



Office of Transport and Traffic Policy and Planning

Executive Summary Report

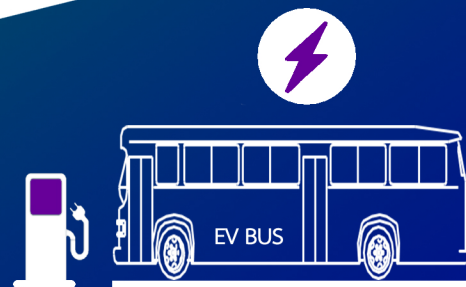
A Study on Electric Vehicle Technology for Public Transport System Development Plan



King Mongkut's Institute of Technology Ladkrabang

King Mongkut's University of Technology Thonburi

August 2020





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Preface

Boundless communication and fierce competition cause rapid technology and innovation development. Global energy trend will change the automobile drive from Internal Combustion Engine (ICE) to Electric Vehicle (EV) because it will decrease pollution and global warming problem. The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius. Responding to global concern, Thailand government targets to reduce 20-25% of greenhouse gas by 2030 by reducing oil and fuel import. In addition, since 2015, the government began to promote Electric Vehicle and assigned many ministries and agencies propose Electric Vehicle promotions plan. Innovation committee, Prime Minister is chairman, approved Thailand Electric Vehicle promotion plan in 7th August 2015. moreover, Ministry of Energy targets to promote 1.2 Million Electric Vehicle cars in Thailand by 2036 which is in line with the Energy Efficiency Plan (EEP) 2018 – 2036.

Ministry of Transport (MOT) propose to shift mass and public transportation operation system – railway and road - to be driven by clean energy. MOT plan is in line with 1) the 20-year National Plan in terms of well-being creation and eco-friendly, 2) the 12nd Economic and Social Development Plan (2017–2021), 7th infrastructure and logistic development strategy, 3) the 20-year transportation system strategy (2018-2037), 5th strategy introducing technology and innovation for transportation system development, and 4) Transportation and Logistics System Integration plan which promote EV to operate in public transportation system in order to increase transportation safety, efficiency, and equality, especially in the urban area and upgrade well-being from green city for all.

This executive summary report presents the essence of transportation system development from electrical automotive technology. The Office of Transport and Traffic Policy and Planning expect this report will be very useful for related concerned agencies for creating efficiency and sustainable transportation development.

The Office of Transport and Traffic Policy and Planning



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Chapter 1

Introduction

Nowadays, many countries develop the Electric Vehicle (EV) technology to replace Internal Combustion Engine (ICE) vehicle in order to reduce pollution. Recently, Thailand starts to encourage electric vehicle policy through many ministries i.e. public electric vehicle operation and encouraging electric vehicle procurement. Electric vehicle becomes known and people more realize to handle environment problem especially in urban area which has high pollution problem. Therefore, the government has to create the practical public electric vehicle transport system development plan and introduce electric vehicle for public service by review policy and national plan together with the executive of related agencies and operator in-dept interview.

The results found the driver of public electric vehicle technology has 3 main obstacles which need urgent solving as:

First obstacle: Electric vehicle main body and automotive parts have higher cost than other vehicles such as production cost, import tax cost, corporate income tax, energy cost, human resources scarcity cost, and battery cost. All costs have direct impact to electric vehicle investment decision. Therefore, the possible attractive policy to induce entrepreneur/operator investment and increase the electric vehicle competitiveness are:

- Electric vehicle body and automotive parts industry promotion
- Battery cell import tax exemption
- Special electric vehicle electricity price
- Electric vehicle training

Second obstacle: The government has to invest in basic infrastructure especially charging station because it has high investment cost. In addition, entrepreneurs do not familiar with new technology so they are afraid to invest. Therefore, the possible solution to eradicate obstacles and create entrepreneur confidence are:

- Setting charging station in electric vehicle garage
- Transportation infrastructure improvement



Third obstacle: Standard, laws and regulations which related to electric vehicle operation

Due to less electric vehicle operation, there are no specific/direct electric vehicle laws and regulations i.e. electric vehicle registration, electric vehicle and automotive parts standard, and forms or documents. Therefore, it takes a long time to apply electric vehicle for public operation. However, this obstacle can be solved as:

- Setting electric vehicle car body and component standard
- Setting the check list form to evaluate electric vehicle performance which is necessary for electric vehicle registration
- Setting electric vehicle standard price
- Collaborate with related agencies for electric vehicle development

Obstacles and solutions which mention earlier will use to analyze and create 10-year public electric vehicle transportation plan. The plan will compose of 28 projects/measures which will divide to 3 phases are short term, medium term, and long term. The plan will consider base on rapid changing technology, battery life cycle, and transportation license. 10-year public electric vehicle transportation plan details are:

Vision

“To upgrade the efficiency of public transportation development by using electric vehicle technology to support country development and sustainable public transportation system”

Mission

“To enhance electric vehicle operation, induce domestic electric vehicle production, support research and enhance people to use public transportation”

Strategy

- First strategy: “electric vehicle usability promotion and knowledge development” strategy

It will reduce electric vehicle and component cost by getting government support such as the development of electric vehicle, related business, technology, and human resources. This strategy composes of 15 projects/measures are:

- (1) The study of the optimal electricity price for the electric bus business
- (2) The production of automotive parts for electric buses promotion
- (3) Promote the production of battery for electric buses and auto parts
- (4) Battery cell import tax exemption program to promote battery manufacturing business
- (5) The study of the modification of internal combustion engines buses to electric buses
- (6) Public relations project to promote the electric buses usability to reduce air pollution
- (7) The Bangkok Mass Transit Authority electric buses procurement
- (8) Public relations project to promote the electric buses usability to reduce air pollution
- (9) Soft loan for the electric bus business
- (10) The optimal battery switching system development for electric buses
- (11) Electric vehicle battery innovation and invention contest project
- (12) The course of electric vehicle technology development for vocational certificate and diploma
- (13) Up-Skill and Re-Skill of electric vehicle production for existing industrial worker project
- (14) Electric vehicle maintenance training project
- (15) Electric vehicle technology development institute project

- Second strategy: “Basic infrastructure development” strategy

The government need to create energy and transportation development plan to respond and be ready for electric vehicle usage and sustainable development. It composes of 5 plans/projects.

- (1) Electric vehicle charger procurement for setting in operator garage
- (2) The study of Thailand smart grid operation for public electric vehicle transportation system development
- (3) A demonstration project of a V2G
- (4) Bus terminal/transit area improvement/construction project
- (5) The establishment of electric bus real time control system, display, and release time table project

- Third strategy: “Standard, law, and regulation preparation” strategy

Encouragement the readiness of electric vehicle standard, law, and regulation and enhance government agencies policy in pilot area. The possible projects are:

- (1) The preparation of electric vehicle car body and component standard project
- (2) Check list for electric vehicle performance evaluation for electric vehicle registration
- (3) Integrated plan of related agencies for electric vehicles development
- (4) Electric vehicles safety standard and after use battery management
- (5) Determination of domestic public buses life limitation
- (6) Electric bus standard price setting project
- (7) The adjustment of electric bus operator selection criteria project
- (8) Buses detection and black smoke emission control

To create concrete transportation changes, Electric Vehicles should be promoted and implemented in selected 6 provinces are Bangkok, Chiangmai, Nakhon-Ratchasima, Ayutthaya, Chonburi, and Phuket. The study covers economic feasibility study of Electric Vehicles by comparing economic return of charging technology type - Quick Charge and Normal Charge. The result shows Normal Charge creates better economic return. Economic analysis of each province is presented in Table 1.4-1

Table 1.4-1 Economic analysis result classify by province

Province	Quick Charge			Normal Charge		
	NPV (Mil. Baht)	EIRR (%)	B/C	NPV (Mil. Baht)	EIRR (%)	B/C
Bangkok	-12.82	10.37	0.94	7.75	12.83	1.04
Nakhon-Ratchasima	22.34	20.63	1.57	35.01	26.36	2.00
Chiangmai	1.49	12.80	1.04	5.19	14.36	1.12
Ayutthaya	-14.17	10.92	0.88	14.65	15.00	1.13
Chonburi	30.60	35.51	2.06	38.85	45.30	2.43
Phuket	3.14	13.22	1.06	12.43	17.07	1.24

Remark: Evaluation criteria : Economic standards are NPV $\geq$ 0, EIRR $\geq$ 12%, and B/C $\geq$ 1

Results in Table 1.4-1 presents changing Internal Combustion Engine (ICE) vehicle to Electric Vehicle creates economic worthiness. In some provinces, electric buses are operated by private sector which mainly concern the financial worthiness. The consultant mainly focus entrepreneur financial scheme analysis by setting Normal Charge as the assumption together with government measures follow the Public Electric Vehicle Transportation Development Plan as:

- Investment promotion to battery, automotive part and Electric Vehicles assembly entrepreneurs through Board of Investment (BOI)
- Import tax exemption and battery cell excise tax to battery producers who get the approval from Investment (BOI)
- Fixed electric charging rate for Electric Vehicles
- Charging station investment support to entrepreneurs
- Standard, law, and regulation prepared

Financial analysis results of the Public Electric Vehicle Transportation Development Plan are classified into 2 groups as:

Group 1 : High potential is the provincial group which has potential to change the existing vehicle (ICE) to Electric Vehicle by getting some government support such as investment promotion on automotive part and electric buses assembly, and battery cell tax exemption through the Board of Investment, fixed electric charging rate, and the preparation of standard, law, and regulation. The analysis results are presented in Table 1.4-2.

Table 1.4-2 High potential group financial analysis result

Province	<u>Do not follow</u> the Public Electric Vehicle Transportation Development Plan			<u>Follow</u> the Public Electric Vehicle Transportation Development Plan		
	NPV (Mil. Baht)	FIRR (%)	B/C	NPV (Mil. Baht)	FIRR (%)	B/C
Bangkok*	-54.14	6.31	0.95	42.41	9.60	1.05
Nakhon-Ratchasima *	16.72	11.54	1.10	31.37	15.72	1.21
Chiangmai*	2.77	8.51	1.02	18.47	11.97	1.11

Remark *: BMTA/private sector invests in charging station 100% and charges the electricity fee follow the policy rate

Group 2: Basic potential is the provincial group which has only basic potential to change the existing vehicle to Electric Vehicle by getting fully support from the government follow the Public Electric Vehicle Transportation Development Plan. Moreover, the government has to subsidize charging station investment in order to create financial worthiness. The analysis results are presented in Table 1.4-3.

Table 1.4-3 Basic potential group financial analysis result

Province	<u>Do not follow</u> the Public Electric Vehicle Transportation Development Plan			<u>Follow</u> the Public Electric Vehicle Transportation Development Plan		
	NPV (Mil. Baht)	FIRR (%)	B/C	NPV (Mil. Baht)	FIRR (%)	B/C
Ayutthaya***	-69.21	1.07	0.82	4.64	8.72	1.01
Chonburi***	-23.42	0.42	0.84	2.97	9.54	1.02
Phuket**	-26.56	4.51	0.88	3.58	8.61	1.02

Remarks: **: Government invests in charging station 50% and charges the electricity fee follow the policy rate

***: Government invests in charging station 100% and charges the electricity fee follow the policy rate

According to above analysis, besides investment promotion in automotive parts and electric buses assemble and battery cell import tax exemption through Board of Investment, fixed electric charging rate for Electric Vehicle, and the preparation of standard, law, and regulation which are main government measures, government needs to support charging station investment which is one of the crucial conditions to expand Electric Vehicle promotion throughout the region and country. If government does not support charging station, only some high potential province/entrepreneur can operate Electric Vehicles and get financial worthiness. Therefore, if government wants to promote Electric Vehicles throughout the region and country, it is necessary to push forward the charging station investment for entrepreneur policy because it is the fundamental factor for Electric Vehicle concrete driving.

Enhancing Electric Vehicle in public transportation is necessary to get government subsidy. The government may assign government agency, Bangkok Mass Transit Authority (BMTA), to operate Electric Vehicle in their own route in order to stimulate Electric Vehicle production industries and businesses and related industries.

Regarding to the infrastructure readiness and Electric Vehicle assembly in Thailand, Bangkok is the most appropriate to be pilot province which corresponding with the pollution reduction policy by using Electric Vehicle. Currently, BMTA reviews the rehabilitation plan

(23rd April 2020 revision) by purchasing/leasing Electric Vehicle 2,511 buses for public service operation.

The economic assessment of purchasing/leasing Electric Vehicle 2,511 buses to replace the existing ICE results show NPV = 8,894 Million Baht, EIRR = 22.62, and B/C = 1.55. It means investment in purchasing/leasing Electric Vehicle 2,511 buses cars create more social benefit than cost. Therefore, it appropriates to invest in Electric Vehicles 2,511 buses.

The financial assessment of purchasing/leasing Electric Vehicles 2,511 buses to replace the existing ICE results show BMTA will get benefit from purchasing/leasing Electric Vehicle by getting NPV = 3,076 Million Baht, FIRR = 9.77, and B/C = 1.05 follow the assumption of government all invest in charging stations and charge the electricity fee follow policy rate.

Moreover, Electric Vehicle promotion will stimulate automotive sector to learn and start automotive production process and Electric Vehicle assembly efficiently. The mentioned investment will stimulate economy and generate domestic employment in automotive and related industries, and generate additional government tax revenue.

According to Input – output analysis, the value from Electric Vehicle 2,511 buses investment is 26,504 Million Baht. The value will distribute to many channels - direct and indirect - such as employment generation, production expansion for automotive and related industries. Employment increasing will benefit for government tax collection especially income tax, consumption tax, production factor tax, and business profit tax which is expected to 5,276 Million Baht. Moreover, it will create employment value around 1,232.11 Million Baht from 2,461 jobs increasing.

Project recommendation

1) Public electric bus route operation encouragement has to consider the existing public vehicle operator. Moreover, it is necessary to explain the worthiness from changing ICE to electric vehicle especially the financial return from electric vehicle long term investment to the entrepreneur. However, the operator/entrepreneur will face high investment cost in the first stage of investment which may not attract operator/entrepreneur investment. Therefore, the government should support soft loan for electric vehicle business operation.

2) Encouragement public electric vehicle transportation development plan to create practical electric vehicle operation. Although Bangkok Mass Transit Authority (BMTA) and the Transport co. ltd. promptly operates electric buses but both agencies have to research on the

electric buses operation route feasibility study by considering number of electric buses, distance, charging technology, and operation timetable framework.

3) In review Bangkok Mass Transit Authority (BMTA) rehabilitation plan should specify public electric buses operation especially domestic electric bus assembly 2,511 buses (26,504 million Baht) in order to stimulate electric bus production and related industry. Domestic electric bus investment and electric bus cell battery and motor import reduction will create a lot of benefits such as creating new 4,095 positions, 2,050 million Baht from employment, government tax income 7,234 million Baht, and reduce 25 percent electric bus import value. Moreover, it will expand electric bus and related industry production both direct and indirect.



Chapter 2

The preparation of Public Electric Vehicle transportation system development plan

2.1 Objective

- 2.1 Knowledge accumulation of domestic and international electric vehicle technology
- 2.2 Designing electric vehicle transportation system development plan and energy infrastructure system which will use to create the electric vehicle modification and changing guideline
- 2.3 Pilot area/city has plan and information to prepare electric vehicle modification and changing

2.2 Problems and the solving guideline of public transportation system development by using electric vehicle

2.2.1 Planning/project review and related agency interview

The preparation of public electric vehicle transportation system development plan needs to review all electric vehicle technology operation system projects in

- 20-year national plan
- 12nd Economic and Social Development Plan
- Strategic plan of the agency under Ministry of Transport
- Strategic plan of the agency under Ministry of Energy
- Electrical infrastructure development plan to respond Thailand electric vehicle. It is the integration of 3 agencies (Electricity Generating Authority of Thailand: EGAT, Provincial Electricity Authority: PEA, and Metropolitan Electricity Authority: MEA)
- The study of sustainable transportation development and climate change reduction master plan

All plans have to support basic infrastructure service such as good service, comfortable, safety, respond to peoples' transportation needs, environment friendly, and health safety.

Moreover, the study covers 23 executives and entrepreneurs in-dept interviews in order to get useful recommendation for designing public electric vehicle transportation development plan and to drive electric vehicle operation practically.



2.2.2 Problem and solution guideline

According to plan/project review and related agencies interview, electric vehicle technology is one of the important factors to reduce environmental and energy problem. However, present potential operators hesitate to invest in electric vehicle because of high investment cost, lacking of domestic infrastructure, and inhospitable of related measures, laws, and regulations which obstruct electric vehicle technology operation in Thailand. There are 3 main electric vehicle obstacles as:

First obstacle: Electric vehicle main body and automotive parts have higher cost than other vehicles such as production cost, import tax cost, corporate income tax, energy cost, human resources scarcity cost, and battery cost. All costs have direct impact to electric vehicle investment decision. Therefore, the possible attractive policy to induce entrepreneur/operator investment and increase the electric vehicle competitiveness are:

- Electric vehicle body and automotive parts industry promotion
- Battery cell import tax exemption
- Special electric vehicle electricity price
- Electric vehicle training

Second obstacle: The government has to invest in basic infrastructure especially charging station because it has high investment cost. In addition, entrepreneurs do not familiar with new technology so they are afraid to invest. Therefore, the possible solution to eradicate obstacles and create entrepreneur confidence are:

- Setting charging station in electric vehicle garage
- Transportation infrastructure improvement

Third obstacle: Standard, laws and regulations which related to electric vehicle operation

Due to less electric vehicle operation, there are no specific/direct electric vehicle laws and regulations i.e. electric vehicle registration, electric vehicle and automotive parts standard, and forms or documents. Therefore, it takes a long time to apply electric vehicle for public operation. However, this obstacle can be solved as:

- Setting electric vehicle car body and component standard
- Setting the check list form to evaluate electric vehicle performance which is necessary for electric vehicle registration
- Setting electric vehicle standard price
- Collaborate with related agencies for electric vehicle development

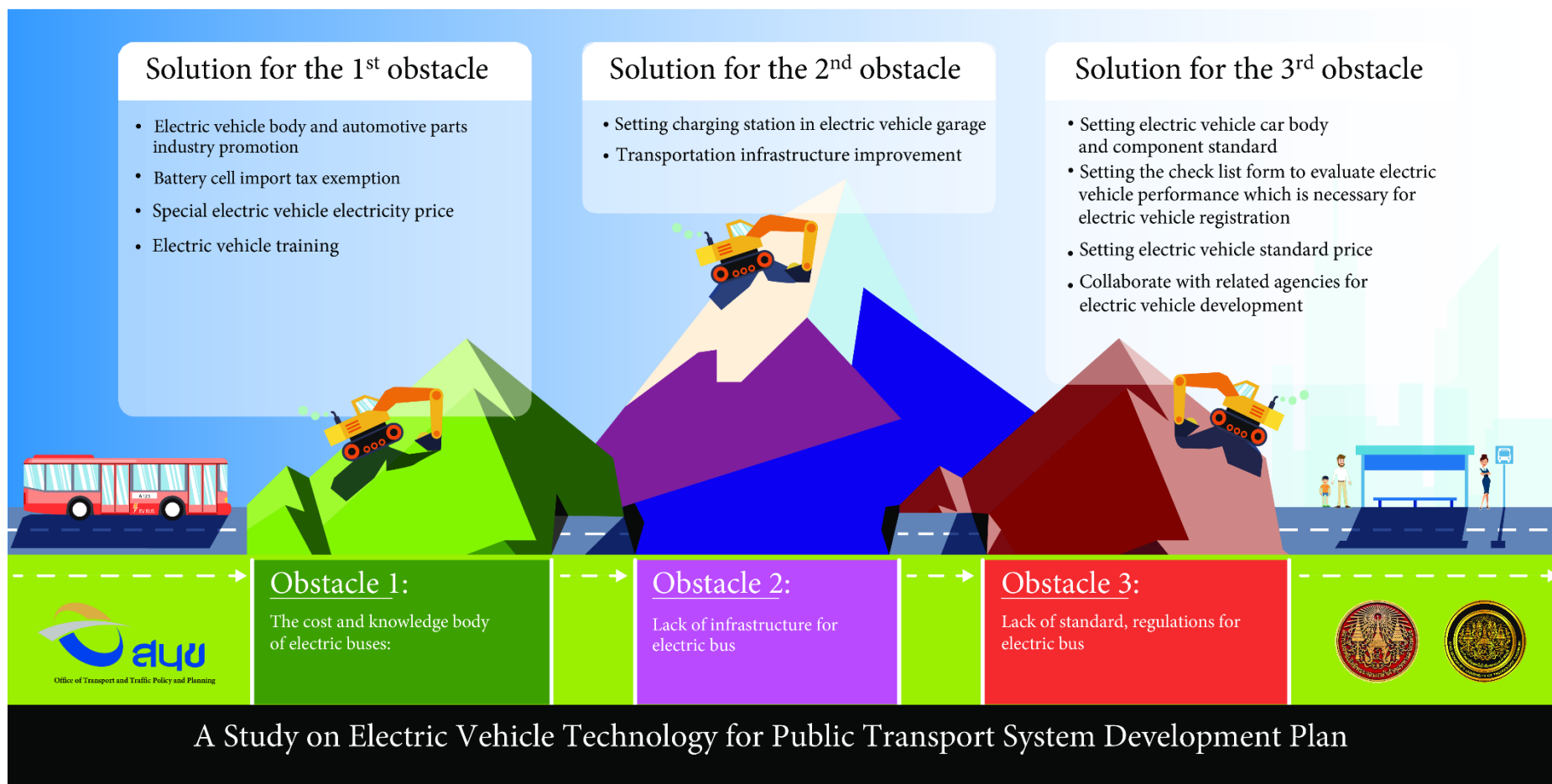


Figure 2.2-1 Obstacles and solutions for driving the electric buses

2.3 Public electric vehicle transportation system development plan

Public electric vehicle transportation system development plan preparation composes of all projects/measures. Projects/measures are divided into 3 phases are short term, medium term, and long term in order to eradicate the obstacle of public electric vehicle system development i.e. electric bus car body and automotive parts cost, basic infrastructure, standard, and laws and regulations. SWOT analysis of public electric vehicle transportation system development presents in Table 2.3-1.

Table 2.3-1 Strength, weakness, opportunity and threat (SWOT Analysis) of Public Electric Vehicle transportation system development

	Subservient factors	Impact factors
	Strength	Weakness
Internal factors	S1: Electric bus helps to reduce air and noise pollution problems S2: Electric bus has high energy consumption efficiency S3: Electric bus has low operation cost and maintenance	W1: High cost of Electric bus W2: High battery cost and dangerous W3: Route and distance are limited by battery size W4: Electrical charging period limitation
	Opportunity	Threat
	O1: Government policy to support electric vehicle usability O2: New business model which is related with electric bus O3: Thailand automotive manufacturing industry get a great opportunity from International electric vehicle market expansion trend O4: PM 2.5 problem seriously intensify O5: Electrical charging at night time will increase energy usability efficiency	T1: Standard, tax, law, and regulation T2: People do not prefer to use public transportation because of traffic jam and poor service quality T3: Demand for charging station area and electrical energy quantity T4: Uncertainly oil price situation T5: Operator and domestic automotive manufacturing industry do not interest T6: Readiness of human resource and technology T7: International electric vehicle technology develops rapidly and the electric vehicle price tend to decrease therefore consumers slow down the purchasing decision.
External factors		

Strategy specification from 4 strategy choices, 1) pro-active strategy (SO), 2) corrective strategy (WO), 3) prevention strategy (ST), and 4) defensive strategy (WT) is presented in Table 2.3-2

Table 2.3-2 Strategy issue and strategy specification

Strategy issue	Strategy
Strategy “The promotion of electric vehicle usability and knowledge development”	S3O1 The strength points of electric bus are low operation cost and maintenance while the weakness is high cost in the initial stage. Therefore, the government and related agencies need to find the initial cost reduction solution in order to persuade operators changing from Internal Combustion Engine (ICE) to electric vehicle.
	S3O5 Enhance operators change buses from Internal Combustion Engine (ICE) to electric bus because it has low operation cost and maintenance and use battery for energy storage.
	W4O2 Promote power generation business in order to reduce electrical energy fee which will facilitate operator’s service.
	S1O3 Enhance entrepreneurs in automotive parts manufacturing industry produces related electric bus parts. This preparation will support domestic and international electric vehicle expansion. Increasing in electric bus will reduce air and noise pollution problem. S2O3 Current electric vehicles in Thailand are imported from foreign country therefore the selling price is high. However, there are many potential Thai entrepreneurs in automotive parts manufacturing industry who can produce electric bus and support automotive parts. The expansion of domestic and international market will increase the number of domestic electric bus usability which will increase the efficiency of energy consumption in transportation sector and a whole country. W1O3 Due to import electric bus is expensive, the government has to promote related electric bus automotive parts manufacturing industry because it will induce domestic electric bus production and reduce the dependence on import which will benefit for operators because it will reduce the car body cost.
	S1W3O4 Due to environmental problems especially PM 2.5 in urban area, the possible solution is changing Internal Combustion Engine (ICE) vehicle to electric vehicle. BMTA, the pilot agency, should play the important role in reducing environmental problems because BMTA has a lot of ICE vehicle. Although electric bus is expensive therefore BMTA has to study the modification of Internal Combustion Engine (ICE) to electric bus in order to reduce the modification cost.

Table 2.3-2 Determination of Strategic Issues and Strategies (Continue)

Strategy issue	Strategy
Strategy “The promotion of electric vehicle usability and knowledge development” (continue)	S3O4 The electric bus usability public relation is important because it will create the recognition of toxic dust and pollution impact. electric bus operation/service is environmentally friendly and will reduce the toxic dust and pollution. In addition, electric bus has lower operation and maintenance cost than ICE bus.
	W1O1 The government policy should emphasize budget allocation or soft loan support for initial investment of changing ICE bus to electric bus because it will increase electric bus operator competition
	S1O1W1 Allocate budget for potential pilot area to support initial changing ICE bus to electric bus investment. Moreover, due to electric bus is expensive therefore it is necessary to have clearly procurement regulation and announcement.
	S1O2O4 Promote electric bus usability to solve air pollution problem and support new related business.
	S2O2 Promote new integrated business of related electric vehicle in order to increase the efficiency of electric vehicle usability in transportation sector and energy consumption.
	S3O2 Inform operators that electric bus has lower operation and maintenance expenditure than ICE. In addition, it necessary to promote the related businesses to operate in the consistent manner.
	W1O2 Promote the study of electric bus cost reduction by supporting new related to public bus usability businesses in order to reduce the electric bus cost.

Table 2.3-2 Determination of Strategic Issues and Strategies (Continue)

Strategy issue	Strategy
	W2O1 Promote domestic battery related research in order to decrease the battery price and increase safety by getting state budget support. W2O2 Promote research in battery cost reduction, increasing the confidence in safety of electric vehicle usability, after use battery elimination, and battery management businesses extension. W2O3 Promote foreign company who has battery production technology and dangerous protection invest in Thailand in order to get technical knowledge transfer. W3O2 Promote battery swappable technology business W3O5 Enhance research of the optimal charging type for electric bus mainly focus at night time in order to increase the efficiency of electric power usability. W4O1 Promote the optimal electric bus charging type research in order to reduce the charging time of each route and use to be the database of timetable management. W3O1 Promote the research of energy demand and battery size for electric bus operation. S1T6 Prepare the readiness of human resource and technology to respond with demand of electric bus operation S2T6 Support electric bus development scholarship to technology staffs and educate related people. S3T6 Although electric bus has low maintenance cost but it still needs to have specific staffs. Therefore, it is necessary to prepare staffs and technology to be ready for electric bus operation.

Table 2.3-2 Determination of Strategic Issues and Strategies (Continue)

Strategy issue	Strategy
Strategy “Basic infrastructure development”	S2O1 Enhance electric bus operation in order to increase the efficiency of electric bus usability in transportation sector and energy consumption. The government needs to formulate government policy and support basic infrastructure construction such as charging station.
	S2O5 Enhance electric bus usability to increase the energy consumption efficiency in transportation sector and solve the power producers Duck Curve problem in power generation by using electric bus as the power storage in daytime.
	S1T2 Upgrade the usability of environment friendly public bus in order to change to people transportation behavior from using personal car to public buses.
Strategy “Readiness preparation of standard, law, and regulation”	S1T1 Due to electric bus has clean energy and the government wants to urgently enhance electric bus usability to solve pollution problem in the urban area. Therefore, related agencies need to prepare the standard, law, and regulation such as registration, and tax rate specification promptly in order to create the efficiency of electric bus usability.
	S1T5 Enhance air and noise pollution emission law to stimulate operator and domestic automotive industry to invest in electric bus production and usability.
	S2O4 Enhance electric bus usability to solve air pollution (toxic dust) and increase the efficiency of transportation sector and energy consumption by increasing electric bus usability and elimination ICE bus because ICE bus creates a lot of problems.
	W1T1 Give subsidy to electric bus operator for initial changing ICE bus to electric bus. It will save electric bus operation cost and induce electric bus demand. Therefore, related electric bus agencies need to prepare laws and regulations. Moreover, laws and regulations of each agency has to consistent with others.

Table 2.3-2 Determination of Strategic Issues and Strategies (Continue)

Strategy issue	Strategy
Strategy “Readiness preparation of standard, law, and regulation” (continue)	S1O1T1 Due to electric bus has clean energy, does not create pollution, and the government wants to urgently enhance electric bus usability to, therefore related agencies have to stimulate electric bus usability. Many agencies have electric bus procurement policy for their own agencies while some agencies cannot purchase electric bus because of standard electric bus price regulation. S1W3T1 Encourage electric bus usability in order to solve urban pollution problem. Related agencies should design incentive measures to persuade electric bus operation such as setting criteria to select potential electric bus operator to operate electric bus. electric bus operation investment has higher cost than ICE because it needs to consider route, distance, and trips per day in order to specify the optimal battery size. S1O4T1 Nowadays, one of the serious air pollutions in urban area come from PM 2.5 especially black smoke from old and inefficient ICE bus. Therefore, changing ICE bus to electric bus together with black smoke emission vehicle detection will reduce air pollution problem.

Public electric vehicle transportation system development plan

Vision

“To upgrade the efficiency of public transportation development by using electric vehicle technology to support country development and sustainable public transportation system”

Mission

“To enhance electric vehicle operation, induce domestic electric vehicle production, support research and enhance people to use public transportation”

Objectives

- 1) To develop public transportation system by using electric vehicle technology to increase the efficiency, convenience, rapidity, safety, frugality, and reliability.
- 2) To develop plan and information to be ready for sustainable electric vehicle public transportation system modification

Benefits

- 1) Electric buses are well operated in the air pollution areas which will help to increase environment quality and operator competition.
- 2) Upgrade life quality and develop to green city by changing to use environmentally friendly transportation.
- 3) Human resource, technology, and related business are developed.

According to SWOT analysis of current electric vehicle public transportation system, development trend, and national plan and policy, the guideline of sustainable public transportation system development upgrading by using electric vehicle technology compose of 3 national strategies, 10 strategies, and 28 projects as:

First national strategy: “Electric bus usability promotion and knowledge development”

To reduce electric bus and component cost by getting government support such as electric bus and related business and technology and human resource development. This national strategy composes of 6 strategies as:

- ✓ 1st strategy Electric bus business promotion
- ✓ 2nd strategy Entrepreneur promotion in automotive parts manufacturing industry
- ✓ 3rd strategy Barge the government and State Enterprises to change ICE bus to electric bus
- ✓ 4th strategy New related electric bus business promotion
- ✓ 5th strategy Electric vehicle technology research promotion
- ✓ 6th strategy Human resource development promotion

Second national strategy: “Basic infrastructure development”

Set up energy and transportation infrastructure development plan to be ready for electric bus usability and sustainable development. This national strategy composes of 2 strategies as:

- ✓ 1st strategy Energy management
- ✓ 2nd strategy Reducing personal cars and increasing public transportation usability promotion

Third national strategy: “Standard, law, and regulation preparation”

Encouragement the readiness of electric bus standard, law, and regulation and enhance government agencies policy in pilot area. This national strategy composes of 2 strategies as:

- ✓ 1st strategy Standard and regulation preparation
- ✓ 2nd strategy Barge transportation operators and government agencies to use electric buses

Table 2.3-3 The timeline of public Electric Vehicle transportation system development plan

No.	Activity	Urgent plan (1-2 years)		Medium term plan (3-5 years)			Long term plans (6-10 years)					Agency
		A.D.2020	A.D.2021	A.D.2022	A.D.2023	A.D.2024	A.D.2025	A.D.2026	A.D.2027	A.D.2028	A.D.2029	
First national strategy: "Electricity vehicle usability promotion and knowledge development"												
	Strategy 1: Electric bus business promotion											
1	Study of optimal electricity price for the electric bus business											Energy Regulatory Commission
	Strategy 2: Entrepreneur promotion in automotive parts manufacturing industry											
2	Promote the production of automotive parts for electric buses											Board of Investment
3	Promote the production of battery for electric buses and autoparts.											Board of Investment
4	Battery cell import tax exemption program to promote battery manufacturing business.											Board of Investment
	Strategy 3: Barge the government and State Enterprises to change ICE bus to electric bus											
5	Study of the modification of internal combustion engines buses to electric buses.											National Science and Technology Development Agency (NSTDA)
6	Promote the electric buses usability in the pilot area.											Other agencies in pilot cities
7	The Bangkok Mass Transit Authority electric buses procurement											MOT/Bangkok Mass Transit Authority
8	Public relations project to promote the electric buses usability to reduce air pollution.											Bangkok Metropolitan administration/Municipality
	Strategy 4 New related electric bus business promotion											
9	Soft loan for the electric bus business.											Ministry of Finance
	Strategy 5 Electric vehicle technology research promotion											
10	The optimal battery switching system development for electric buses											National Science and Technology Development Agency (NSTDA)
11	Electric vehicle battery innovation and invention contest project											National Innovation Agency (Public Organization)
	Strategy 6 Human resource development promotion											
12	The course of electric vehicle technology development for vocational certificate and diploma											Offive of the Vocational Education Commission
13	Up-Skill and Re-Skill of electric vehicle production for existing industrial worker											Ministry of Industry/Department of Land Transport
14	Electric vehicle maintenance training											Ministry of Industry/Department of Land Transport
15	Electric vehicle technology development institute											Ministry of Higher Education, Science, Research and Innovation

note : ■ Discontinuous project
■■■■■ Continuous projects

Table 2.3-3 implemented the develop public transportation for electric vehicle technology plan (Continue)

No.	Activity	Urgent plan (1-2 years)		Medium term plan (3-5 years)			Long term plans (6-10 years)					Agency
		A.D.2020	A.D.2021	A.D.2022	A.D.2023	A.D.2024	A.D.2025	A.D.2026	A.D.2027	A.D.2028	A.D.2029	
Second national strategy: "Basic infrastructure development"												
	Strategy 1 : Energy Management											
16	Electric vehicle charger procurement for setting in operator garage	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	Metropolitan Electricity Authority/Provincial Electricity Authority
17	The study of Thailand smart grid operation for public electric vehicle transportation system development	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■						Metropolitan Electricity Authority/ Provincial Electricity Authority /Electricity Generating Authority of Thailand
18	A demonstration project of a V2G			■■■■■	■■■■■	■■■■■						Metropolitan Electricity Authority/Provincial Electricity Authority /Electricity Generating Authority of Thailand
19	Bus terminal/transit area improvement/construction	■■■■■	■■■■■									MOT/Bangkok Metropolitan administration/Municipality
20	The establishment of electric bus real time control system, display, and release time table	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■						Department of Land Transport
Third national strategy: “Standard, law, and regulation preparation”												
	Strategy 1 : Standard and regulation preparation											
21	The preparation of electric vehicle car body and component standard	■■■■■										Department of Land Transport
22	Check list for electric vehicle performance evaluation for electric vehicle registration	■■■■■										Department of Land Transport
23	Integrated plan of related agencies for electric vehicles development	■■■■■	■■■■■	■■■■■								Office of Transport and Traffic Policy and Planning
24	Electric vehicles safety standard and after use battery management	■■■■■	■■■■■									Thai Industrial Standards Institute (TISI)/ Pollution Control Department
25	Determination of domestic public buses life limitation			■■■■■	■■■■■							Department of Land Transport
	Strategy 2: Barge transportation operators and government agencies to use electric buses											
26	Electric bus standard price setting	■■■■■										The Comptroller General's Department
27	The adjustment of electric bus operator selection criteria	■■■■■										Department of Land Transport
28	Buses detection and black smoke emission control	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	Department of Land Transport/ Royal Thai Police

note : ■■■■■ Discontinuous project
■■■■■ Continuous projects

2.4 Province/prototype

The Public Electric Vehicle Transportation Development Plan analysis composes of 1) potential of public transportation system development which is scored base on province and investment potential, and 2) province activities characteristics. After analysis, the selected provinces are Bangkok, Chiangmai, Nakhon-Ratchasima, Ayutthaya, Chonburi, and Phuket. The public Electric Vehicle operation analysis can be described as follow:

2.4.1 Bangkok

2.4.1.1 Pilot route detail and physical characteristic

Pilot route in Bangkok is route no. 137 which is operated by BMTA. Regarding to route no. 137 survey, it passes crucial and important place such as Ramkhamhaeng university and MRT station (Ladprao – Ratchadaphisek – Sutthisan – Thailand Cultural center – Central Rama IX). Route detail and physical characteristic are presented in Figure 2.4.1-2

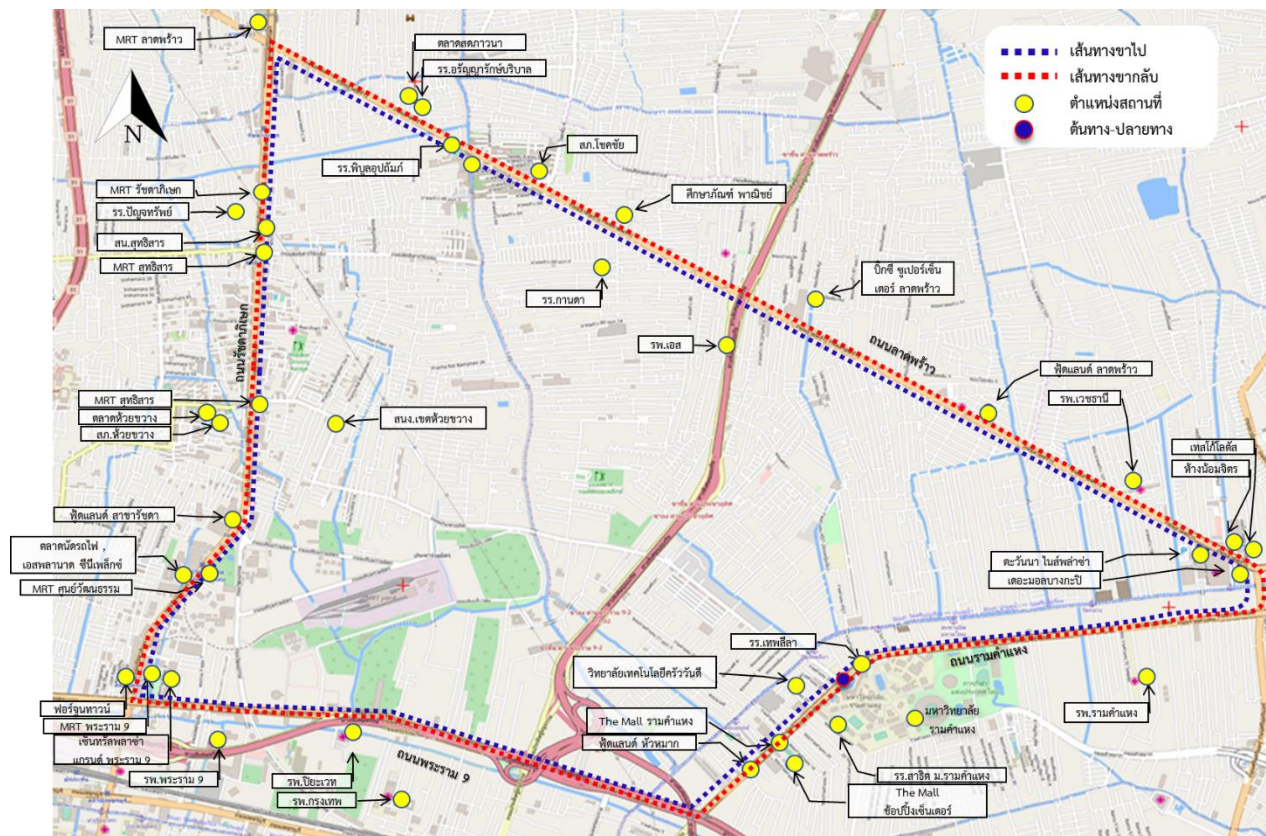
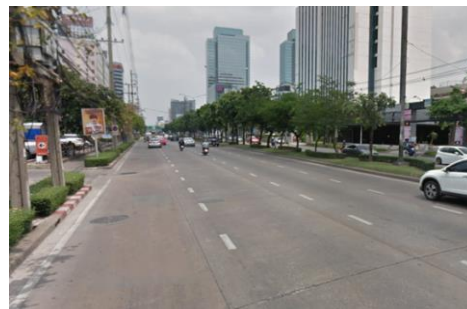


Figure 2.4.1-1 Route no. 137



Ladprao Rd.



Ratchadaphisek Rd.



Rama 9 Rd.



Ramkhamhaeng Rd.

Figure 2.4.1-2 Physical route characteristic

2.4.1.2 Electric Vehicle route management

Route no. 137 transportation survey and analysis and the traffic and urban logistics model forecast are used to specify the Electric Vehicle route management together with 12-meter Electric Vehicle, transport 46 passengers (35 seats and 11 stands) and basic pilot route information. The summary of Electric Vehicle type, amount and timetable detail are presented in Table 2.4.1-1 and Table 2.4.1-2

Table 2.4.1-1 The amount of 12-meter Electric Vehicle for route no. 137 in Bangkok

No.	Province	Year	12-meter Electric Vehicle (buses)
1	Bangkok	2020	28
		2025	40
		2030	40
		2035	40
		2040	40

Table 2.4.1-2 Route no. 137 Electric Vehicle operation timetable in Bangkok

No.	Timetable	2020	2025	2030	2035	2040
1	4.30-6.00 (1.5 hrs.)	9	9	9	9	9
2	6.00-9.00 (3 hrs.)	36	51	51	51	51
3	9.00-16.00 (7 hrs.)	42	42	42	42	42
4	16.00-19.00 (3 hrs.)	36	51	51	51	51
5	19.00-23.00 (4 hrs.)	24	24	24	24	24
Trips		147	177	177	177	177

2.4.1.3 Economic analysis result

The economic feasibility study of Electric Vehicles results show Normal Charge creates the highest economic return in Electric Vehicle operation in Bangkok. The result details are presented in Table 2.4.1-3.

Table 2.4.1-3 Economic analysis of Normal Charge technology in Bangkok

Province	NPV (Million Baht)	EIRR (%)	B/C
Bangkok	7.75	12.83	1.04

2.4.1.4 Financial analysis

The financial analysis of 12-meter Electric Vehicle of route no. 137, which is operated by BMTA, will analyze base on 4 Cases of government financial subsidies / measures as:

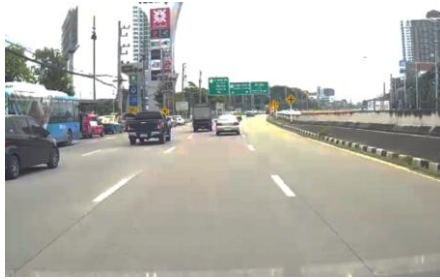
- Case 1 Entrepreneur takes all responsible costs (base Case)
- Case 2 Operation follows the public Electric Vehicle transportation development plan
- Case 3 Corporate and value-added tax exemption
- Case 4 The combination of Case 2 and 3

Table 2.4.1-4 Financial feasibility study of route no. 137 Normal Charge investment in Bangkok

Case	Financial indicators								
	NPV (Million Baht)			FIRR (%)			B/C		
	A	B	C	A	B	C	A	B	C
1	-54.14	-10.65	32.84	6.31	7.65	9.15	0.95	0.99	1.04
2	42.41	85.90	129.39	9.60	11.47	13.67	1.05	1.10	1.16
3	108.34	155.21	202.09	11.15	12.78	14.63	1.12	1.18	1.25
4	205.92	252.79	299.67	15.24	17.59	20.40	1.26	1.34	1.43

Remarks: A: BMTA/private sector invests in charging station 100% and charges the electricity fee follow the policy rate
 B: Government invests in charging station 50% and charges the electricity fee follow the policy rate
 C: Government invests in charging station 100% and charges the electricity fee follow the policy rate

Results in Table 2.4.1-4 present if BMTA invests and takes all costs, does not get any subsidy from the government to change from ICE to Electric Vehicles (Case 1), the financial return will not worth. However, if the government provides all supports follow the Public Electric Vehicle Transportation Development Plan (Case 2), BMTA will get the worthiness to invest although BMTA has to pay all charging stations investment by itself (Case 2A). Furthermore, It suggests that government has to consider and support all charging stations investment together with push forward all projects follow the Public Electric Vehicle Transportation Development Plan (Case 2C) in order to persuade the Electric Vehicle changing decision, create rapid services, and concrete changes.



Road no. 11



Keawnawarat Rd.



Changklan Rd.



Chiangmai – Lamphun Rd.



Mahidol Rd.



Chareonprathet Rd.

Figure 2.4.2-2 Physical route characteristic

2.4.2.2 Electric Vehicle route management

Pilot route transportation survey and analysis and the traffic and urban logistics model forecast are used to specify the Electric Vehicle route management in Chiangmai together with 8-meter Electric Vehicle, maximum transport 23 passengers, and pilot route basic information. The summary of Electric Vehicle type, amount and timetable detail are presented in Table 2.4.2-1 and Table 2.4.2-2

Table 2.4.2-1 The amount of 8-meter Electric Vehicle in Chiangmai

No.	Province	Year	8-meter Electric Vehicle (buses)
1	Chiangmai	2020	6
		2025	6
		2030	10
		2035	10
		2040	10

Table 2.4.2-2 Electric Vehicle operation timetable in Chiangmai

No.	Timetable	2020		2025		2030		2035		2040	
		Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)
1	6.00-9.00 (3 hrs.)	12	12	12	12	18	18	18	18	18	18
2	9.00- 15.00 (6 hrs.)	18	18	18	18	18	18	18	18	18	18
3	15.00- 18.00 (3 hrs.)	12	12	12	12	18	18	18	18	18	18
4	18.00- 21.00 (3 hrs.)	9	9	9	9	9	9	9	9	9	9
Trips		102		102		126		126		126	

2.4.2.3 Economic analysis result

The economic feasibility study of Electric Vehicle results show Normal Charge creates the highest economic return in Electric Vehicle operation in Chiangmai. The result details are presented in Table 2.4.2-3

Table 2.4.2-3 Economic analysis of Normal Charge technology in Chiangmai

Province	NPV (Million Baht)	EIRR (%)	B/C
Chiangmai	5.19	14.36	1.12

2.4.2.4 Financial analysis result

The financial analysis of 8-meter Electric Vehicle of pilot route in Chiangmai will analyze base on 4 Cases of government financial subsidies / measures as:

- Case 1 Entrepreneur takes all responsible costs (base Case)
- Case 2 Operation follows the public Electric Vehicle transportation development plan
- Case 3 Corporate and value-added tax exemption
- Case 4 The combination of Case 2 and 3

Table 2.4.2-4 Financial feasibility study of pilot route Normal Charge investment in Chiangmai

Case	Financial indicators								
	NPV (Million Baht)			Case			NPV (Million Baht)		
	A	B	C	A	B	C	A	B	C
1	2.77	9.26	15.74	8.51	9.81	11.31	1.02	1.05	1.09
2	18.47	24.96	31.45	11.97	13.84	16.09	1.11	1.16	1.21
3	36.25	42.96	49.67	14.1	15.74	17.65	1.23	1.28	1.34
4	51.83	58.53	65.24	18.3	20.69	23.62	1.36	1.42	1.49

Remarks: A: Private sector invests in charging station 100% and charges the electricity fee follow the policy rate

B: Government invests in charging station 50% and charges the electricity fee follow the policy rate

C: Government invests in charging station 100% and charges the electricity fee follow the policy rate

Results in table 2.4.2-4 show if private sector/entrepreneur pays all investment cost including charging station and does not get any subsidies from the government to change from ICE to Electric Vehicles (Case 1), the financial return still worthiness. However, it suggests that government has to consider and support all charging stations investment together with push forward all projects follow the Public Electric Vehicle Transportation Development Plan (Case 2C) in order to persuade the Electric Vehicle changing decision, create rapid services, and concrete changes.

2.4.3 Nakhon-Ratchasima

2.4.3.1 Pilot route detail and physical characteristic

According to survey and analysis, the practical route in Nakhon-Ratchasima is the Orange route which is in line with Traffic Master Plan and Nakhon-Ratchasima Public Transportation Master Plan (OTP, 2017). The pilot route passes the crucial and important place such as Suranari monument, Big C super center, Assumption Nakhon-Ratchasima school, Saint Mary hospital, and the 2nd Nakhon-Ratchasima bus station. Route detail and physical characteristic are presented in Figure 2.4.3-2.

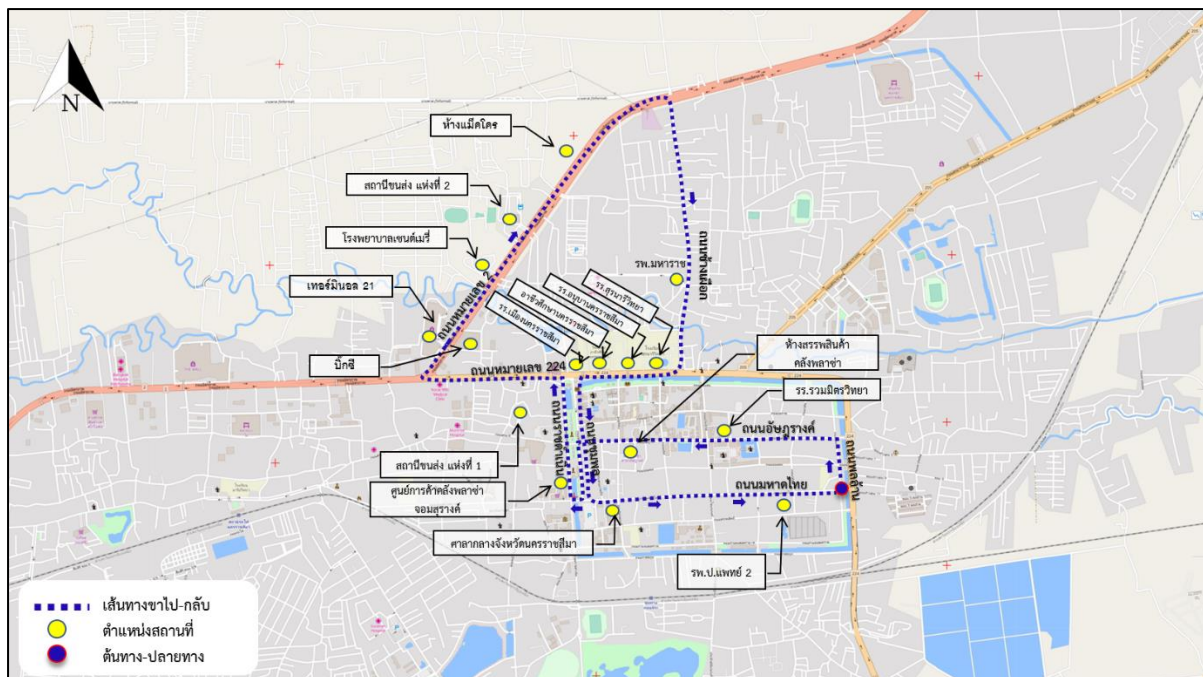


Figure 2.4.3-1 Pilot route in Nakhon-Ratchasima



Polran Rd.



Assadang Rd.



Chumpol Rd.



Ratchadamneon Rd.



Changperk Rd.

Figure 2.4.3-2 Physical route characteristic

2.4.3.2 Electric Vehicle route management

Pilot route transportation survey and analysis and the traffic and urban logistics model forecast are used to specify the Electric Vehicle route management in Nakhon-Ratchasima together with 12-meter Electric Vehicle, maximum transport 46 passengers (35 seats and 11 stands), and pilot route basic information. The summary of Electric Vehicle type, amount and timetable detail are presented in Table 2.4.3-1 and Table 2.4.3-2.

Table 2.4.3-1 The amount of 12-meter Electric Vehicle in Nakhon-Ratchasima

No.	Province	Year	12-meter Electric Vehicle (buses)
1	Nakhon-Ratchasima	2020	5
		2025	5
		2030	5
		2035	7
		2040	7

Table 2.4.3-2 Electric Vehicle operation timetable in Nakhon-Ratchasima

No.	Timetable	2020	2025	2030	2035	2040
		Trips	Trips	Trips	Trips	Trips
1	6.00-9.00 (3 hrs.)	24	24	24	30	30
2	9.00-15.00 (6 hrs.)	36	36	36	36	36
3	15.00-18.00 (3 hrs.)	24	24	24	30	30
4	18.00-21.00 (3 hrs.)	18	18	18	18	18
Trips		102	102	102	114	114

2.4.3.3 Economic analysis result

The economic feasibility study of Electric Vehicles results show the Normal Charge creates the highest economic return in Electric Vehicle operation in Nakhon-Ratchasima. The result details are presented in Table 2.4.3-3

Table 2.4.3-3 Economic analysis of Normal Charge technology in Nakhon-Ratchasima

Province	NPV (Million Baht)	EIRR (%)	B/C
Nakhon-Ratchasima	35.01	26.36	2

2.4.3.4 Financial analysis result

The financial analysis of 12-meter Electric Vehicle of pilot route in Nakhon-Ratchasima. will analyze base on 4 Cases of government financial subsidies / measures as:

- Case 1 Entrepreneur takes all responsible costs (base Case)
- Case 2 Operation follows the public Electric Vehicle transportation development plan
- Case 3 Corporate and value-added tax exemption
- Case 4 The combination of Case 2 and 3

Table 2.4.3-4 Financial feasibility study of pilot route Normal Charge investment in Nakhon-Ratchasima

Case	Financial indicators								
	NPV (Million Baht)			Case			NPV (Million Baht)		
	A	B	C	A	B	C	A	B	C
1	16.72	23.89	31.05	11.54	13.40	15.58	1.10	1.16	1.21
2	31.37	38.54	45.70	15.72	18.35	21.57	1.21	1.28	1.35
3	51.50	59.05	66.60	17.99	20.29	22.98	1.37	1.45	1.54
4	66.25	73.80	81.36	23.10	26.41	30.49	1.53	1.63	1.75

Remarks: A: Private sector invests in charging station 100% and charges the electricity fee follow the policy rate

B: Government invests in charging station 50% and charges the electricity fee follow the policy rate

C: Government invests in charging station 100% and charges the electricity fee follow the policy rate

Results in table 2.4.3-4 show if private sector/entrepreneur pays all investment cost including charging station and does not get any subsidies from the government to change from ICE to Electric Vehicles (Case 1), the financial return still worthiness. However, it suggests that government has to consider and support all charging stations investment together with push forward all projects follow the Public Electric Vehicle Transportation Development Plan (Case 2C) in order to persuade the Electric Vehicle changing decision, create rapid services, and concrete changes.

2.4.4 Ayutthaya

2.4.4.1 Pilot route detail and physical characteristic

According to survey and analysis, the practical route in Ayutthaya are Route 1 (Left loop) and Route 2 (Right loop). Both routes pass the crucial and important place such as Ayutthaya Park Department store, Ratchathani hospital, Ayutthaya commercial technology collage, Ayuttahya Highways District, Ayutthaya railway station, Chaoprom market, Hua-ro market, and Ayutthaya hospital. Route detail and physical characteristic are presented in Figure 2.4.4-2

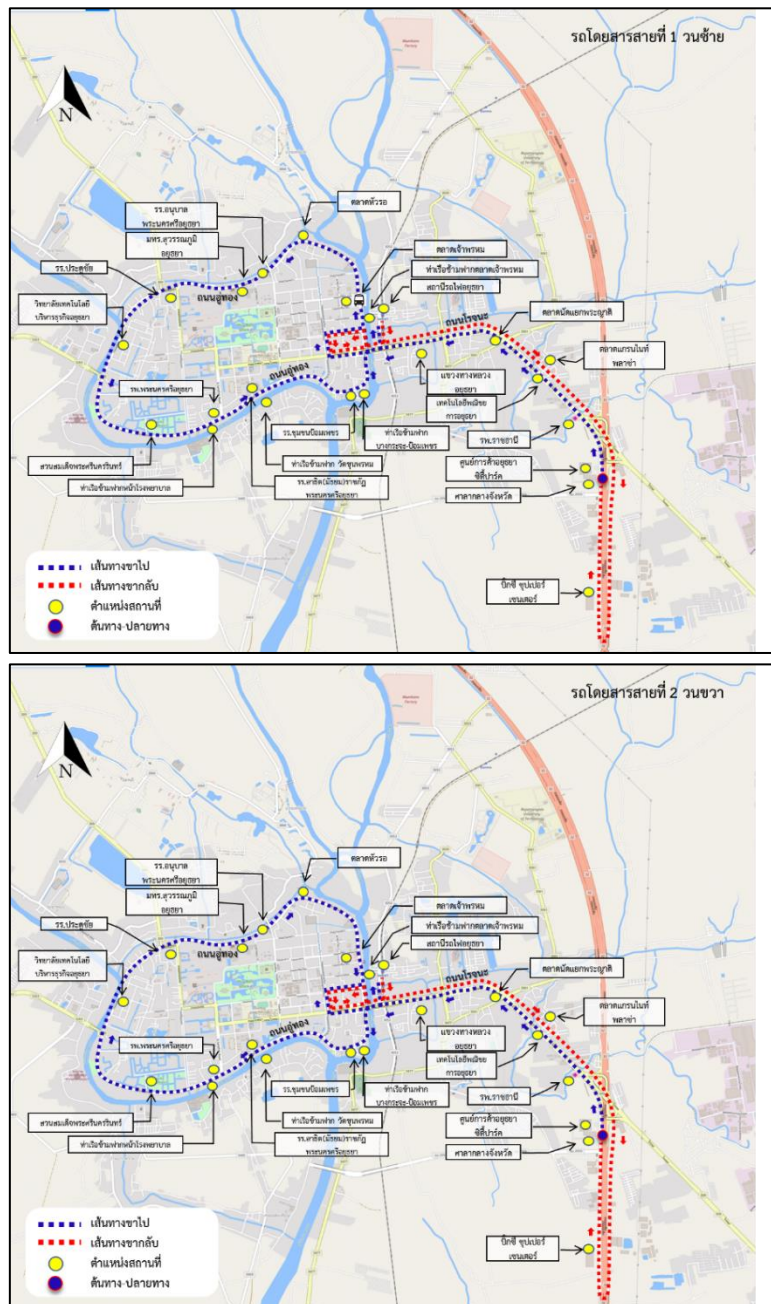


Figure 2.4.4-1 Pilot route in Ayutthaya



Rojana 17+000 Rd.



U-thong Rd. in Rajamangala University of
Technology Suvarnabhumi area



U-thong Rd. in Siriyalai palace area

Figure 2.4.4-2 Physical route characteristic

2.4.4.2 Electricity vehicle route management

Pilot route transportation survey and analysis and the traffic and urban logistics model forecast are used to specify the Electric Vehicle route management in Ayutthaya together with 12-meter Electric Vehicle, maximum transport 46 passengers (35 seats and 11 stands,) and pilot route basic information. The summary of Electric Vehicle type, amount and timetable detail are presented in Table 2.4.4-1 and Table 2.4.4-2.

Table 2.4.4-1 The amount of 12-meter Electric Vehicles in Ayutthaya

No.	Province	Year	12-meter Electric Vehicle (buses)
1	Ayutthaya	2020	10
		2025	14
		2030	16
		2035	18
		2040	24

Table 2.4.4-2 Electric Vehicle operation timetable in Ayutthaya

No.	Time table	2020		2025		2030		2035		2040	
		Trip (Right loop)	Trip (Left loop)	Trip (Right loop)	Trip (Left loop)	Trip (Right loop)	Trip (Left loop)	Trip (Right loop)	Trip (Left loop)	Trip (Right loop)	Trip (Left loop)
1	6.00-9.00 (3 hrs.)	13	13	19	19	21	21	24	24	28	28
2	9.00-15.00 (6 hrs.)	24	24	24	24	24	24	24	24	24	24
3	15.00-18.00 (3 hrs.)	13	13	19	19	21	21	24	24	28	28
4	18.00-21.00 (3 hrs.)	12	12	12	12	12	12	12	12	12	12
Trips		124		148		156		168		184	

2.4.4.3 Economic result analysis

The economic feasibility study of Electric Vehicles results show the Normal Charge creates the highest economic return in Electric Vehicle operation in Ayutthaya. The result details are presented in Table 2.4.4-3.

Table 2.4.4-3 Economic analysis of Normal Charge technology in Ayutthaya

Province	NPV (Million Baht)	EIRR (%)	B/C
Ayutthaya	14.65	15	1.13

2.4.4.4 Financial analysis result

The financial analysis of 12-meter Electric Vehicle of pilot route in Ayutthaya will analyze base on 4 Cases of government financial subsidies / measures as:

- Case 1 Entrepreneur takes all responsible costs (base Case)
- Case 2 Operation follows the public Electric Vehicle transportation development plan
- Case 3 Corporate and value-added tax exemption
- Case 4 The combination of Case 2 and 3

Table 2.4.4-4 Financial feasibility study of pilot route Normal Charge investment in Ayutthaya

Case	Financial indicators								
	NPV (Million Baht)			Case			NPV (Million Baht)		
	A	B	C	A	B	C	A	B	C
1	-69.21	-49.86	-30.51	1.07	2.53	4.27	0.82	0.87	0.91
2	-34.07	-14.71	4.64	3.93	6.02	8.72	0.90	0.96	1.01
3	-18.11	1.84	21.80	6.33	8.19	10.48	0.95	1.02	1.07
4	16.76	36.71	56.66	9.84	12.58	16.23	1.05	1.12	1.20

Remarks: A: Private sector invests in charging station 100% and charges the electricity fee follow the policy rate

B: Government invests in charging station 50% and charges the electricity fee follow the policy rate

C: Government invests in charging station 100% and charges the electricity fee follow the policy rate

Results in Table 2.4.4-4 present if private sector/entrepreneur pays all investment cost including charging station and does not get any subsidies from the government to change from ICE to Electric Vehicles (Case 1), the financial return will not worth. However, if government provides all supports follow the Public Electric Vehicle Transportation Development Plan (Case 2A), private sector/entrepreneur still not worth. Therefore, the private sector/entrepreneur financial return will worthiness when getting the fully government support in charging station investment which is in line with the Public Electric Vehicle Transportation Development Plan (Case 2C) in order to persuade the Electric Vehicle changing decision, create rapid services, and concrete changes

2.4.5 Chonburi

2.4.5.1 Pilot route detail and physical characteristic

According to survey and analysis, the practical route in Chonburi is the route which starts from Amata industrial zone and stop at Chonburi railway station. This route passes the crucial and important place such as Amata industrial zone, Sripatum university, Chonburi sport school, Chonburi transport office, Chonburi Highway District 1, Chonburi Sukkhabot School, Fort Nawamintharachini hospital, and Chonburi railway station. Route detail and physical characteristic are presented in Figure 2.4.5-2.

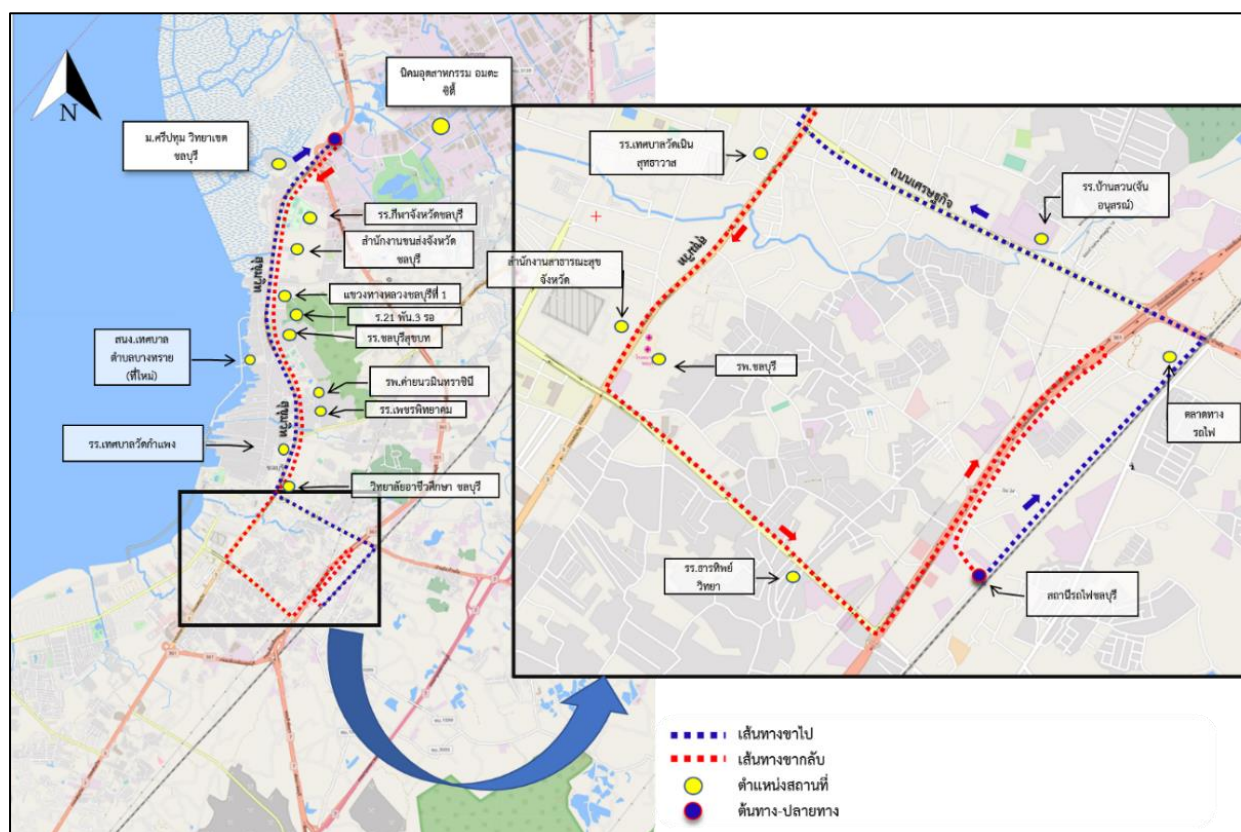


Figure 2.4.5-1 Pilot route in Chonburi



Sukhumvit 88+000 Rd.



Sukhumvit 90+000 Rd.



Sukhumvit 92+000 Rd.



Sukhumvit 95+000 Rd.



Setthakit Rd.

Figure 2.4.5-2 Physical route characteristic

2.4.5.2 Electric Vehicle route management

Pilot route transportation survey and analysis and the traffic and urban logistics model forecast are used to specify the Electric Vehicle route management in Chonburi together with 8-meter Electric Vehicle, maximum transport 23 passengers, and pilot route basic information. The summary of Electric Vehicle type, amount and timetable detail are presented in Table 2.4.5-1 and Table 2.4.5-2

Table 2.4.5-1 The amount of 8-meter Electric Vehicle in Chonburi

No.	Province	Year	8-meter Electric Vehicle (buses)
1	Chonburi	2020	4
		2025	6
		2030	8
		2035	10
		2040	10

Table 2.4.5-2 2 Electric Vehicle operation timetable in Chonburi

No.	Time table	2020		2025		2030		2035		2040	
		Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)
1	6.00-9.00 (3 hrs.)	12	12	18	18	18	18	20	20	20	20
2	9.00-15.00 (6 hrs.)	18	18	18	18	18	18	18	18	18	18
3	15.00-18.00 (3 hrs.)	12	12	12	12	12	12	20	20	20	20
Trips		84		96		96		116		116	

2.4.5.3 Economic analysis result

The economic feasibility study of Electric Vehicles results show the Normal Charge creates the highest economic return in Electric Vehicle operation in Chonburi. The result details are presented in Table 2.4.5-3

Table 2.4.5-3 Economic analysis of Normal Charge technology in Chonburi

Province	NPV (Million Baht)	EIRR (%)	B/C
Chonburi	38.85	45.3	2.43

2.4.5.4 Financial analysis result

The financial analysis of 8-meter Electric Vehicle of pilot route in Chonburi will analyze base on 4 Cases of government financial subsidies / measures as:

- Case 1 Entrepreneur takes all responsible costs (base Case)
- Case 2 Operation follows the public Electric Vehicle transportation development plan
- Case 3 Corporate and value-added tax exemption
- Case 4 The combination of Case 2 and 3

Table 2.4.5-4 Financial feasibility study of pilot route Normal Charge investment in Chonburi

Case	Financial indicators								
	NPV (Million Baht)			Case			NPV (Million Baht)		
	A	B	C	A	B	C	A	B	C
1	-23.42	-17.22	-11.02	0.42	1.87	3.62	0.84	0.88	0.92
2	-9.43	-3.23	2.97	4.28	6.56	9.54	0.93	0.97	1.02
3	-3.03	3.35	9.73	7.10	9.10	11.60	0.98	1.03	1.08
4	10.76	17.14	23.52	11.88	15.01	19.18	1.09	1.15	1.21

Remarks: A: Private sector invests in charging station 100% and charges the electricity fee follow the policy rate

B: Government invests in charging station 50% and charges the electricity fee follow the policy rate

C: Government invests in charging station 100% and charges the electricity fee follow the policy rate

Results in table 2.4.5-4 show if private sector/entrepreneur pays all investment cost including charging station and does not get any subsidies from the government to change from ICE to Electric Vehicles (Case 1), the financial return still worthiness. However, it suggest that government has to consider and support all charging stations investment together with push forward all projects follow the Public Electric Vehicle Transportation Development Plan (Case 2C) in order to persuade the Electric Vehicle changing decision, create rapid services, and concrete changes.



Phangnga Rd.



Ranong Rd. Zone way)



No. 4020 Rd.
0+700



No. 4029 Rd.
2+500



200-year Rat-Uthit (one way)



Thawo-wong Rd. (one way)

Figure 2.4.6-2 Physical route characteristic

2.4.6.2 Electric Vehicle route management

Pilot route transportation survey and analysis and the traffic and urban logistics model forecast are used to specify the Electric Vehicle route management in Phuket together with 12-meter Electric Vehicle, maximum transport 46 passengers (35 seats and 11 stands), and pilot route basic information. The summary of Electric Vehicle type, amount and timetable detail are presented in Table 2.4.6-1 and Table 2.4.6-2

Table 2.4.6-1 The amount of 12-meter Electric Vehicle in Phuket

No.	Province	Year	12-meter Electric Vehicle (buses)
1	Phuket	2020	6
		2025	10
		2030	10
		2035	10
		2040	10

Table 2.4.6-2 Electric Vehicle operation timetable in Phuket

No.	Timetable	2020		2025		2030		2035		2040	
		Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)	Trip (Departure)	Trip (Return)
1	6.00-9.00 (3 hrs.)	6	6	12	12	12	12	12	12	12	12
2	9.00-15.00 (6 hrs.)	12	12	12	12	12	12	12	12	12	12
3	15.00-18.00 (3 hrs.)	6	6	12	12	12	12	12	12	12	12
4	18.00-21.00 (3 hrs.)	2	2	2	2	2	2	2	2	2	2
Trips		52		76		76		76		76	

2.4.6.3 Economics analysis result

The economic feasibility study of Electric Vehicles results show the Normal Charge creates the highest economic return in Electric Vehicle operation in Phuket. The result details are presented in Table 2.4.6-3

Table 2.4.6-3 Economic analysis of Normal Charge technology in Phuket

Province	NPV (Million Baht)	EIRR (%)	B/C
Phuket	12.43	17.07	1.24

2.4.6.4 Financial analysis result

The financial analysis of 12-meter Electric Vehicles of pilot route in Phuket will analyze base on 4 Cases of government financial subsidies / measures as:

- Case 1 Entrepreneur takes all responsible costs (base Case)
- Case 2 Operation follows the public Electric Vehicle transportation development plan
- Case 3 Corporate and value-added tax exemption
- Case 4 The combination of Case 2 and 3

Table 2.4.6-4 Financial study of pilot route Normal Charge investment in Phuket

Case	Financial indicators								
	NPV (Million Baht)			Case			NPV (Million Baht)		
	A	B	C	A	B	C	A	B	C
1	-26.56	-17.85	-9.14	4.51	5.51	6.64	0.88	0.91	0.95
2	-5.13	3.58	12.29	7.2	8.61	10.27	0.97	1.02	1.07
3	7.06	16.19	25.32	8.86	10.09	11.51	1.04	1.09	1.14
4	28.41	37.55	46.68	12.1	13.89	16.06	1.16	1.22	1.3

Remarks: A: Private sector invests in charging station 100% and charges the electricity fee follow the policy rate

B: Government invests in charging station 50% and charges the electricity fee follow the policy rate

C: Government invests in charging station 100% and charges the electricity fee follow the policy rate

Results in table 2.4.6-4 show if private sector/entrepreneur pays all investment cost including charging station and does not get any subsidies from the government to change from ICE to Electric Vehicles (Case 1), the financial return still worthiness. However, it suggests that government has to consider and support all charging stations investment together with push forward all projects follow the Public Electric Vehicle Transportation Development Plan (Case 2C) in order to persuade the Electric Vehicle changing decision, create rapid services, and concrete changes.

2.5 Economic and Financial return Analysis

Regarding Electric Vehicle, economic analysis base on the charging technology comparison - Quick Charge and Normal Charge. The result presents Normal Charge creates better economic return than Quick Charge. The economic analysis results of each province are presented in Table 2.5-1.

Table 2.5-1 Economic and financial return classify by province

Province	Quick Charge			Normal Charge		
	NPV (Million Baht)	EIRR (%)	B/C	NPV (Million Baht)	EIRR (%)	B/C
Bangkok	-12.82	10.37	0.94	7.75	12.83	1.04
Nakhon-Ratchasima	22.34	20.63	1.57	35.01	26.36	2.00
Chiangmai	1.49	12.80	1.04	5.19	14.36	1.12
Ayutthaya	-14.17	10.92	0.88	14.65	15.00	1.13
Chonburi	30.60	35.51	2.06	38.85	45.30	2.43
Phuket	3.14	13.22	1.06	12.43	17.07	1.24

Remark: Evaluation criteria: Economic standards are NPV≥0, EIRR≥12%, and B/C≥1

Results in Table 2.5-1 present changing Internal Combustion Engine to Electric Vehicle creates economic worthiness. In some provinces, electric buses are operated by private sector which mainly concern the financial worthiness. This analysis mainly focuses on entrepreneur financial scheme analysis by setting Normal Charge as the assumption together with government measures follow the Public Electric Vehicle Transportation Development Plan as:

- Investment promotion to battery, automotive part and Electric Vehicles assembly entrepreneurs through Board of Investment (BOI)
- Import tax exemption and battery cell excise tax to battery producers who get the approval from Investment (BOI)
- Fixed electric charging rate for Electric Vehicles
- Charging station investment support to entrepreneurs
- Standard, law, and regulation must be prepared

Financial analysis results of the Public Electric Vehicle Transportation Development Plan are classified into 2 groups as:

Group 1 : High potential is the provincial group which has potential to change the existing vehicle (Internal Combustion Engine: ICE) to Electric Vehicle by getting some government support such as investment promotion on automotive part and electric buses assembly, and battery cell tax exemption through the Board of Investment, fixed electric charging rate, and the preparation of standard, law, and regulation. The analysis results are presented in Table 2.5-2

Table 2.5-2 High potential group financial analysis result

Province	<u>Do not follow</u> the Public Electric Vehicle Transportation Development Plan			<u>Follow</u> the Public Electric Vehicle Transportation Development Plan		
	NPV (Mil. Baht)	FIRR (%)	B/C	NPV (Mil. Baht)	FIRR (%)	B/C
Bangkok*	-54.14	6.31	0.95	42.41	9.60	1.05
Nakhon-Ratchasima *	16.72	11.54	1.10	31.37	15.72	1.21
Chiangmai*	2.77	8.51	1.02	18.47	11.97	1.11

Remark *: BMTA/private sector invests in charging station 100% and charges the electricity fee follow the policy rate

Group 2: Basic potential is the provincial group which has only basic potential to change the existing vehicle to Electric Vehicle by getting fully support from the government follow the Public Electric Vehicle Transportation Development Plan. Moreover, the government has to subsidize charging station investment in order to create financial worthiness. The analysis results are presented in Table 2.5-3

Table 2.5-3 Basic potential group financial analysis result

Province	<u>Do not follow</u> the Public Electric Vehicle Transportation Development Plan			<u>Follow</u> the Public Electric Vehicle Transportation Development Plan		
	NPV (Mil. Baht)	FIRR (%)	B/C	NPV (Mil. Baht)	FIRR (%)	B/C
Ayutthaya***	-69.21	1.07	0.82	4.64	8.72	1.01
Chonburi***	-23.42	0.42	0.84	2.97	9.54	1.02
Phuket**	-26.56	4.51	0.88	3.58	8.61	1.02

Remarks: **: Government invests in charging station 50% and charges the electricity fee follow the policy rate

***: Government invests in charging station 100% and charges the electricity fee follow the policy rate

2.6 Conclusion and recommendation

The important factor of the study result which has changing from Internal Combustion Engine (ICE) to Electric Vehicle/bus is the clarity and continuous government policy. The first stage of transition, the Public Electric Vehicle Transportation Development Plan enforcement focuses on solving 3 main Electric Vehicle obstacles are 1) Electric Vehicle parts and cost, 2) Basic infrastructure for Electric Vehicle system, and 3) Standard, laws, and regulations which are related with Electric Vehicle operation. The plan composes of 3 strategies, 10 action plans, and 28 projects.

After plan had implemented and applied in 6 pilot provinces, it shows economic worthiness because Electric Vehicle technology has more energy and environment advantage than Internal Combustion Engine. However, Electric Vehicle technology has disadvantage of high initial cost, almost 2 times, therefore entrepreneurs do not interest to invest in Electric Vehicle technology and cause the stagnation.

The government has to step in stagnation problem by working on supporting measures follow the Public Electric Vehicle Transportation Development Plan. The main points of the plan are:

- Investment promotion to battery, automotive part and Electric Vehicles assembly entrepreneurs through Board of Investment (BOI)
- Import tax exemption and battery cell excise tax to battery producers who get the approval from Investment (BOI)
- Fixed electric charging rate for Electric Vehicles
- Charging station investment support to entrepreneurs
- Standard, law, and regulation must be prepared

Financial analysis results of the Public Electric Vehicle Transportation Development Plan are classified into 2 groups as:

Group 1 : High potential is the provincial group which has potential to change the existing vehicle (ICE) to Electric Vehicle by getting some government support such as investment promotion on automotive part and electric buses assembly, and battery cell tax exemption through the Board of Investment, fixed electric charging rate, and the preparation of standard, law, and regulation.

Group 2: Basic potential is the provincial group which has only basic potential to change the existing vehicle to Electric Vehicle by getting fully support from the government follow the Public Electric Vehicle Transportation Development Plan. Moreover, the government has to subsidize charging station investment in order to create financial worthiness. The results of charging station subsidy analysis are presented in Table 2.6-1

Table 2.6-1 Financial analysis: Government subsidizes charging stations investment

Province	Financial indicators								
	NPV (Mil. Baht)			FIRR (%)			B/C		
	A	B	C	A	B	C	A	B	C
Financial analysis: High potential provincial group									
Bangkok	42.41	85.90	129.39	9.60	11.47	13.67	1.05	1.10	1.16
Nakhon-Ratchasima	31.37	38.54	45.70	15.72	18.35	21.57	1.21	1.28	1.35
Chiangmai	18.47	24.96	31.45	11.97	13.84	16.09	1.11	1.16	1.21
Financial analysis: Basic potential provincial group									
Ayutthaya	-34.07	-14.71	4.64	3.93	6.02	8.72	0.90	0.96	1.01
Chonburi	-9.43	-3.23	2.97	4.28	6.56	9.54	0.93	0.97	1.02
Phuket	-5.13	3.58	12.29	7.2	8.61	10.27	0.97	1.02	1.07

Remarks: A: BMTA/private sector invests in charging station 100% and charges the electricity fee follow the policy rate

B: Government invests in charging station 50% and charges the electricity fee follow the policy rate

C: Government invests in charging station 100% and charges the electricity fee follow the policy rate

According to above analysis, besides investment promotion in automotive parts and electric buses assemble and battery cell import tax exemption through Board of Investment committee, fixed electric charging rate for Electric Vehicle, and the preparation of standard, law, and regulation which are main government measures, government needs to support charging station investment which is one of the crucial conditions to expand Electric Vehicle promotion throughout the region and country. If government does not support charging station, only some high potential province/entrepreneur can operate Electric Vehicles and get financial worthiness. Therefore, if government wants to promote Electric Vehicles throughout the region and country, it is necessary to push forward the charging station investment for entrepreneur policy because it is the fundamental factor for Electric Vehicle concrete driving.

Enhancing Electric Vehicle in public transportation is necessary to get government subsidy. The government may assign government agency, Bangkok Mass Transit Authority (BMTA), to operate Electric Vehicle in their own route in order to stimulate Electric Vehicle production industries and businesses and related industries.

Regarding to the infrastructure readiness and Electric Vehicle assembly in Thailand, Bangkok is the most appropriate to be pilot province which corresponding with the pollution reduction policy by using Electric Vehicle. Currently, BMTA reviews the rehabilitation plan (23rd April 2020 revision) by purchasing/leasing Electric Vehicle 2,511 buses for public service.

The economic assessment of purchasing/leasing Electric Vehicle 2,511 buses to replace the existing ICE results show NPV = 8,894 Million Baht, EIRR = 22.62, and B/C = 1.55. It means investment in purchasing/leasing Electric Vehicle 2,511 buses create more social benefit than cost. Therefore, it appropriates to invest in Electric Vehicles 2,511 buses.

The financial assessment of purchasing/leasing Electric Vehicles 2,511 buses to replace the existing ICE results show BMTA will get benefit from purchasing/leasing Electric Vehicle by getting NPV = 3,076 Million Baht, FIRR = 9.77, and B/C = 1.05 follow the assumption of government all invest in charging stations and charge the electricity fee follow policy rate.

Moreover, Electric Vehicle promotion will stimulate automotive sector to learn and start automotive production process and Electric Vehicle assembly efficiently. The mentioned investment will stimulate economy and generate domestic employment in automotive and related industries, and generate additional government tax revenue.

According to Input – output analysis, the value from Electric Vehicle 2,511 buses investment is 26,504 Million Baht. The value will distribute to many channels - direct and indirect - such as employment generation, production expansion for automotive and related industries. Employment increasing will benefit for government tax collection especially income tax, consumption tax, production factor tax, and business profit tax which is expected to 5,276 Million Baht. Moreover, it will create employment value around 1,232.11 Million Baht from 2,461 jobs increasing.

Project recommendation

- 1) Public electric bus route operation encouragement has to consider the existing public vehicle operator. Moreover, it is necessary to explain the worthiness from changing ICE to electric vehicle especially the financial return from electric vehicle long term investment to the entrepreneur. However, the operator/entrepreneur will face high investment cost in the first stage of investment which may not attract operator/entrepreneur investment. Therefore, the government should support soft loan for electric vehicle business operation.
- 2) Encouragement public electric vehicle transportation development plan to create practical electric vehicle operation. Although Bangkok Mass Transit Authority (BMTA) and the

Transport co. ltd. promptly operates electric buses but both agencies have to research on the electric buses operation route feasibility study by considering number of electric buses, distance, charging technology, and operation timetable framework.

3) In review Bangkok Mass Transit Authority (BMTA) rehabilitation plan should specify public electric buses operation especially domestic electric bus assembly 2,511 buses (26,504 million Baht) in order to stimulate electric bus production and related industry. Domestic electric bus investment and electric bus cell battery and motor import reduction will create a lot of benefits such as creating new 4,095 positions, 2,050 million Baht from employment, government tax income 7,234 million Baht, and reduce 25 percent electric bus import value. Moreover, it will expand electric bus and related industry production both direct and indirect.



Abbreviations

Agency	Contraction
Ministry of Transport	MOT
Board of Investment	BOI
Bangkok Mass Transit Authority	BMTA
Office of Transport and Traffic Policy and Planning	OTP
Energy Regulatory Commission	ERC
Department of Industrial Promotion	DIP
National Science and Technology Development Agency	NSTDA
Ministry of Finance	MOF
National Innovation Agency	NIA
Vocational Education Commission	VEC
Ministry of Industry	M-Industry
Department of Land Transport	DLT
Ministry of Higher Education, Science, Research and Innovation	MHESI
Department of Alternative Energy Development and Efficiency	DEDE
Office of the National Economics and Social Development Council	NESDB
Metropolitan Electricity Authority	MEA
Provincial Electricity Authority	PEA
Electricity Generating Authority of Thailand	EGAT
Bangkok Metropolitan Administration	BMA
Thai Industrial Standards Institute	TISI
Pollution Control Department	PCD
The Comptroller General's Department	CGD
Royal Thai Police	-
Provincial Administrative Organizations	-
Municipality	-

