventory in city-level government offices to help increase e2w usage

## Focus Area 3: Economic and Financial measures

To make e2ws more affordable and accessible, a comprehensive subsidy program should be designed. This program should cover not only the purchase of e2ws but also ongoing operational costs, maintenance, and insurance. Extending the national EV3.5 subsidy campaign to include e2ws will provide financial support to a broader range of electric vehicle users, making it easier for more people to make the switch.

Exploring innovative financing models, such as leasing programs and shared ownership schemes, can help lower the financial barriers for potential e2w users. Collaborating with private sectors and financial institutions to offer reduced-rate loans and other financial products for e2w purchases will also be beneficial.

Financial education campaigns is crucial in informing potential users about the available subsidies, incentives, and financing options. Providing information on swapping battery subscription rates and the financial benefits of switching to e2ws will help users make informed decisions.

For long-term financial sustainability, it is essential to identify and develop sustainable revenue streams to fund e2w infrastructure and incentives. Public-private partnerships and green bonds can provide the necessary funding while ensuring that the programs remain financially viable. Regular cost-benefit analyses will help ensure the financial viability and sustainability of e2w programs, adjusting as needed based on the latest data.

In summary, the city of Bangkok could consider the following regulatory measures to support the e2w roadmap:

- ✓ e2w subsidy program: expand the national EV3.5 subsidy campaign for e2w
- ✓ Adjust parking fees for e2w: reduce or waive public parking fee for e2w usage in the city
- ✓ Attractive e-mobility lending program: negotiate with private sectors and financial institutions to offer a reduced rate on loans to purchase an e2w for both personal and commercial uses so that potential riders to help to reduce the cost gap of an e2w compared with an ICE 2w. Information on swapping battery subscription rates applied in the SOLUTIONSplus demonstration project will provide valuable insights into riders' willingness to pay, which is essential for scaling up the initiative effectively.
- ✓ Reduce land and building tax for charging infrastructure: this will incentivize land and/or building owners to install e2w charging/battery swapping stations with reduced rate for land and building tax levied by the city.

## Focus Area 4: Charging infrastructure

Developing a comprehensive plan for e2w charging infrastructure is critical to support widespread adoption. This plan should include a mix of slow, fast, and ultra-fast charging stations to cater to different user needs. Identifying strategic locations for charging hubs, particularly in high-demand areas, will maximize coverage and accessibility.

Collaborating with utility companies to manage grid capacity and ensure stability with the increased demand from e2w charging is essential. Planning for the integration of renewable energy sources into the charging infrastructure will promote sustainability and reduce the environmental impact of e2ws.

Public awareness campaigns will play a vital role in informing citizens about the availability and benefits of new charging infrastructure. Highlighting the environmental and economic advantages of using e2ws, such as reduced emissions and lower operational costs, will encourage more people to adopt this mode of transportation.

Ensuring that charging infrastructure is designed to be resilient to local climate conditions, including heavy rains and potential flooding, will enhance its reliability. Regular maintenance schedules should be established to ensure that charging stations remain operational and efficient.Ensuring the availability of sufficient charging infrastructure with widespread coverage is essential to make it acceptable for motorcycle owners to switch to e2ws.

In this regard, the city of Bangkok could consider some of the following actions:

- ✓ Fast track permits for e2w charging infrastructure: Streamline the permitting processes for e2w charging and battery swapping stations and implement building codes that accommodate e2w infrastructure.
- ✓ Strategic locations for charging infrastructure: Designate strategically positioned city-owned locations for the installation of charging hubs for e2ws. Establish a public-private partnership with a competitive selection process to appoint a charging operator for these sites
- ✓ Plan for electricity demand increase: collaborate with utilities and grid operators to accommodate additional electricity demand from e2w charging infrastructure.
- ✓ Incentivized renewable energy sources for e2w charging: Partner with the solar rooftop program to incentivize the use of solar electricity or other renewable energy sources for e2w charging in the future.

## Focus area 5: Partnerships and public awareness

Engaging stakeholders through a structured framework is critical to the successful implementation of the e2w roadmap. Regular meetings, feedback sessions, and collaborative projects will help foster partnerships with businesses, NGOs, community organizations, and government agencies. These partnerships will play a crucial role in promoting e2w adoption and developing a supportive ecosystem.

Public education programs should be developed to raise awareness about e2ws, addressing common misconceptions and highlighting success stories. Organizing events such as e2w days and electric motorcycle conversion contests will engage and educate the public, showcasing the benefits of electric two-wheelers.

Collaboration with the private sector is essential for the development and operation of e2w infrastructure. Promoting public-private partnerships for funding and implementing e2w initiatives will leverage private sector expertise and resources, accelerating the adoption process.

Capacity building and training programs is necessary to ensure the long-term sustainability of the e2w ecosystem. Supporting the organization of short courses and upskilling programs will help individuals develop the skills needed for the e2w business value chain. Technical training for the maintenance and operation of e2ws and charging infrastructure will ensure that these systems remain functional and efficient.

In short, the city of Bangkok could consider the following actions related to partnerships and public awareness to support the e2w roadmap:

- ✓ Develop a communication strategy for the transition to e-mobility, including a mapping of the audiences the city wants to reach.
- ✓ E2w campaign: regular campaigns planned to engage and inform stakeholders and city inhabitants about e2ws . Promote for example the demonstration project in public media, on the website and other on-line channels.
- ✓ Capacity building: support the organization of training and capacity building programs, such as short courses for upskilling, especially in the technical field, to get a job in the e2w business value chain.

- ✓ EV climate program[46]: launch a platform to reward customers who use e2w taxi, e.g. coffee coupon, reduced fare to metro network, reduced parking fee in existing initiative/plan.

### Implementation monitoring

Demonstration Phase (2024-2027): During this phase, various demonstration and pilot projects are implemented to highlight the feasibility and benefits of e2ws. Suitable areas for ZEZ pilots along metro networks needs to be identified, and business models from pilot projects is developed. Technical capacity-building initiatives should be provided to stakeholders. Implement (shared) motorcycle pilots, develop business models from various pilot/demonstration projects, and provide technical capacity building and awareness raising.

Scale-Up Phase (2027-2030): This phase focuses on introducing incentives and regulatory frameworks to stimulate demand for e2ws. Lessons learned from the demonstration phase is used to announce and prepare for the implementation of ZEZs. Government procurement of e2ws for shared systems should be mandated step-by-step, ensuring a gradual but steady increase in e2w adoption. Step-by-step mandate government procurement of e2w for the shared system, announce and prepare implementation of the ZEZ based on lessons learned from the pilot phase. Continued structured stakeholder dialogue sessions, step-by-step EV charging master plan implementation, provision of subsidies and financial incentives where relevant to support the investment of EVs and charging infrastructure, launch public awareness campaigns e.g. e2w day e2w conversion competition for wider uptake.

Mainstream Phase (2030 onwards): By this phase, e2ws should be positioned as the default choice for two-wheelers due to their superior performance and lower costs. Full implementation of ZEZs and widespread charging infrastructure should be achieved, making e2ws a standard part of Bangkok's transportation system. Full operation of the ZEZ, initiate e2w battery recycling implementation with regional co-operation, full roll-out of public charging and battery swapping stations.

A robust monitoring and evaluation framework needs to be established to track progress, measure impact, and make data-driven adjustments. Periodic consultations with stakeholders will ensure continuous improvement and address any challenges that arise. Regular reporting and transparency in the implementation process will maintain public trust and support for the e2w transition.

## 5. Conclusion and next steps

To successfully transition to electric two-wheelers (e2ws) in Bangkok, a comprehensive and well-coordinated plan is essential. This plan should cover urban planning, regulations, economic and financial incentives, charging infrastructure, and partnerships, ensuring e2ws are effectively integrated into the city's transportation system. By sticking to a detailed timeline and phased approach, Bangkok can make significant progress in e-mobility adoption.

The e2w roadmap for Bangkok aims to improve urban mobility, reduce environmental impact, and promote sustainable transportation. It aligns with national and city targets, contributing to broader climate goals. The plan's phased implementation includes the Demonstration Phase (2024-2027), Scale-Up Phase (2027-2030), and Mainstream Phase (2030 onwards), offering a structured path to achieve these objectives. To stay relevant and effective, the roadmap should be flexible, allowing for adjustments as new challenges and opportunities emerge. This approach ensures adaptability and responsiveness to the evolving e2w landscape in Bangkok.

The first step is to establish a steering committee with representatives from the government, private sector, NGOs, and community organizations. This committee will guide and oversee the implementation, ensuring alignment with the goals and addressing challenges as they arise.

Demonstration and pilot projects are crucial to showcase the feasibility and benefits of e2ws. During the Demonstration Phase (2024-2027), suitable locations for Zero Emission Zones (ZEZ) pilots will be identified, and business models and capacity-building programs will be developed to support these initiatives. These projects will provide practical examples of how e2ws can be integrated into Bangkok's urban mobility landscape.

In the Scale-Up Phase (2027-2030), regulatory frameworks will be established to introduce incentives and regulations that stimulate demand for e2ws. Lessons from the demonstration phase will inform the preparation and implementation of ZEZs. This phase will also require the government to procure e2ws for shared systems, increasing their adoption across the city.

Expanding the charging infrastructure is critical. A comprehensive plan will include a mix of slow, fast, and ultra-fast charging stations. Collaboration with utility companies will manage grid capacity and incorporate renewable energy sources into the charging infrastructure, promoting sustainability and ensuring a reliable power supply for the growing number of e2ws.

Public-private partnerships will be vital. Collaborating with businesses, NGOs, community organizations, and government agencies will foster an environment conducive to e2w infrastructure development and operation. Promoting private sector involvement will leverage expertise and resources, accelerating adoption.

Public awareness campaigns will address misconceptions and highlight the benefits of e2ws. These campaigns will include events like e2w days and electric motorcycle conversion contests to engage and educate the public, showcasing the environmental and economic advantages of e2ws.

Capacity-building programs will provide technical training for maintaining and operating e2ws and charging infrastructure. These programs will ensure individuals and organizations have the necessary skills to support the long-term sustainability of the e2w ecosystem.

Lastly, establishing a robust framework for monitoring and evaluating progress is essential. This framework will track progress, measure impact, and make data-driven adjustments. Regular consultations with stakeholders will ensure continuous improvement and maintain transparency throughout the implementation process.

By following these steps and adhering to the timeline, Bangkok can effectively transition to a sustainable and efficient electric two-wheeler ecosystem, enhancing urban mobility, reducing environmental impact, and positioning the city as a leader in sustainable transportation. The commitment and collaboration of all stakeholders will be crucial in achieving these ambitious goals and ensuring the long-term success of the e2w roadmap.

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