

The Project on Study and Development of Marginal Abatement Cost (MAC) Tool in Greenhouse Gas Emission Reduction under Measures and Policies on Energy Efficient Transport

Executive Summary Report



Presented by



Naresuan University



Thammasat University



PSK Consultants Co., Ltd.



March 2019

Preface

Today, there is greater global awareness of the impacts of climate change, triggered by an increase in greenhouse gas (GHG) emissions resulting primarily from burning. In Thailand, GHG emissions in the transport sector have become a major concern and deserve serious attention. From Thai economic growth forecast for the next two decades (or by 2030), the transport sector energy consumption and GHG emissions will steadily follow a worrisome upward trend.

The cabinet resolution on November 25, 2014 approved an intention of Thailand's Nationally Appropriate Mitigation Actions (NAMAs) based on a voluntary basis to reduce GHG emissions in the range of 7-20% below the business-as-usual (BAU), in energy and transport sector in 2020, since Thailand is a member of the United Nations Framework Convention on Climate Change (UNFCCC). Therefore; the achievement depends on performance of GHG emission reduction in the sectors. The Nationally Appropriate Mitigation Actions (NAMAs) focuses on the operation of sector's GHG emission reduction through various measures such as power generation from renewable energy, biofuel use, sustainable transport measures, creating database on GHG emission in national, local and branch levels, development of Measurement, Reporting and Verification (MRV) system, as well as development of finance and market mechanism to support the GHG emission reduction, adaptation plan, development of related database and knowledge, etc.

This "Executive Summary" is derived from the "Study and Development of Marginal Abatement Cost (MAC) Tool in GHG Emission Under Measures and Policies on Energy Efficient Transport". To ensure tangible results of the implementation of sustainable transport and the elimination of problems in the transport sector energy consumption and GHG emission, the Office of Transport and Traffic Policy and planning (OTP) under Ministry of Transport has developed a Marginal Abatement Cost (MAC) Tool in GHG Emission Under Measures and Policies on Energy Efficient Transport which is necessary and important at the early stage in knowing the marginal abatement cost (MAC) of GHG emission reduction (baht per ton of carbon dioxide equivalent) as an indicator to achieve goals of the 12th National Economic and Social Development Plan in the 4th strategy, environmental friendly development for sustainable development, the 4th goal – increasing efficiency of GHG reduction and enhancement of capacity for climate change adaptation and the 7th strategy infrastructure and logistics development.

This report is prepared to propose outcomes of the study and development of Marginal Abatement Cost (MAC) tool in GHG emission under measures and policies on energy efficient transport, whereby the results of the project could be achieved as expected, as well as to propose the analysis method in details and recommendations from the project, so as to be a guideline for the concerned agencies in decision and planning of projects relevant to reductions of energy consumption and GHG emission in the transport sector under the goal of GHG emission reduction in Thailand.

The OTP hopes indeed that the results of this study could help to promote sustainable transport system development in conformity with the Energy Efficiency Plan 2015 - 2036 and the 12th National Economic and Social Development Plan and enable Thailand to have in place information for analyzing and evaluating a guideline on preparedness for the policy on reduction of transport sector energy consumption and GHG emission for the optimum efficiency.

Office of Transport and Traffic Policy and Planning (OTP)
March 2562

Abstract

Prime Minister General Prayut Chan-o-cha has given importance to the climate change issue. At the 21st session of the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change, held on November 30, 2015 in Paris, France, the Prime Minister stated that Thailand intends to reduce its greenhouse gas (GHG) emissions by 20% from the projected business-as-usual (BAU) level by the year 2030 and the level of contribution could increase up to 25% subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support through a balanced and ambitious global agreement under the United Nations Framework Convention on Climate Change (UNFCCC). As such, both the public sector and the private agencies in the country have played a part in the endeavors to lower GHG emissions by 2030. At the same time, the transport sector has had a crucial role in enabling the country to achieve the GHG reduction goal by implementing the policy on energy efficiency in the transport sector and the user-friendly sustainable transportation.

The Ministry of Transport has therefore assigned the Office of Transport and Traffic Policy and Planning (OTP) to conduct a study on development of Marginal Abatement Cost (MAC) tool in GHG emission reduction under measures and policies on energy efficient transport in order to provide the government sector with a clear information for making decisions and planning on the policy on energy consumption and GHG emission reduction in the transport sector.

There are three main goals of the project implementation, i.e. 1) to study and develop the Marginal Abatement Cost (MAC) tool in GHG emission reduction under measures and policies on energy efficient transport of Thailand, 2) to analyze marginal abatement costs of GHG emission reduction (baht per ton of carbon dioxide equivalent) for the transport sector's projects and plans, and 3) to formulate Transport Sector's NDC Action Plan 2021 - 2030 in order to reduce the GHG emission and prepare Transport Sector's NDC Roadmap 2021 - 2030 to reduce the emission according to goals of Nationally Determined Contribution (NDC) from 20% - 25% by 2030.

It has been found from the project results that, as the evaluation of GHG reduction potentials using Sustainable Transport System of "Avoid-Shift-Improve (A-S-I)" of the projects and plans in transport sector, the transport sector has total potentials to reduce GHG emission of 35.42 MtCO_{2e} from the determined target of transport sector of 31 MtCO_{2e} and as the marginal abatement cost evaluation, it is found that New Railway projects have the highest potential for GHG reduction at -302,808 baht per tCO_{2e} followed by mass transit electric train and suburban train projects, dual-track railways and improvement of public transport system connectivity through Non-Motorized Transport (NMT) which are the shift mode project and are in the Strategic Operation Plan of Ministry of Transport 2017 - 2020. These projects have the MAC values between -45,000 to -138,000 Baht/tCO_{2e}. A negative value of the project means that a benefit of project implementation is higher than a cost; on the other hand, a positive value means that the project has low benefit.

As a consequence of the "Project on Study and Development of Marginal Abatement Cost (MAC) Tool in GHG Emission Reduction Under Measures and Policies on Energy Efficient Transport", we have produced the "Handbook and Program for analyzing Marginal Abatement Cost Curve (MACC) of GHG emission reduction" so that the concerned officials not only could understand the approach and method for evaluating the MAC, but also could efficiently use the MAC tool and plan for properly outlining a policy and guideline on GHG emission reduction and setting the emission reduction target.

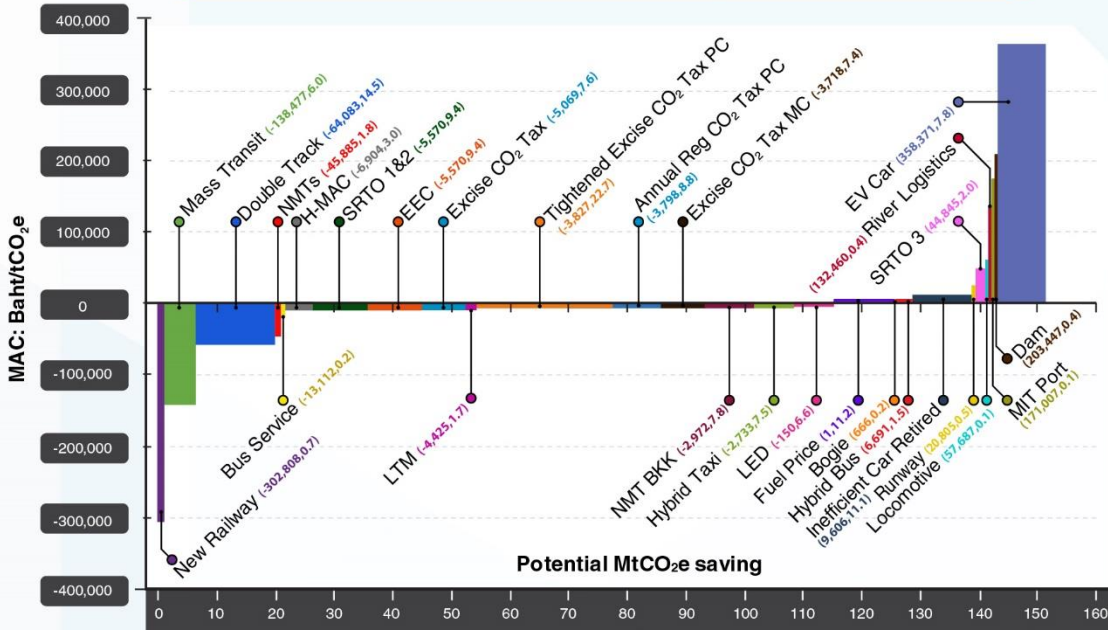
TABLE OF CONTENT

	Page
Outputs & Results and Discussion of the Project	1
Chapter 1 Introduction	13
Chapter 2 Literature review	18
Chapter 3 The selection of the transport sector's projects and plans related to and having the potentials to reduce the GHG emissions	19
Chapter 4 Data collection and mode shift survey	22
Chapter 5 The evaluation of GHG emission reduction for transport sector's projects and plans	29
Chapter 6 Project efficiency evaluation on GHG emission reduction, and economic, social and environmental impact analysis	46
Chapter 7 Comparison of Economic, Social and Environmental Impacts	62
Chapter 8 Marginal Abatement Cost (MAC) Analysis of GHG emission reduction for transport sector's projects and plans	65
Chapter 9 The formulation of action plan for transport sector	88
Chapter 10 Marginal Abatement Cost (MAC) tool for GHG emission reduction under measures and policies on energy efficient transport	151
Results and Discussion	154
Summary	156
Expected Benefits	156
Suggestions	157

Outputs of the Project

1 Marginal Abatement Cost (MAC)

MAC Curve for Transport Sector Mitigation Options



Marginal Abatement Cost (MAC) (baht per ton of carbon dioxide equivalent) is one of the indicators for GHG reduction efficiency evaluation under the 12th National Economic and Social Development Plan, B.E. 2560 – 2564 (2017 – 2021) in the 4th strategy, environmental friendly development for sustainable development. Consequently, it is an important variable for GHG reduction operations. The Marginal Abatement Cost Curve (MACC) is developed based on Excel-based spreadsheet to process and rank value for investment in plans and projects relevant to GHG reduction in a graph form. The MACC is an effective tool in prioritizing the potentials and significant projects by considering the lowest value for investment in Baht/tCO₂e.

Legend:

A Avoid/Reduce

TDM

Development of Travel Demand Management (TDM) Mechanism

TOD

Development of areas surrounding public transport stations (Transit Oriented Development, TOD)

S Shift/Maintain

Double Track

Construction of dual track railways for 32 lines

Mass Transit

Construction of mass transit electric train systems and suburb train systems for 20 lines (including extensions)

New Railway

New railway construction for 14 lines

EEC

High-speed train + EEC railways for 4 lines

SRT0 1 & 2

Development of Single Rail Transfer Operator (SRT0) at Laem Chabang port, Phase 1 and 2

SRT0 3

Development of Single Rail Transfer Operator (SRT0) at Laem Chabang Port, Phase 3

DAM

Construction of Chao Praya and Nan river dams for water transport operation

River Logistics

Enhancement of goods transport system via Pasak river

Ferry

Ferry development linking upper gulf of Thailand

MIT Port

Maptaphut Industrial Terminal Development, Phase 3

NMT BKK

Promoting walking and bicycle uses to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and vicinity

NMTs

Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla

Bus Service

Improvement of urban and outskirt public service via hybrid passenger vehicles

I Improve

Tightened Excise CO₂ Tax PC

Excise tax rate adjustment according to CO₂ emission (reflecting direct fuel consumption rate) for new cars

Excise CO₂ Tax MC

Excise tax rate adjustment according to CO₂ emission quantity (reflecting direct fuel consumption rate) for new motorcycle

Annual Reg CO₂ Tax PC

Annual car tax rate adjustment according to CO₂ emission quantity (reflecting direct fuel consumption rate)

EV Car

Expansion of Electric vehicles (EV)

EV Bus

Procurement of 35 electric buses including electric charging station construction

Hybrid Bus

Procurement of 1,453 hybrid buses / Hybrid public bus rent (7 years) for 400 buses

Bogie

8 & 12 power bogie modification (61-64)

Locomotive

Provision of diesel electric locomotives to replace 50 GE diesel electric locomotives (2018-2021)

Runway

Runway constructions, line 3 and 4 of Suvarnabhumi Airport

LTM

Promotion of Logistics and Transport Management (LTM) for energy-saving

Excise CO₂ Tax

Excise tax rate adjustment according to CO₂ emission (reflecting direct fuel consumption rate) for private cars based on strict tax measure

Inefficient Car Retired

Promote disposal of deteriorated vehicles (old vehicles) from the system (more than 15 years of service or exceeding 200,000 km)

H-MAC

Improvement of air conditioning systems (H-MAC) in cars

Fuel Price

Use of fuel mechanism to push forward use of effective vehicles

EV Minibus

Replace air-conditioned passenger vans with 4,626 electric minibuses

Hybrid Taxi

Promoting use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla

Delivery MC

Replace delivery motorcycles with electric motorcycles in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla

Backhauling

Backhaul Management

DC

Establish Distribution Center (DC)

LTM Center

Establish training center to train for energy-saving driving in 5 regions nationwide

TMS

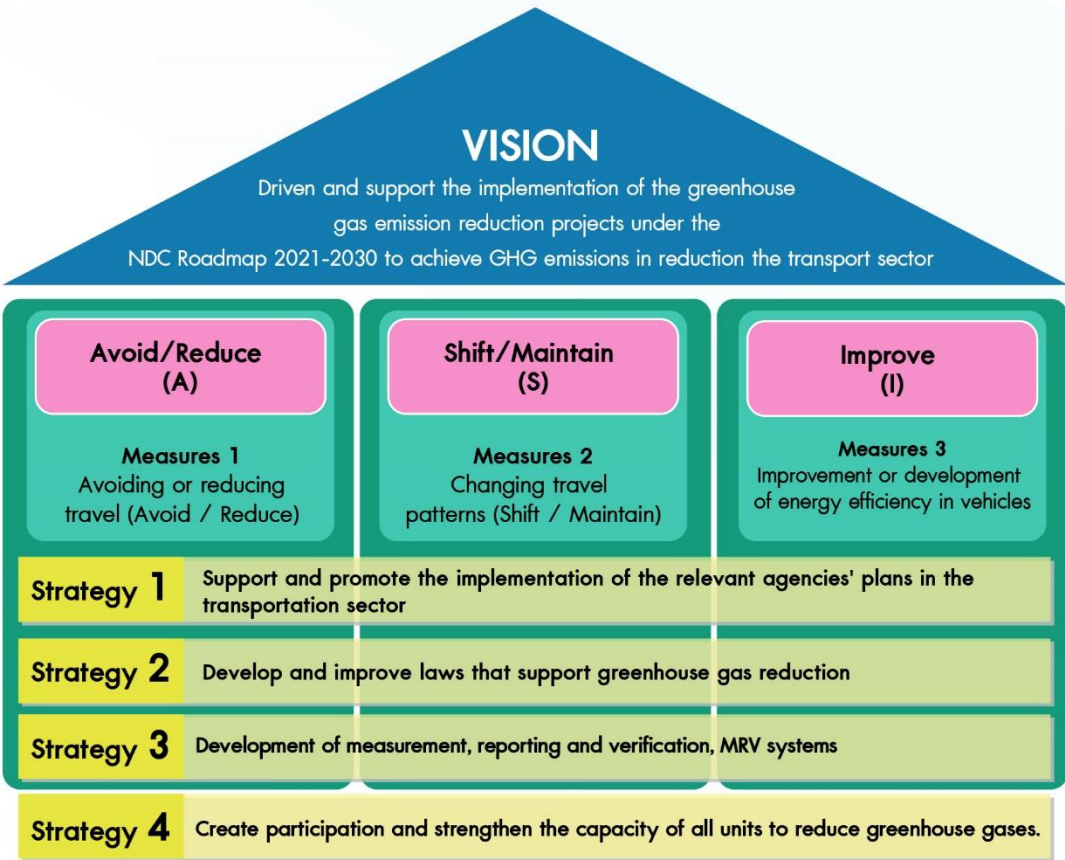
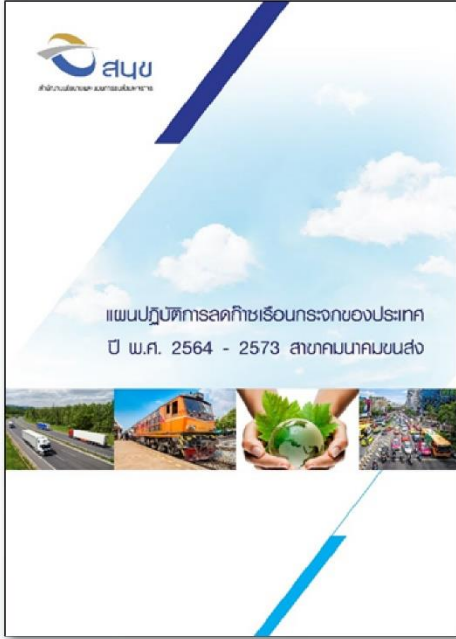
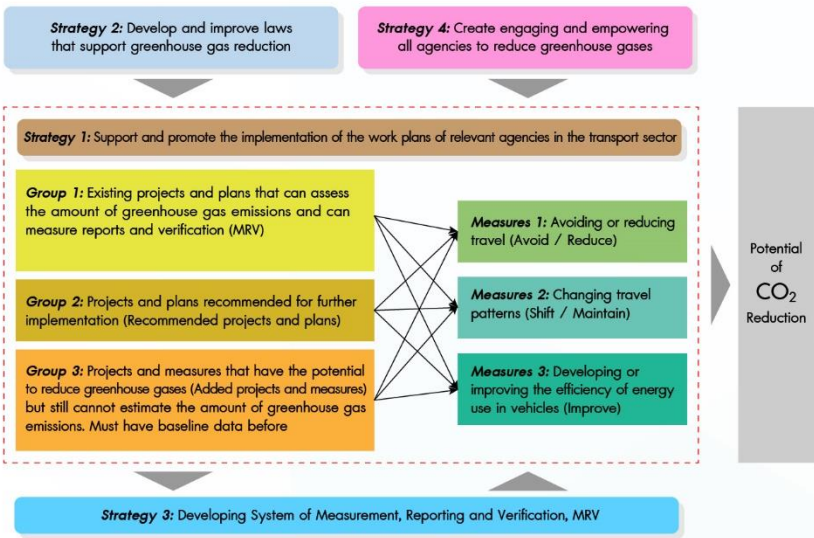
Development of Transportation Management System (TMS)

LED

Change of LED light bulbs in all ports/airports/highways

3 Transport Sector's NDC Action Plan 2021 – 2030 and Transport Sector's NDC Roadmap 2021 – 2030

Transport Sector's NDC Action Plan 2021 – 2030



Transport Sector's NDC Roadmap 2021 – 2030

Nationally Appropriate Mitigation Actions (NAMAs) 7-20 % from BAU by 2020

Intended Nationally Determined Contribution (NDC) 20-25 % from BAU, October 1, 2015

Paris Agreement entered into force November 4, 2016

Thailand formulated NDC Roadmap 2021-2030

Formulated Transport Sector's NDC Action Plan

End of NAMAs

Transport Sector's NDC Roadmap 2021-2030 and Transport Sector's NDC Action Plan 2021-2030 Start

NDC pledge of 20-25 % GHG emission reduction from BAU achieved

2014

2015

2016

2017

2018

2020

2021

2030

Project grouping by A-S-I Approach

A-S-I Approach

Avoid/Reduce (A)

Measures 1: Avoiding or reducing travel (Avoid / Reduce)

Shift/Maintain (S)

Measures 2: Changing travel patterns (Shift / Maintain)

Improve (I)

Measures 3: Developing or improving the efficiency of energy use in vehicles (Improve)

Locomotive & Bogie



LTM & Backhauling



Dam & River Logistics



Runway



Bus Service



2561

2563

2564

2565

2566

2567

2568

2569

2573

Rail Based Infrastructure



Public Bus



EV Car



Excise CO₂ Tax PC & MC

H - MAC



SRT0 1 & 2



Ferry



LED



Excise CO₂ Tax



DC & TMS



NMT BKK NMTs



MIT Port



TOD



TDM



SRTO 3



Hybrid Taxi



Inefficient Car Retired

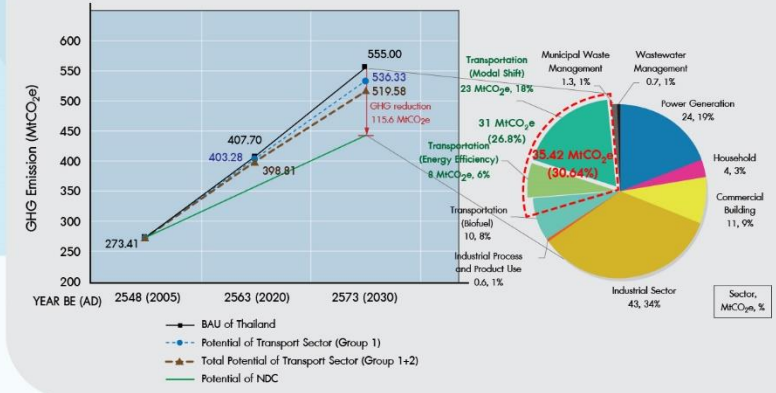


Delivery Motorcycle



EV Minibus

Transport Sector's NDC Action Plan



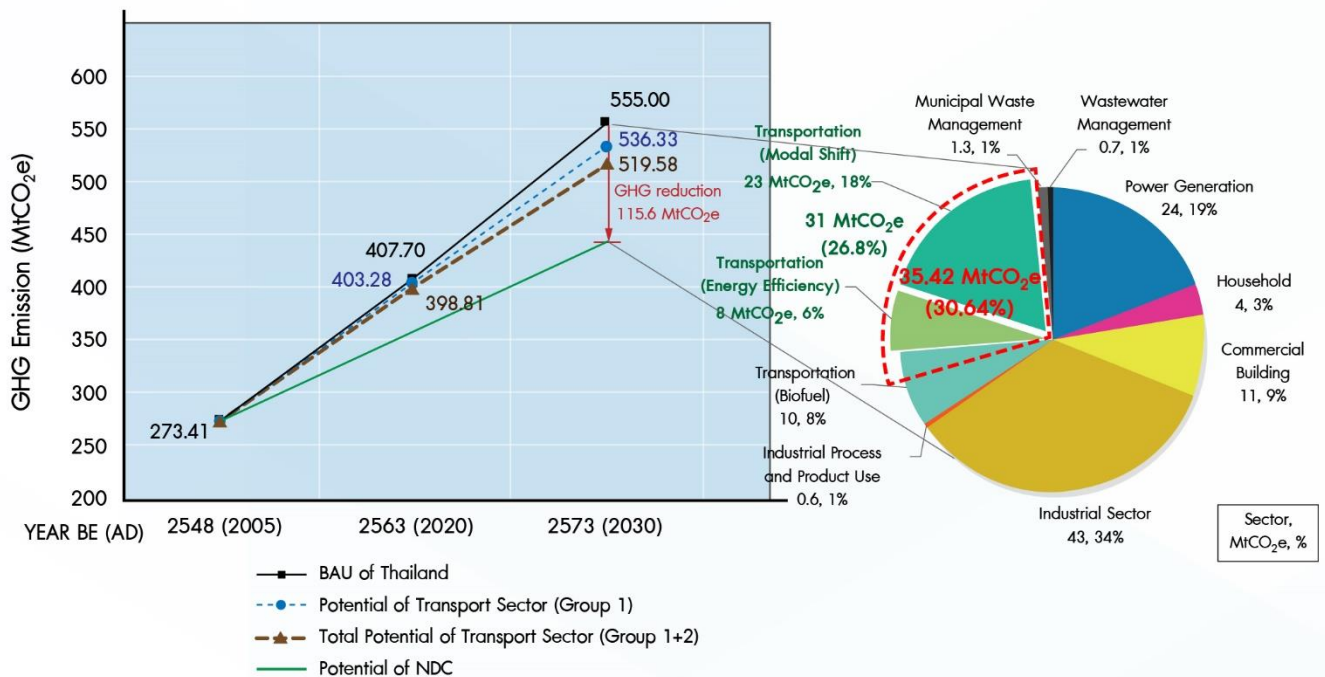
Transport Sector's NDC Roadmap 2021 - 2030 to achieve 31 MtCO₂e in 2030

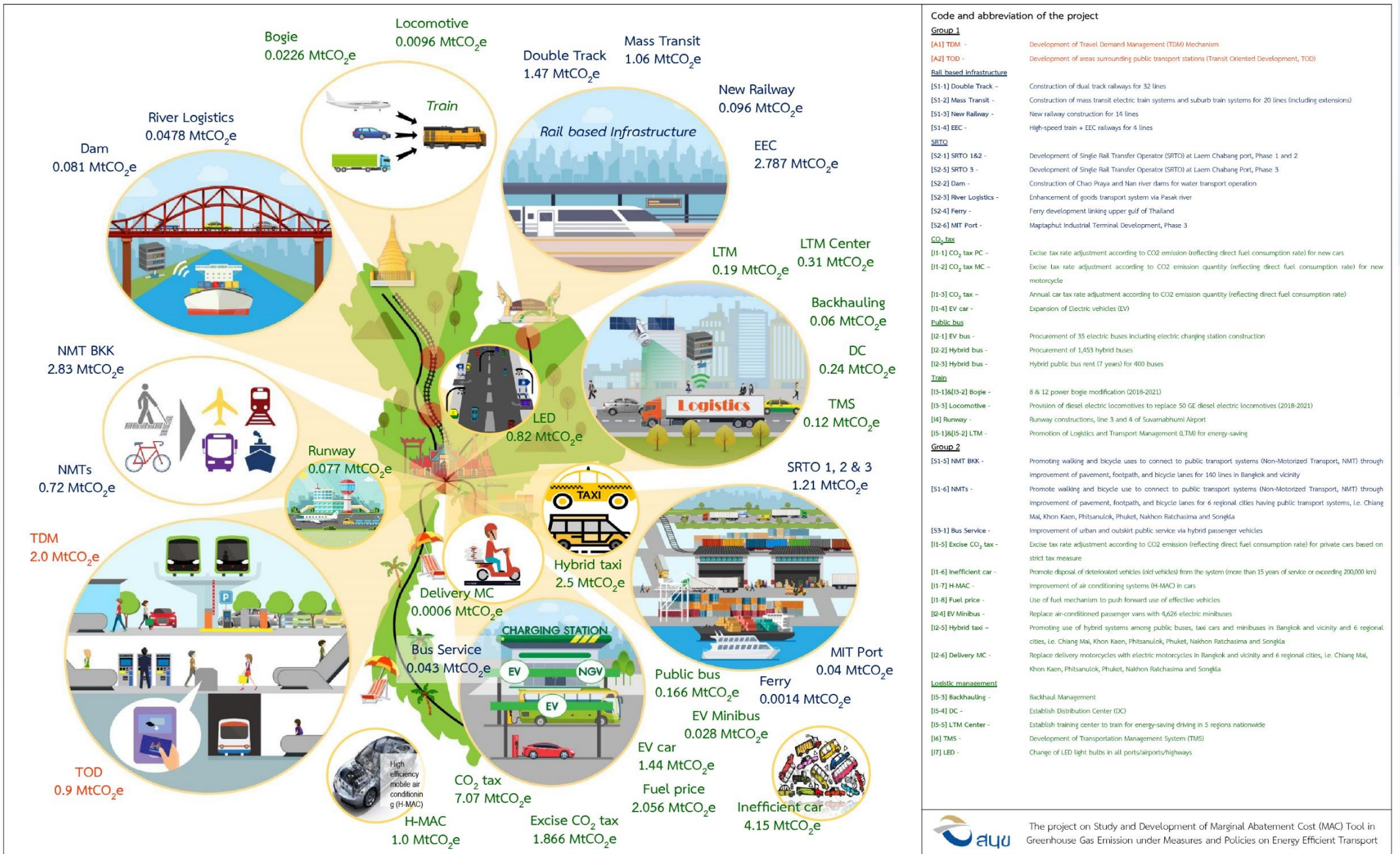
TDM = Development of Travel Demand Management (TDM) Mechanism | **TOD** = Development of areas surrounding public transport stations (Transit Oriented Development, TOD) | **Double Track** = Construction of dual track railways for 32 lines | **Mass Transit** = Construction of mass transit electric train systems for 20 lines (including extensions) | **New Railway** = New railway construction for 14 lines | **EEC** = High-speed train + EEC railways for 4 lines | **SRT0 1 & 2** = Development of Single Rail Transfer Operator (SRT0) at Laem Chabang port, Phase 1 and 2 | **SRT0 3** = Development of Single Rail Transfer Operator (SRT0) at Laem Chabang Port, Phase 3 | **DAM** = Construction of Chao Praya and Nan river dams for water transport operation | **River Logistics** = Enhancement of goods transport system via Pasak river | **Ferry** = Ferry development linking upper gulf of Thailand | **MIT Port** = Maiphatulok Industrial Terminal Development, Phase 3 | **NMT BKK** = Promoting walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpaths, and bicycle lanes for 140 lines in Bangkok and vicinity | **NMTs** = Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpaths, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla | **Bus Service** = Improvement of urban and outskirts public service via hybrid passenger vehicular Tightened Excise CO₂ Tax PC = Excise tax rate adjustment according to CO₂ emission (reflecting direct fuel consumption rate) for new cars | **Excise CO₂ Tax MC** = Excise tax rate adjustment according to CO₂ emission quantity (reflecting direct fuel consumption rate) for new motorcycle | **Annual Reg CO₂ Tax PC** = Annual car tax rate adjustment according to CO₂ emission quantity (reflecting direct fuel consumption rate) | **EV Car** = Expansion of Electric vehicles (EV) | **EV Bus** = Procurement of 35 electric buses including electric charging station construction | **Hybrid Bus** = Procurement of 1,453 hybrid buses & Hybrid public bus rent (7 years) for 400 buses | **Bogie** = 8 & 12 power bogie modification (61-64) | **Locomotive** = Provision of diesel electric locomotives to replace 50 GE diesel electric locomotives (2018-2021) | **Runway** = Runway constructions, line 3 and 4 of Suvarnabhumi Airport | **LTM** = Promotion of Logistics and Transport Management (ITM) for energy-saving | **Excise CO₂ Tax** = Excise tax rate adjustment according to CO₂ emission (reflecting direct fuel consumption rate) for private cars based on strict tax measure | **Inefficient Car Retired** = Promote disposal of deteriorated vehicles (old vehicles) from the system (more than 15 years of service or exceeding 200,000 km) | **H-MAC** = Improvement of air conditioning systems (H-MAC) in cars | **Fuel Price** = Use of fuel mechanism to push forward use of effective vehicles | **EV Minibus** = Replace air-conditioned passenger vans with 4,626 electric minibuses | **Hybrid Taxi** = Promoting use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla | **Delivery MC** = Replace delivery motorcycles with electric motorcycles in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla | **Backhauling** = Backhaul Management | **DC** = Establish Distribution Center (DC) | **LTM Center** = Establish training center to train for energy-saving driving in 5 regions nationwide | **TMS** = Development of Transportation Management System (TMS) | **LED** = Change of LED light bulbs in all ports/airports/highways

Results and Discussion

1

According to the Nationally Appropriate Mitigation Actions (NAMAs) stating that “Thailand aims to reduce GHG emission by 20% - 25% below the business-as-usual (BAU) or 111 MtCO₂e in 2030. Thailand had an estimation of GHG reduction potentials from domestic activities and expected that Thailand had an ability to reduce GHG emissions to 115.6 MtCO₂e in 2030. Target for GHG reduction in transport sector is 41 MtCO₂e; energy use efficiency enhancement measure at 31 MtCO₂e and biofuel use measure for vehicles at 10 MtCO₂e. According to evaluation of GHG reduction potentials using Sustainable Transport System of “Avoid-Shift-Improve (A-S-I)” of the projects and plans in transport sector, the transport sector has total potentials to reduce GHG emission of 35.42 MtCO₂e. As the transport sector’s projects and plans, it was found that if we complete the implementation of the existing projects and plans in Ministry of Transport including the recommended projects and plans within 2030, the transport sector will reduce GHG emissions in total of 35.42 MtCO₂e.





The project on Study and Development of Marginal Abatement Cost (MAC) Tool in Greenhouse Gas Emission under Measures and Policies on Energy Efficient Transport



2 The Nationally Determined Contribution Action Plan (2021 – 2030) in transport sector (Transport Sector’s NDC Action Plan 2021 – 2030) is devised to move forward and promote the GHG emission reduction under the Thailand’s Nationally Determined Contribution Roadmap on Mitigation 2021 – 2030 (NDC Roadmap 2021 – 2030), to achieve the reduction target with a mission to support and promote related agencies’ implementation of the operation plans in the NDC roadmap 2021 – 2030, and to develop mechanism for GHG reduction promotion and the Measurement, Reporting and Verification (MRV) through determining the GHG reduction methods to provide related agencies with clear procedures. The meeting of Committee on Policy Coordination and Climate Change and Sustainable Transport Implementation with Permanent Secretary of Ministry of Transport as the Chairman has passed a resolution to approve the draft of Transport Sector’s NDC Action Plan 2021 – 2030 on October 31, 2018. Then, the National Climate Change Policy Committee with Deputy Prime Minister (Gen. Prawit Wongsuwan) as the Chairman has passed a resolution to approve the draft of Transport Sector’s NDC Action Plan 2021 – 2030 on November 19, 2018, and Gen. Surasak Karnjanarat as the Deputy Minister of the Ministry of Natural Resources and Environment has stated on behalf of Thailand to show vision on global climate change operation and reported the progress of the draft of NDC Action Plans 2021 – 2030 in energy, transport, municipal waste, industrial process and product use, and industrial waste sectors in the 24th United Nations Framework Convention on Climate Change (COP24) which held from December 3-14, 2018 in Poland.

3 Marginal Abatement Cost per unit (baht per ton of carbon dioxide equivalent) is one of the indicators for GHG reduction efficiency evaluation under the 12th National Economic and Social Development Plan, B.E. 2560 – 2564 (2017 – 2021), the fourth strategy, environmental friendly development for sustainable development. Consequently, it is an important variable for GHG reduction operations. According to the marginal abatement cost evaluation, it is found that New Railway projects have the highest potential for GHG reduction, at -302,808 baht per tCO₂, followed by mass transit electric train and suburban train projects, dual-track railways and improvement of public transport system connectivity through Non-Motorized Transport (NMT) which are the shift mode project and are in the Strategic Operation Plan of Ministry of Transport 2017 – 2020. These projects have potentials for GHG reduction between -45,000 to -138,000 Baht/tCO₂e. A negative value of the project means that a benefit of project implementation is higher than a cost; on the other hand, a positive value means that the project has low benefit.

4 The Marginal Abatement Cost Curve (MACC) is developed based on Excel-based spreadsheet to process and rank projects with potential and significance for the operations including properly and efficiently compare profits from investment of plans and projects relevant to GHG reduction in a graph form.



Summary

Marginal Abatement Cost Curve (MACC) is an effective tool in prioritizing the potential and significant projects mainly regarding costs and comparing the value for investment in plans and projects related to GHG reduction as a curve. However, in the decision of appropriate projects for investment depends on the Government in considering preferable the value of investments, enhancing of national economic developments or the NDC target of GHG reduction. There are many factors that need to be used for decision making, such as economic conditions, urgent policies, or investment readiness, etc.

In decision of the project, it is unnecessary to always select the negative marginal abatement cost (-). It should consider the high potential project on GHG emission reduction. For example, if considering MACC, the marginal abatement cost (MAC) of the electric vehicle car project (EV car) has positive (+). This means that this project is not worth for investment. But if considering CO₂ reduction, this project will have more contribution to achieve the NDC target.

The electric vehicle car (EV car) is the positive value (+) project with the MAC of 358,371 Baht/tCO₂e. Even though it has high potential on GHG reduction of 7.8 MtCO₂e but the benefit is lowest. Due to current electric vehicle value of 2018 (upfront price and operation and maintenance costs) is higher than diesel vehicle. On the other hand, the MAC of the new railway project is negative value (-) which evaluated from infrastructure investment cost, travel and operation and maintenance costs of rail-based system of which the value is lower than road-based system. However, if compared the MAC of the electric vehicle car (EV car) in other countries, the MAC have positive (+) values or low benefits. The results of MAC evaluation of the EV car in Thailand has higher cost due to Thailand does not have production base for EV car. If Thailand has own base, it will decrease EV car technology cost lower and economy to scale. Therefore, EV car is an effective project to push forward in contribution with the GHG emission reduction in lifetime or for reducing environmental impact in long term.



Executive Summary

Chapter 1 Introduction

1.1 Principles and Rationale

The cabinet resolution on November 25, 2014 approved an intention of Thailand's Nationally Appropriate Mitigation Actions (NAMAs) based on a voluntary basis, to reduce GHG emissions in the range of 7-20% below the business-as-usual (BAU), in energy and transport sector in 2020, since Thailand is a member of the United Nations Framework Convention on Climate Change (UNFCCC). Therefore; the achievement depends on performance of greenhouse gas (GHG) emission reduction in the sectors. The Nationally Appropriate Mitigation Actions (NAMAs) focuses on the operation of sector's GHG emission reduction through various measures such as power generation from renewable energy, biofuel use, sustainable transport measures, creating database on GHG emission in national, local and branch levels, development of Measurement, Reporting and Verification (MRV) system, as well as development of finance and market mechanism to support the GHG emission reduction, adaptation plan, development of related database and knowledge, etc.

Under the 12th National Economic and Social Development Plan, B.E. 2560 – 2564 (2017 – 2021), the fourth strategy, environmental friendly development for sustainable development, the 4th goal – increasing efficiency of GHG reduction and adjustment capacity for climate change, GHG emission in the energy and transport sectors will be reduced at least 7% of the business as usual within 2020. This clearly determine the goal for GHG emission reduction in the energy and transport sectors, so that the country's intentions as shown under the United Nations Framework Convention on Climate Change (UNFCCC) and the 12th National Economic and Social Development Plan achieve the goal regarding the GHG reduction at 7%, and the 7th strategy infrastructure and logistics development according to overall development goal, indicators are determined to reduce the Energy Intensity: EI) at 7.7 kilotons equivalent to crude oil per billion baht in 2021. Proportion of final energy use per Gross Domestic Product (GDP) will be reduced. In addition, under the Ministry of Transport's strategies, the 4th goal is determined to encourage energy saving and environmental friendly transport. Under missions of the Office of Transport and Traffic Policy and Planning (OTP), article 2, safety and environment under the traffic and transport systems are promoted.

As a result, study and development of a tool for Marginal Abatement Cost (MAC) is necessary and important at the early stage in knowing the marginal abatement cost (MAC) of GHG emission reduction (baht per ton of carbon dioxide equivalent) which is an indicator to achieve both goals of the 12th National Economic and Social Development Plan.

1.2 Purposes of the Project

- 1) To study and develop the Marginal Abatement Cost (MAC) tool in GHG emission reduction under measures and policies on energy efficient transport of Thailand.
- 2) To analyze marginal abatement costs of GHG emission reduction (baht per ton of carbon dioxide equivalent) for the transport sector's projects and plans.
- 3) To formulate Transport Sector's NDC Action Plan 2021 - 2030 in order to reduce the GHG emission according to the goals of Nationally Appropriate Mitigation Actions (NAMAs) from 7% - 20% by 2020, and prepare Transport Sector's NDC Roadmap 2021 - 2030 to reduce the emission according to goals of Nationally Determined Contribution (NDC) from 20% - 25% by 2030.

1.3 Overview of Operations

In the project operation, the first step is to study and review various policies, plans and development projects related to sustainable and potential development for GHG emission reduction, in accordance with the government's policies and the Ministry of Transport's strategies such as the 20-year national strategies from 2017 – 2037, 12th National Economic and Social Development Plan, etc. Later, methods, tools and approaches for the Marginal Abatement Cost analysis for Thailand's transport measures and policies are studied, and the plans and projects to be used for investment estimation will be selected. During the study and analysis, Mode Shift Survey is performed and prepared the baseline data for agencies, to evaluate the GHG emission reduction for related projects, and analyze the marginal abatement costs of GHG emission reduction for the transport sector's projects and plans. Analysis of the project efficiency and economic, social and environmental impacts is undertaken as the project's information and data. Comparing the project's costs regarding the GHG emission reduction, and the Transport Sector's Action Plan will be formulated. The projects will be ranked the priority and potential for the GHG emission reduction to achieve the 7% reduction goal of NAMAs by 2020 and the 20% of NDC by 2030.

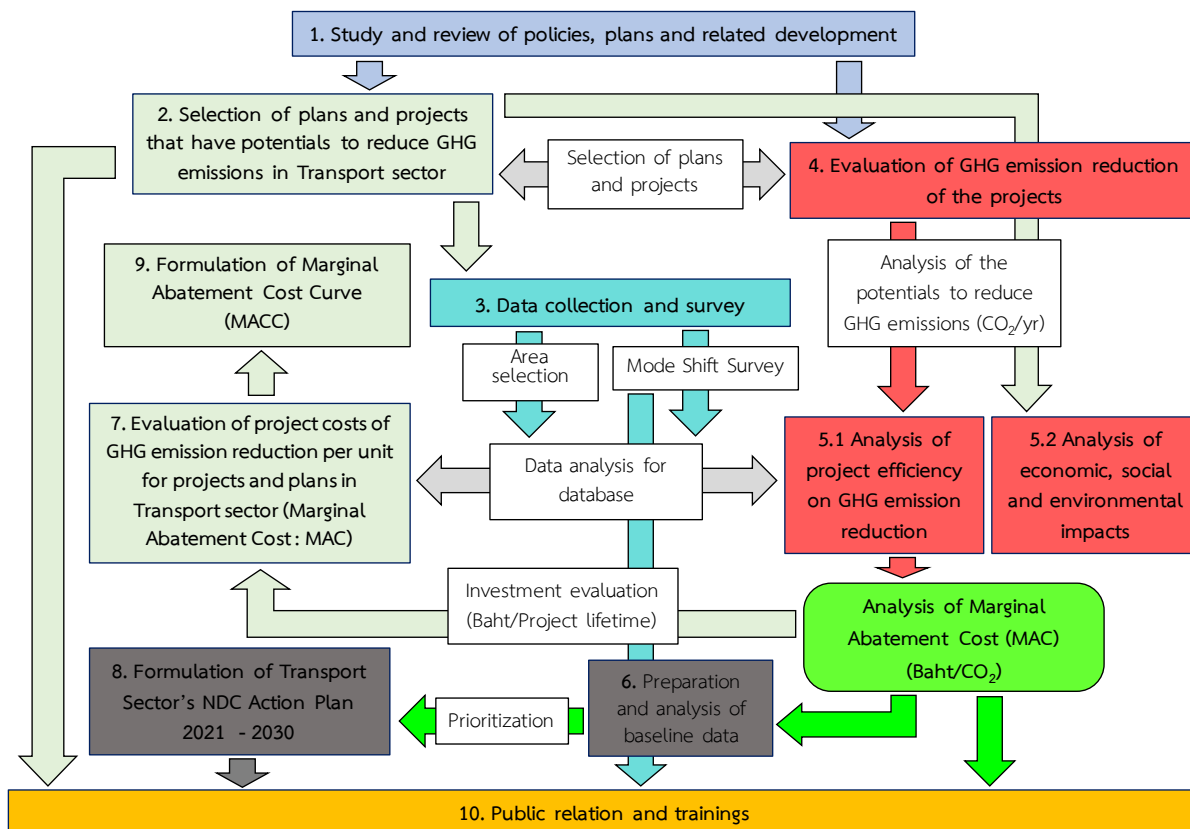


Figure 1.4-1 Project framework

1.4 Methods and Procedures

Methods, procedures and results expected from each sector can be summarized according to Table 1.4-1.

Table 1.4-1 Methods, procedures and expected results

No.	Section	Methods	Procedures	Expected Results
1	Study and review of policies, action plans and related development	Collect and analyze secondary data	<ul style="list-style-type: none"> Study issues and consistency of policies, plans and related development with this project's study Analyze data and methods for study and design of tools to be used in the project's study 	Able to identify issues related to the climate change and sustainable transport and significance of this project's operation
2	Select related and potential action plans and projects for reduction of GHG emission in transport sector	Determine criteria for selection of action plans and projects	<ul style="list-style-type: none"> Review and select related and potential plans and projects for reduction of GHG emission in transport Consider plans and projects related to sustainable development and GHG emission reduction under the Strategic plans of Ministry of Transport, 2017 -2021 	Obtain related and potential action plans and projects for reduction of GHG emission in transport sector

No.	Section	Methods	Procedures	Expected Results
3	Collect and survey for data to prepare Mode Shift Survey	Collect secondary data from related agencies and survey on change of transport modes to prepare Mode Shift Survey	<ul style="list-style-type: none"> ● Prepare questionnaire on the public's decision and selection of transport modes ● Survey the public's decision and selection of transport modes and analyze the results based on statistic approaches 	The agency will obtain basic data on the transport mode shift and its proportion
4	Evaluation of the project's GHG emission reduction	Apply the Measurement, Reporting and Verification (MRV) as the operating guideline, and evaluate individual projects related to the sustainable transport and GHG reduction	<ul style="list-style-type: none"> ● Study the Measurement, Reporting and Verification (MRV) ● Estimate the current transport demands, energy use and CO₂ emission amount ● Forecast the future transport demands, energy use and CO₂ emission amount based on traffic and energy models 	To realize amount of GHG emission in the transport sector of the Ministry of Transport's agencies individually (tCO ₂ e/yr) for 2020 and 2030
5	Analyze the project's efficiency on GHG emission reduction and economic, social and environmental impacts	economic, social and environmental impacts using PESTEL as analysis tool	<ul style="list-style-type: none"> ● Analyze the project's potential through calculation of transport demands, energy use and CO₂ emission amount in 2020 and 2030 ● Analyze the economic, social and environmental impacts 	Able to realize amount of GHG emission in related plans and projects with potential to reduce the emission in the transport sector in 2020, 2030, and the economic, social and environmental impacts
6	Prepare the project baseline data to compare economic, social and environmental analysis	Compare economic, social and environmental analysis impacts using Multi-Criteria Analysis (MCA) as analysis tool for decision-making	<ul style="list-style-type: none"> ● Analyze and compare the economic, social and environmental impacts 	Able to identify the economic, social and environmental impacts in order to support initial selection of projects
7	Analyze the project and prepare costs of the GHG emission reduction per unit (MAC) in transport sector	Estimate costs of the GHG emission reduction as net cost (cost - benefit)	<ul style="list-style-type: none"> ● Estimate the project value as investment and maintenance costs throughout the project until 2030 ● Estimate the project value per amount of GHG emission reduction ● Prepare costs of the GHG emission reduction per unit (MAC) in transport sector ● Estimate MACC as amount of CO₂ emission reduction (tCO₂e) vs. Marginal abatement cost (baht/tCO₂e) through calculating the project value analysis results, divided by CO₂ emission reduction amount for each project as of 2030 	Able to realize costs of the GHG emission reduction per unit for the project (MAC) in transport sector for each project as baht/ project lifetime for 2020 and 2030
8	Formulate an action plan for transport sector	Consider significance and potential plans and projects for GHG reduction in accordance with the NAMA's goals at 7% - 20% by 2020	<ul style="list-style-type: none"> ● Prioritize the obtained projects and plans, estimate incremental costs for GHG reduction using (MAC) as analysis tool ● Prepare Transport Sector's NDC Action Plan considering significance and potential for achieving the NAMA's goals from 7% - 20% by 2020 and select the priority projects 	<ul style="list-style-type: none"> ● Able to know clear data and figures of GHG emission reduction from the MACC ● Able to identify which projects and plans in the transit sector have the most potential for the reduction

No.	Section	Methods	Procedures	Expected Results
			<p>and plans for the best benefits and the most reduction of the GHG</p> <ul style="list-style-type: none"> • Prepare roadmap using estimate results of the GHG reduction amount and potential made as Infographic for easy understanding and guideline for related agencies to be used as procedure for operating and driving the transport projects accurately and concretely 	<ul style="list-style-type: none"> • Able to identify which projects and plans in the transit sector are worth the investment • The government sector can observe the overview of GHG emission reduction in the transport sector
9	Prepare analysis tool for MAC of GHG emission reduction under the transport sector's measures and policies	Develop the Marginal Abatement Cost Curve (MACC) for the GHG emission reduction under the transport sector's measures and policies	<ul style="list-style-type: none"> • Study commercial Marginal Abatement Cost Curve (MACC) in the market • Develop the tool based on factors related to each project's incremental cost estimate such as data source, fuel costs, transport mean shift proportion, CO₂ emission rate, etc. • Modify the tool for highest efficiency and accuracy 	Related agencies have the Marginal Abatement Cost Curve (MACC) both in Top-down method and Bottom-up method which are able to analyze the project in policy aspect such as transport mean shift or to increase energy use efficiency.
10	Hold a seminar meeting and public relation for the project	Hold a seminar meeting, training for knowledge transfer and public relation for the project	<ul style="list-style-type: none"> • Hold a seminar meeting for the project orientation and presentation of the project studies • Hold a training for knowledge transfer to improve knowledge, understanding, develop skills and capacity for the officers and staff • Hold a public relation for the project to publicize and distribute information and news related to the project 	The staff and related persons gain knowledge and understanding about the project's operations and activities.

Chapter 2 Literature Review

Summary of the study and review of policies, plans and related development are as follows.



Figure 2-1 Summary of the study and review of policies, plans and related development

Chapter 3 The Selection of the Transport Sector's Projects and Plans Related to and Having the Potentials to Reduce the GHG Emissions

3.1 The Criterion of the Project and Plan Selection

The criterion of the project and plan selection is summarized as the following details:

- 1) It is the project and plan related to sustainable transportation development. Most of them are the projects in strategy 1, the development of basic transportation systems to link thoroughly and be environmentally friendly. And in strategy 3, the development of transportation systems to increase the competitiveness and drive the country's economic development.
- 2) It is the project and plan related to GHG reduction according to evaluation method of Measurement, Reporting and Verification (MRV) in bottom-up level and A-S-I Approach.
- 3) It is the project and plan related to freight and passenger travels and public transportation system.
- 4) It is the project and plan with clearly defined budgets and responsible agencies.

3.2 The Selection of Transport Sector's Projects and Plans

From the strategic operation plan of the Ministry of Transport in 2017 - 2021, it classifies the type of transport system and responsible agencies and budgets for investment. For the selection, it reviews the project and plan related to sustainable development and the reduction of the amount of GHG emissions of the strategic operation plan of the Ministry of Transport in 2017 - 2021. For the strategic issue 1, it is "throughout and environmentally friendly"; strategy 1.2, develop the service of fundamental public transportation to be comprehensive and accessible; strategy 1.3, increase the flexibility and connection between modes of transportation; strategy 1.5, promote and develop the transportation systems that reduce energy consumption, rely on clean energy, and be environmentally friendly. And for the strategic issue 3, "Efficiency and Capability"; strategy 3.1, develop the transportation infrastructure to support the country's economic development because these 2 strategic issues considerably involve sustainable development and reduction of GHG emissions.

To classify the projects, it is classified by the level, type and criterion as follows:

The level of project for investment evaluation

- 1) By land – Rural Roads, National Highways, Intercity Motorways, Expressways, Local Highways, etc.
- 2) By railway –Suburb trains, Airport rail link trains, Metro, Double-track trains, etc.
- 3) By water – Cruise ports, Ferries, Ports
- 4) By air – Airports

The type of project for investment evaluation

1) Infrastructure, 2) directing, 3) policies and plans, 4) business, and 5) promoting

The criterion for project classification for investment evaluation

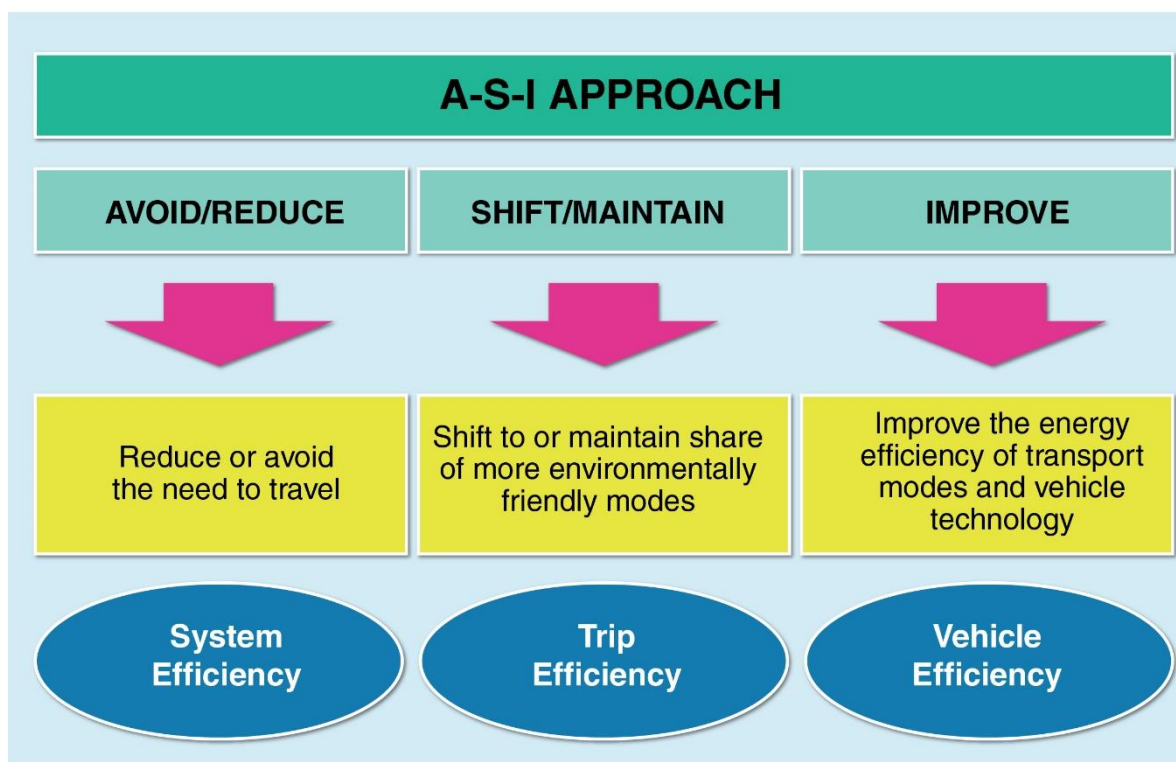
- 1) The project is related to freight.
- 2) The project is related to the travel of passengers or public transportation system.

3.3 The Project Grouping Using A-S-I Approach

For the investment evaluation of projects and plans related to and having the potential to reduce the GHG emissions in transport sector, it is necessary to firstly select the projects that are related to sustainable development and the reduction of the amount of GHG emissions of the strategic operation plan of the Ministry of Transport in 2017-2021. Then, it needs to group the project according to evaluation method of Measurement, Reporting and Verification (MRV), bottom-up level and A-S-I Approach.

A-S-I Approach or “avoid-shift-improve” principle is an important principle used to change and create the sustainable transport of the projects and plans in transport.

In many countries, the A-S-I approach is used for the systematic transportation planning. The A-S-I approach or Avoid/Reduce (A) is to reduce or avoid the needs of travel by increasing or improving the efficiency of system. Shift/Maintain (S) is to change or use the environmentally friendly modes of travel by increasing or improving the efficiency of travel. Improve (I) is to improve energy efficiency in transportation and automotive technology by increasing or improving the efficiency of vehicle as shown in **figure 3.4-1**.



Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (giz) GmbH

Figure 3.4-1 A-S-I approach

A-S-I approach is consisted of 3 parts;

(1) **Avoid/Reduce** – This policy is to encourage the people to avoid the travel or reduce unnecessary travel distance by appropriate integrating between city planning and transportation planning, such as developing the functional areas in the form of compact areas, promoting the work-at-home measure, building a government centers or shopping center in the area, etc.

(2) **Shift/Maintain** – This policy is to encourage the people to change from private vehicle use to more efficient and environmentally friendly transportation modes, such as public transport and non-motorized transport (travel by bicycle and on foot).

(3) **Improve** – This policy is to focus on automotive development and using the same infrastructure for more efficiency, such as automotive energy saving technology, alternative energy using, gasohol oil use promotion, and electric cars and bicycles use promotion.

In project grouping according to evaluation of MRV system, the project type can be dividing into; Avoid/Reduce (A), Shift/ Maintain (S) and Improve (I). The purpose is to systematically classify the analysis and calculation the amount of GHG emission reduction in each project and plan; for example, the projects of mass transit and rail-based transportation system. They are mostly the “Shift mode”. The calculation is considered at the proportion of travel demand from one mode shift to rail-based mode. In promotion of the measure of energy efficiency, the calculation uses “Improve” mode or better efficiency value, etc.

Chapter 4 Data Collection and Mode Shift Survey

4.1 Important Information for Marginal Abatement Cost (MAC) Analysis in Reducing GHG Emissions

Important information for analysis of Marginal Abatement Cost (MAC) in reducing GHG emission are as follows:

- 1) Type of project/ type of transportation system
- 2) Share mode and shift mode
- 3) Fuel economy
- 4) Riderships, freights or number of vehicles
- 5) Vehicle kilometer of travel (VKT) and average vehicle kilometer of travel

The data of shift mode in the organization is a lack of frequency data collection. This project is for data survey of mode shift using questionnaire. It is useful for considering the project efficiency analysis related to public transport system in transport sector and for estimating GHG emission reduction in the future.

4.2 Methodology of Data Collection and Survey

4.2.1 Criteria of Area Selection

Criteria of area selection is considered from the key factors of geography, economy and society affecting to people in consideration as follows:

- 1) Number of riderships
- 2) Hub or linkage point of transport system
- 3) Importance of the area; main station of the city or region, attractive area or economic area, etc.
- 4) Opportunity of growth
- 5) Comfortable for travel

As considered above criteria of land, rail and air modes, the suitable area for the data survey were in Bangkok and Metropolitan Area. Due to high number of riderships and main hub of transport system compared to other regions.

4.2.2 Survey Area

1) Urban Transport

Purple line metro station was used as the area for mode shift survey of the urban transport. The results of the survey were used in considering the project efficiency analysis related to public transport system in the urban area such as other line metros in Bangkok and Metropolitan Area.

2) Inter-City Transport

Bangkok Bus Station (Jatuchak), Bangkok Bus Station (Ekkamai), Bangkok Railway Station (Hua Lampong) and Don Muang Airport were used as the areas for mode shift survey of the inter-city transport. The results of the survey were used in considering the project efficiency analysis related to public transport system in the inter-city area such as Double Track Railways, New Railways and High-Speed Railways, etc.

4.2.3 Data Survey Methodology

There are 5 areas for the mode shift survey used of the questionnaires as in Appendix B. The result of the survey used for estimating GHG emission by MRV method in Bottom-up level. Summary of areas, samples and period is as shown in **Table 4-1**.

Table 4-1 Mode shift survey methodology

Travel type	Source of data	No. of sample	Area	Period	Time	Application
1. Urban Transport						
- Rail		450	1. Purple Line Metro Station	Mar-May		Mode shift survey
2. Inter-City Transport						
- Land	Questionnaire (Appendix B)	250	2. Bangkok Bus Station (Jatuchak)	Mar-May	Weekday and weekend	Mode shift survey
		100	3. Bangkok Bus Station (Ekkamai)			
- Rail		250	4. Bangkok Railway Station (Hua Lampong)			
- Air		200	5. Don Muang Airport			

4.2.4 Survey Results

There are 2 types of situations in the survey; 1) proportions and factors in deciding the passengers travel shift mode from each vehicle/mode to rail-based transport system in urban area, and 2) proportions and factors in deciding the passenger travel shift mode from old transport system to new transport system in inter-city area.

4.2.4.1 Inter-City Transport

Purple line metro station

From the shift mode survey of 450 samples, it was found that most passengers used this station shifted from private car to this rail-base transport system of 49.72%, from public bus of 30.78% and from public motorcycle of 8.8%, respectively as shown in **Figure 4-1**.

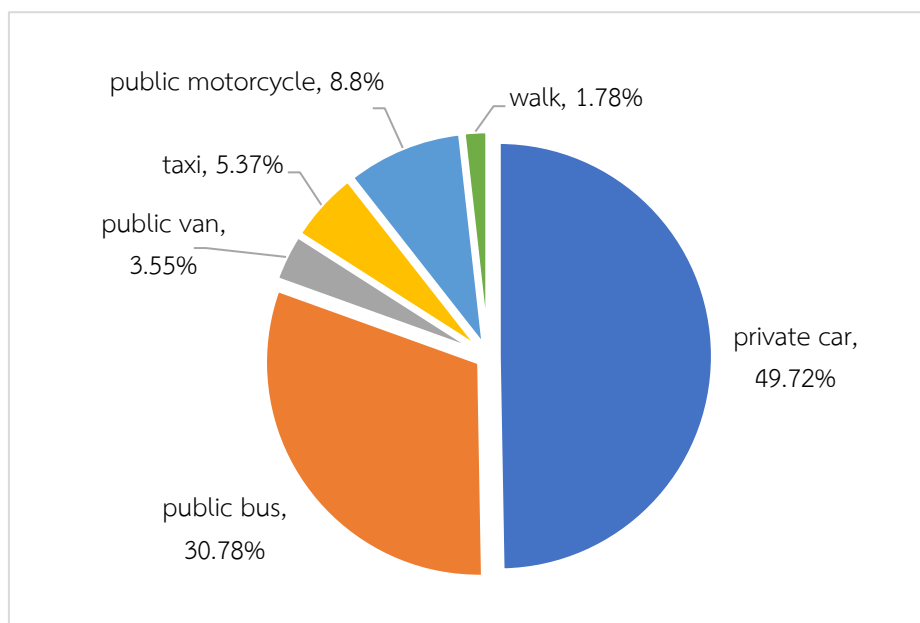


Figure 4-1 Proportions of passenger shift mode in urban transport from each vehicle to rail-base transport system

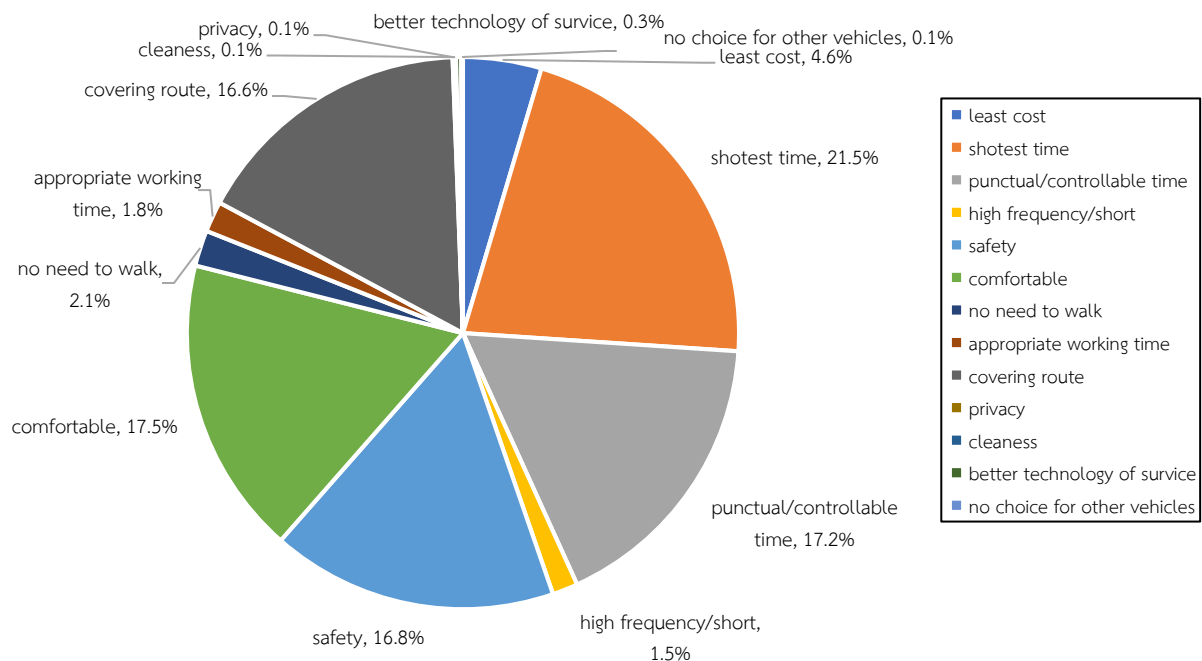


Figure 4-2 Factors of passenger shift mode in urban transport from each vehicle to rail-base transport system

Factors of passenger shift mode in urban transport from each vehicle to rail-base transport system (Figure 4-2) were found that the shortest time was the key factor in deciding the shift mode of 21.5%, followed by comfortable of 17.5% and punctual/controllable time of 17.2%, respectively.

As the survey result, it was found that public transport has capability to enhance efficiency in term of shift mode to cover and access the areas about 50% (public bus, public van, taxi and public motorcycle) and has capability to improve energy efficiency up to 50%. Moreover, the factor of time was the most important indicator in deciding the shift mode.

4.2.4.2 Inter-City Transport

Proportion of passenger kilometer of travel in the inter-city area

Proportion of passenger kilometer of travel in the inter-city area was classified according to vehicle kilometer of travel to use in considering proportions and factors of passenger shift mode in inter-city transport as the distance. Figure 4-3, it was found that the passenger kilometer of travel in Bangkok Bus Station (Jatuchak) was the same proportion of 37% in 300-500 kilometers and more than 500 kilometers and in 0-300 kilometers of 25%. Most of the passenger kilometer of travel in Bangkok Bus Station (Ekkamai) was less than 300 kilometers and in Don Muang Airport was more than 500 kilometers.

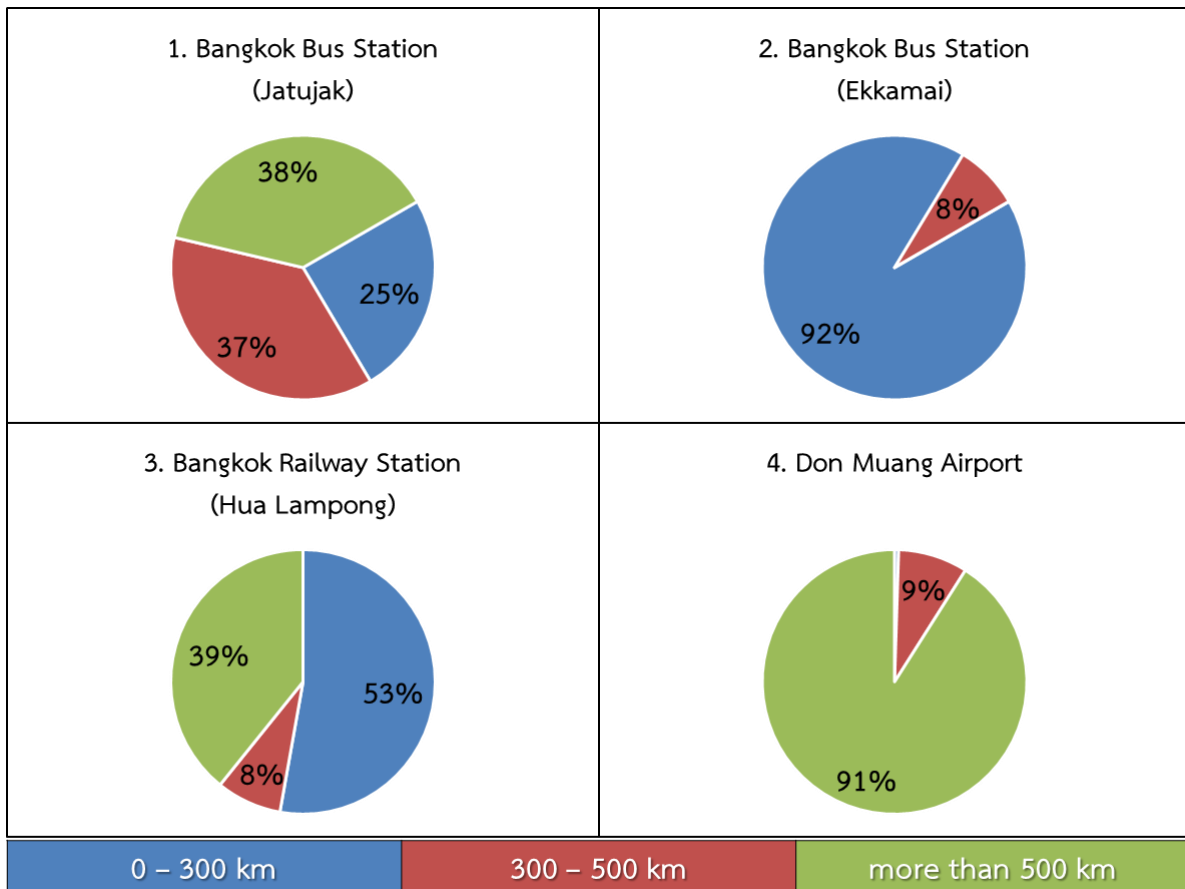


Figure 4-3 Proportion of passenger kilometer of travel in the inter-city area

Proportion of passenger travel shift mode from old transport system to new transport system in inter-city area

Summary of the survey was found that most sample chose high-speed railway as a new alternative transport system of 640 samples or 80%, followed by airplane of 94 samples or 12% and double track/new railways of 32 samples or 4% as shown in Figure 4-4.

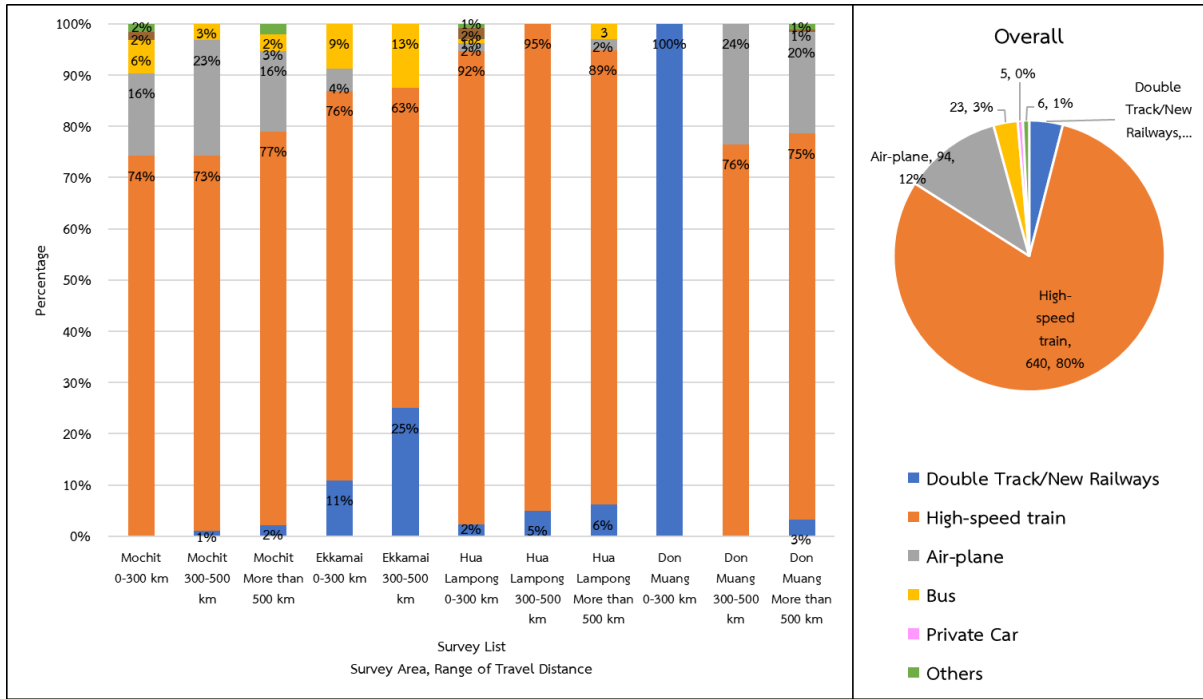


Figure 4-4 Proportion of passenger travel shift mode from old transport system to new transport system in inter-city area

Factors of passenger travel shift mode in inter-city area

Summary of the survey was found that most sample chose the shortest time of 319 samples or 40%, followed by the least cost of 117 samples or 22% and the comfortable of 21 samples or 21%. as shown in Figure 4-5.

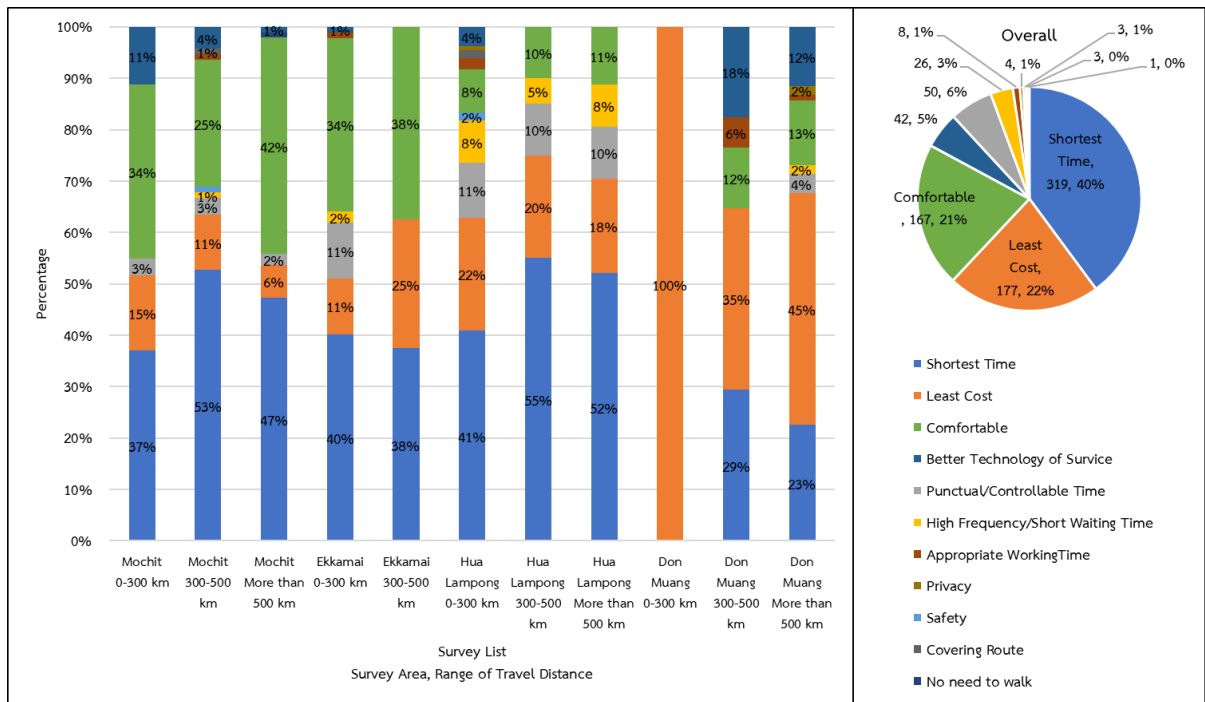


Figure 4-5 Factors of passenger travel shift mode in inter-city area

From the survey result, it was found that the passengers traveled between the cities (inter-city) were interested in high-speed train in high proportion from buses, conventional trains and airplanes about 80%. The factor of time was the most important indicator in deciding the shift mode of 40%, followed by the cost of 22% and the comfortable of 21%, respectively.

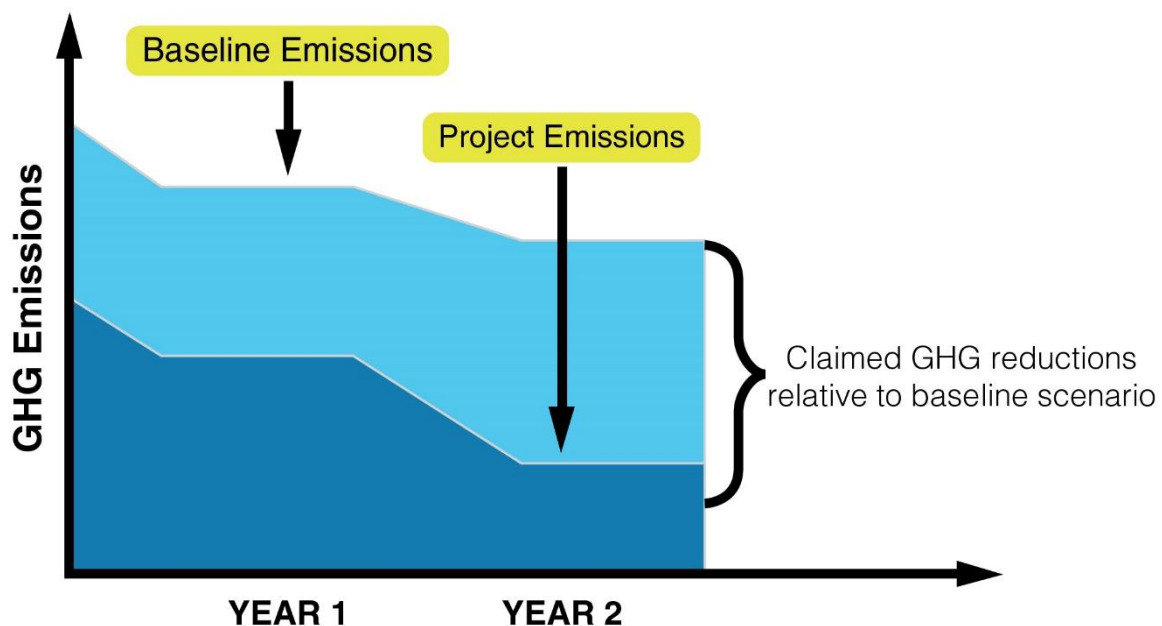
Chapter 5 The Evaluation of GHG Emission Reduction for Transport Sector's Projects and Plans

5.1 Measurement, Reporting and Verification (MRV)

MRV system (Measurement, Reporting and Verification) is the system to measure, report and verify the activities of GHG emissions reduction in order to prove the success of the implementation according to measure, project, system, and other policies to reduce GHG. It is also known as the administrative tools to monitor the GHG emissions and reduction according to the stated intent.

MRV system was firstly originated from cooperation of many countries to reduce GHG due to climate change in order to maintain the world temperature not to exceed 2 degrees Celsius. In order to operate and monitor the reduction of GHG appropriately, the measurement, reporting and verification system, thus, have been set up, leading to the specified goals in global and national levels.

In the study of this project, MRV system is used for mitigation actions and goals to estimate the GHG reduction in policy base and project base by evaluating the amount of GHG that can be reduced comparing with the base case.



Source: World Resources Institute, 2014 https://www.thepmr.org/system/files/documents/Sesion%2018%20-%20WRI_MRVR%20Panorama%20general.pdf

5.2 The Methods to Evaluate the GHG Emission Reduction

Using MRV system, an analytic method to evaluate the reduction of GHG emissions, is consisted of 2 methods:

1. Top-Down Method
2. Bottom-Up Method

The different points of analytic results obtained from these two analytic methods is that Top-Down Method obtains the overview of domestic transportation system. However, it cannot analyze and specify the amount of GHG generated from each type of vehicle or in each study area. It, thus, cannot concretely evaluate the transportation policy whether which policy can actually reduce the GHG and how much it is reduced.

On the contrary, Bottom-up method can provide specific results. It can specify the type of vehicle in designated study area and it can separate the travel of passengers or freights. Therefore, it is generally used for transport policy assessment.

The details of each analysis method used for calculating the amount of CO₂ gas emissions are as follows:

1) Top-Down Method

Top-down analysis or Top-down method is a method to estimate CO₂ gas directly from the amount of fuel sold in the area. This information has already been collected by the Department of Energy Business, the Ministry of Energy by calculating the amount of CO₂ gas emissions from fuel combustion. It can be calculated by equation (1):

$$\begin{array}{c} \text{GHG} \\ \text{Emissions} \end{array} = \begin{array}{c} \text{Fuel} \\ \text{Quantity} \\ \text{Litre} \\ \text{Scf /m}^3 \end{array} \times \begin{array}{c} \text{Net Calorific} \\ \text{Value (NCV)} \\ \text{TJ/Unit} \end{array} \times \begin{array}{c} \text{Emission} \\ \text{Factor (EF)} \\ \text{kg/TJ} \end{array} \dots(1)$$

2) Bottom-Up Method

Bottom-Up analysis or Bottom-Up Method is a method to estimate CO₂ gas indirectly from the amount of actual travel demand and can be mainly measured by using ASIF (Activity–Structure–Intensity–Fuel) principle. Regarding the calculation of CO₂ gas emissions ratio, it can be summarized in ASIF equation as shown in equation (2):

$$\begin{array}{c} \text{GHG} \\ \text{Emission} \\ \text{Estimation} \end{array} = \begin{array}{c} \text{Activity} \\ \text{(A)} \\ \text{Transport} \\ \text{performance} \\ \text{(pkm, tkm) or} \\ \text{vehicle-km} \end{array} \times \begin{array}{c} \text{Modal Share} \\ \text{(S)} \\ \text{modal-split of} \\ \text{passenger and} \\ \text{freight transport} \end{array} \times \begin{array}{c} \text{Energy} \\ \text{Intensity} \\ \text{(I)} \\ \text{the energy} \\ \text{demand by mode} \\ \text{and by fuel per} \\ \text{pkm, tkm or Vkm} \end{array} \times \begin{array}{c} \text{Carbon} \\ \text{Intensity} \\ \text{(F)} \\ \text{the carbon} \\ \text{intensity per unit} \\ \text{of energy demand} \\ \text{by fuel} \end{array} \dots(2)$$

5.3 Baseline Data for Marginal Abatement Costs (MAC) Analysis of GHG Emission Reduction

The baseline data used to analyze the marginal abatement costs of GHG emission reduction

- 1) Project/type of transportation system
- 2) Share mode
- 3) Fuel economy
- 4) Riderships, freights or number of vehicles
- 5) Vehicle kilometer of travel and average vehicle kilometer of travel

The data collected from both “without a project or business-as-usual (BAU)” case and “with project or measure case (Scenario)” case use to evaluate the amount of energy saving and GHG emission as of 2030.

For the secondary data collection, it is used to analyze the incremental costs to reduce GHG emissions. The information has been collected from website or annual report of agency. If the information is not published, such information is requested directly from agencies.

5.4 The Evaluation of GHG Emission Reduction in Project-based

To evaluate the GHG emission reduction of the project, the projects and measures have been set into 3 groups, according to “Avoid, Shift, and Improve” modes. The projects and measures focus on the development of efficient and sustainable transportation system to reduce energy consumption in transport sector, reduce traffic jam problem, create livable city, and reduce GHG emissions to the atmosphere which will lead to stable and sustainable economic growth. There are 3 components:

Measure 1 Avoid or reduce the transportation (Avoid or Reduce)

This policy is to encourage the people to avoid the transportation or reduce nonessential travel distance by appropriately integrating between city planning and transportation planning, e.g., developing the functional areas in the form of compact areas, promoting the work-at-home measure, building a government centers or shopping center in the area, etc.

Measure 2 Change transportation modes (Shift/Maintain)

This policy is to encourage the people to change from private vehicle use to more efficient and environmentally friendly transportation modes, e.g., public transportation and non-motorized transport (travel by bicycle and on foot).

Measure 3 Improve or develop the efficiency of automobile energy use (Improve)

This policy is to focus on automotive development, increase the capacity on fuel use, and using the same infrastructure for more efficiency, such as automotive energy saving technology, alternative energy using, gasohol oil use promotion, and electric cars and bicycles use promotion, etc.

5.4.1 Avoid/Reduce Project

According to estimate of GHG emission reduction for the Avoid/Reduce projects; for instance, the Travel Demand Management (TDM) projects consisting of parking fee collection policy and road pricing policy in high-traffic zones with details as follows:

Action Plan 1.1.1.1	Travel Demand Management, TDM
Project 1.1.1.1-1	Parking fee collection measures in high-traffic zones
Project 1.1.1.1-2	Road pricing measures in high-traffic zones
Reasons and Necessities	Principles of the Travel demand management (TDM) focus on management, control and change the travel demand to be in an appropriate level with the existing travel support components. The control methods consist of various types such as change of working hours, flexible working hours and working at home, increment of car occupancy through Car Sharing or Car Pooling, parking control in urban or business areas with freight public transport system, especially rail systems, high parking prices, adding more parking forbidden zones, modification of building control laws to control parking lots, use of intelligent traffic control and data system to facilitate or prioritize the commuters, determination of travel restricted zones such as walking street or car forbidden areas. In this study, the Road Pricing or Congestion Charge is presented and used for an example of GHG reduction estimate.
Nature of Project	Parking fee collection is performed to prevent private car use. This should be initiated when all 10 electric train lines are operated for services. In addition, the fee collected can be allocated to public transport supporting fund in order to encourage more people to shift to public transport systems. Road pricing measure is one of the travel management measures to prevent private car use. In addition, the charge collected can be allocated to public transport supporting fund in order to encourage more people to shift to public transport systems.
Objective of Project	Reduce private cars in high-traffic areas
Indicator	Amount of private cars and trucks entering into the determined areas
Target value	Amount of private cars and trucks entering into the determined areas is reduced by 15%
Budget	600 million baht
Source of Fund	Bureau of the Budget + Urban public transport promotion fund
Main departments	BMA, DLT
Supporting departments	OTP, Traffic Police Division

Results of the Project	
Amount of energy use reduction as of 2030	754.93 million liters 650.77 kilo ton of oil equivalent (ktoe)
Amount of GHG emission reduction as of 2030	2.0 million ton of CO ₂ equivalent (MtCO ₂ e)
Marginal Abatement Cost, baht/tCO ₂ e	50.76

Evaluation Methods

As for Travel demand management (TDM) analysis, data obtained from London, England was used as reference, since the city collects road user charges in controlled areas based on the Intelligent Transportation System (ITS) as control tool. According to the recorded data, it is found that the average Vehicle Kilometer of Travel (VKT) was reduced after the measure was announced, as shown in the table below:

Table 5.4-1 Case study on Travel Demand Management (TDM) in England

Types of Vehicles	Vehicle Kilometer of Travel (VKT) (million trips) in 2002		Vehicle Kilometer of Travel (VKT) (million trips) in 2003		Shift Proportion (%)
All types of vehicles	1.64	(100%)	1.45	(100%)	-12%
Four-wheel or above	1.44	(88%)	1.23	(85%)	-15%
Potential vehicles for collecting charges	1.13	(69%)	0.85	(58%)	-25%
Car	0.77	(47%)	0.51	(35%)	-34%
Van	0.29	(18%)	0.27	(19%)	-5%
Trucks or others	0.07	(4%)	0.07	(5%)	-7%
Taxi car with license	0.26	(16%)	0.31	(21%)	+22%
Bus or coach	0.05	(3%)	0.07	(5%)	+21%
Two-wheel	0.20	(12%)	0.23	(16%)	+14%

Source: London Congestion Charge, GIZ/ Frank Dunnebeil (2014)

According to evaluation of GHG emission reduction from the Travel demand management (TDM)'s measures based on registered vehicle data from the Department of Land Transport in 2017, and CO₂ emission proportion classified by vehicle types from the Project on Study of an Approach to Tracking of Energy Consumption Reduction from the Transport Sector Measures, OTP 2018, the following table shows calculation of GHG emission reduction amount as acquired from the TDM measures:

Table 5.4-2 Calculation of GHG emission reduction amount of TDM measures

Data	Types of Vehicles				
	Private car/Personal trucks	Trucks	Taxi car	Bus/Coach	Motorcycle
Number of registered vehicles in 2017 (cars)					
Nationwide	14,951,079	1,056,068	117,979	157,071	20,291,305
Bangkok	5,514,280	138,245	102,468	43,849	3,393,056
BAU Case					
Amount of CO ₂ emission in 2030 (MtCO ₂ e)					
Nationwide	75	20	2	10	20
Bangkok (in proportion)	27.7	2.6	1.7	2.8	3.3
Measure Case					
Vehicle Kilometer of Travel (VKT) changed resulting from road pricing measure					
London	-34%	-7%	22%	21%	14%
Bangkok and vicinity (Controlled areas such as CBD) (hypothesis at 25% compared to London)	-8.5%	-1.8%	5.5%	5.3%	3.5%
CO ₂ changed (MtCO ₂ e)	-2.35	-0.05	0.10	0.15	0.12
Total CO ₂ reduction (MtCO ₂ e)	-2.0				

Source: Study and development of Marginal Abatement Cost analysis tool for GHG emission reduction analysis resulting from transport measures and policies for effective use of energy, OTP 2018

5.4.2 Shift/Maintain Project

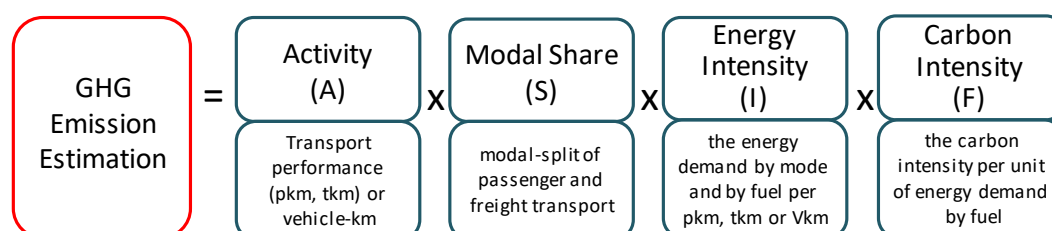
In evaluation of GHG emission reduction for individual Shift/Maintain type projects, for example, new rail line construction with details as follows:

Action plan 1.1.2.1	Infrastructure Development to support transport mean shift in railway transport system
Project 1.1.2.1-3	New rail line construction
Reasons and Necessities	Rail network development aims to increase the rail capacity which increases operation efficiency and safety for convenient, fast and safe travel. This is able to support increasing transport demands for both passenger transport and logistics. The railway system development will double its capacity resulting to faster and safe operations without having to wait for shunting which will facilitate punctual operations. This can strengthen confidence in the system operations, and more logistics operators will shift to the railway transport systems (Modal Shift) which will be beneficial for overall national energy use and transport cost reduction.
Objectives of Project	<ul style="list-style-type: none"> ● To promote thorough and accessible transport infrastructure development ● To reduce proportion of private car use, increase proportion of railway system use, and reduce energy use and GHG emission
Indicator	<ul style="list-style-type: none"> ● Railway system riderships ● Percentage of GHG emission in railway system
Target Value	Railway system service coverage at 100% by 2030 Proportion of railway system transport increased by 10% by 2030
Budget	501,690 million baht
Source of Budget	Bureau of Budget + Government fund
Main department	SRT
Supporting department	-

Results of Project	
Amount of energy use reduction as of 2030	87.92 Million liters per year 66.51 kilo ton oil equivalent (ktoe)
Amount of GHG emission reduction as of 2030	0.092 million ton carbon dioxide equivalent (MtCO _{2e})
Marginal Abatement Cost, baht/tCO _{2e}	-302,808.32

Evaluation Methods

The energy use and GHG emission reduction is evaluated based on Bottom-Up Method, which indirectly measures CO₂ mainly based on actual and measured travel demand using ASIF principle (Activity-Structure-Intensity-Fuel) as shown in the equation.



As for this evaluation, the passenger kilometer travel or ton kilometer travel (PKT, TKT) [A] changed between the base case and measure case is used for energy use and GHG emission reduction.

Hypothesis of Evaluation

Railway transport evaluation hypothesis are as follows:

- A number of passengers and freights are increased in accordance with linear regression growth proportion as referred in the study of Master Plan for Railway Network Development on Promoting Special Economic Zones, Tourism, and Area Development.
- Overall travel proportion, nationwide and regional, as referred in the study of Master Plan for Railway Network Development on Promoting Special Economic Zones, Tourism, and Area Development classified by each transport type such as land, railway, water and air transport in current year and 2030, and adjust proportion of specific systems to be shifted to railway system only.
- Determine that passengers who use public transport systems such as public vans, tour buses, airplanes and private cars shift to railway system, and freight transports are shifted from four-wheel, six-wheel, ten-wheel lorries and above and trailer trucks to the railway systems, based on increasing passenger and freight transport distance through railway systems equivalent to reduced passenger and freight transport distance through public transport systems for each public transport type in accordance with transport mode proportion.
- Proportions of transport modes and energy types used by each vehicle type – use transport mode shift survey conducted through the project’s questionnaire.
- Determine that average passenger-kilometer travelled was at 44% of each route distance, while the ton-kilometer travelled uses actual loading distance in ton-km unit
- For the calculation, an analysis of number of passengers and freights increased from the base year and the increased number of passengers and freights was applied to calculate amount of energy use and CO₂ emission reduction

Data used in the analysis

Data used for evaluating MRV based on Bottom-up method is as follows:

(1) Travel demand in the study area (A and S)

- Number of passengers and freights changed between base case and measure case

Changed riderships as of 2030	=	134,418	passenger-trip/day
Changed freight amount as of 2030	=	42,174	million ton-km/year
Total distance	=	2,363	kilometers
- Travel proportion for each vehicle type used in the passenger and freight transport

■ Travel proportion of each vehicle type used for passenger transport

No.	Vehicle Type	Current Year	2030	Reduced Proportion	Mode shift proportion
Passenger Transport Types					
1.1	Tour/Coach/Passenger Vehicles	38.57%	35.71%	-2.86%	37.00%
1.2	Airplanes	3.74%	3.10%	-0.64%	8.28%
1.3	Private cars	51.27%	47.04%	-4.23%	54.72%
	Total	100.00%	100.00%		100.00%

Source: Railway Network Development Master Plan for Promoting Special Economic Zones, Tourism, and Area Development, OTP 2018

■ Travel proportion of each vehicle type used for freight transport

No.	Vehicle type	Mode shift proportion							
		North	North East	Center	South	East	West	Bangkok and metropolitan	Natio nwide
Freight Transport Types									
2.1	Four-wheel trucks/ pickup truck	73.93%	65.40%	35.87%	70.27%	56.82%	64.64%	59.68%	63.47%
2.2	Six-wheel medium trucks	9.06%	11.56%	18.72%	9.93%	14.09%	11.43%	14.26%	12.09%
2.3	Ten-wheel heavy trucks and above	5.86%	7.30%	11.20%	5.69%	9.08%	6.78%	9.39%	7.58%
2.4	Trailer trucks	11.15%	15.74%	34.21%	14.12%	20.01%	17.16%	16.67%	16.86%

Source: Department of Land Transport, 2013

■ Average ridership on vehicles (Occupancy rate)

Vehicle Type	Average Occupancy rate		
	Bangkok and metropolitan ¹		Inter-city ²
	Working days	Non-working days	
1. Motorcycles and motor tricycles	1.1	1.1	n/a
2. Personal vehicles and taxi cars	1.15	1.2	2.1
3. Personal vans and pickups	1.2	1.25	1.82
4. Public vans	5.2	4.7	n/a
5. Small passenger vehicles (minibus)	9.6	10.1	14.01
6. Medium passenger vehicles	13.8	13.8	32.9
7. Large passenger vehicles	25.1	20.9	n/a
8. Medium trucks	1.7	1.9	1.56
9. Large trucks	1.7	1.7	1.39
10. Passenger boats	-	-	36
11. Tour bus/Coach ³	-	-	25
12. Airplanes	-	-	100
13. Double track railways ⁴	-	-	80

Source: ¹ Road network development and integration master plan for river and traffic crossing bridges in Bangkok and vicinity (OTP, 2011)

² Study on economic and engineering feasibility and environmental impacts of the highway master plan (Department of Highways, 2008)

³ Report on traffic amount on highways, Department of Highways, 2008

⁴ Railway Network Development Master Plan for Promoting Special Economic Zones, Tourism, and Area Development, OTP 2018

- Freight load rate

Vehicle type	Average load rate (ton)
train ¹	800
Four-wheel trucks/ pickup truck ²	1.1
Six-wheel medium trucks ²	2.67
Ten-wheel heavy trucks and above ²	7.71
Trailer trucks ²	15

Source: ¹Study on economic and engineering feasibility and environmental impacts of the highway master plan (Department of Highways, 2008)

² The Inter-city Toll Motorway Projects in the Kingdom of Thailand, JICA, 2537

(2) Energy use proportion of each transport mode (I)

- Total distance proportion classified by vehicle and fuel types

Vehicle type	Proportion of fuel used								Total fuel use classified by vehicle types
	Benzene 95	Gasohol 91	Gasohol 95	E20	E85	Diesel	LPG	CNG	
Personal vans/cars/pickups	3.87%	17.32%	10.72%	34.78%	4.70%	23.54%	5.08%	0.00%	100%
Personal motorcycles	45.08%	2.53%	2.24%	27.43%	0.00%	0.00%	0.00%	0.00%	77%
Taxi cars							23.83%	76.17%	100%
Public buses						63.76%		36.24%	100%
Public vans						50.00%		50.00%	100%

Source: Survey results of energy use reduction tracking project resulting from transport measures, OTP, 2018

- Fuel Economy (FE)

Fuel type	Benzene 95 (km/L)	Gasohol 91 (km/L)	Gasohol 95 (km/L)	E20 (km/L)	E85 (km/L)	Diesel B7 (km/L)	LPG (km/kg)	NGV/CNG (km/kg)	Electricity (km/kWh)
Cars ¹	12.63	13.47	12.64	15.00	12.69	12.45	11.38	12.56	0.16
4-wheel trucks/pickups ¹	13.50	12.98	11.75	17.63		12.96	12.02	14.04	
Taxi cars ¹	10.38						12.27	11.75	
Public vans	13.50	8.50	8.30	9.00		11.37	11.02	11.19	
Electric cars ²									0.066
Motorcycles	33.907	33.303	34.751	35.37					
Motor tricycles	12.98	16.83	27.25				15.75	15.86	
Public vans ³						5.84			0.45
Public buses ⁴					3.50	8.793	11.40	5.31	0.749
Passenger boats						3.00			
Freight transport boats						0.025			
Tour buses/Coach	4.00					4.215		3.70	
Airplanes (aviation fuel)						40.00			
Dual track trains						2.00			
Medium trucks						5.011			
Large trucks						4.606		3.91	
Trailer trucks						3.886			

Source: Pollution Control Department, 2011

¹ Energy Policy and Planning Office, 2013

² Summary of electricity charges of electric train purple line (MRTA, 2016)

³ <http://www.nrca.gc.ca/node/16745>

⁴ <https://www.thaipost.net/main/detail/10408>,

<https://chargedevs.com/newswire/nrel-report-battery-electric-buses-are-four-times-more-fuel-efficient-than-cng/>

(3) Amount of CO₂ emission classified by fuel use types (F)

● CO₂ emission rate

Vehicle Type	CO ₂ emission rate per vehicle traveling distance 1 km (gCO ₂ /หน่วย)							
	Fuel Type							
	Benzen e 91, 95	Gasohol 91, 95	E20	E85	Diesel	LPG	CNG	Electricity
Motorcycles	64.62	57.98	49.60					
Service motorcycles	64.62	57.98	49.60					
Motor tricycles	168.79	89.51				107.24	211.73	
Taxi cars	211.07				215.79	137.66	285.90	
Minibus	162.29	159.53	99.53		195.49	140.51	239.12	
Public bus					286.17	148.18	628.15	
Public vans	162.29	234.86	194.96		222.87	153.34	299.97	
Electric cars	Source: Referred to international study hypothesis www.co2nnect.org							65
Private cars	173.54	151.11	116.95	26.54	203.43	148.43	267.27	118.53
Passenger boats					899.57			
Tour bus/coach	549.51				596.96		901.21	
Airplanes					60.425			
Dual track trains					1,360			
Medium trucks					502.13			
Large trucks					546.27		852.71	
Trailer trucks					647.46			
Public passenger buses					286.17	148.18	628.15	

Source: OTP, 2011 referred to model development data provided from the Pollution Control Department, IPCC and www.co2nnect.org

● Conversion factor and Energy Content

Conversion Factor (toe/m ³)						
CNG	LPG	diesel	bio diesel	petrol (benzene)	Electricity (1 MWh)	Jet fuel
0.51	0.78	0.98	0.78	0.86	0.0851	0.817

Conversion Factor (MJ/ unit)				
Benzene 95 (l)	Gasohol 91 (l)	Gasohol 95 (l)	E20 (l)	E85 (l)
31.48	28.33	28.33	25.18	4.72
Diesel B7 (l)	LPG (l)	NGV/CNG (l)	Electricity (kWh)	Jet fuel (l)
36.43	26.62	29.45	3.6	34.53

Emission Factor (kgCO ₂ /TJ)				
Benzene 95	Gasohol 91	Gasohol 95	E20	E85
69,300	69,300	69,300	69,300	69,300
Diesel B7	LPG	NGV/CNG	Electricity (kgCO ₂ /kWh)	Jet fuel
74,100	63,100	56,100	0.94	70,000

Source: Annual Report of Thailand Energy, Department of Alternative Energy Department and Efficiency <https://carbonpositivelife.com/co2-per-kwh-of-electricity/>

Table 5.4-3 Example of evaluation results of energy saving and GHG emission reduction

ประเภทการเดินทางของผู้โดยสาร	AS						I		ปริมาณการใช้พลังงาน			F			GHG ของแต่ละประเภทยานพาหนะรายเชื้อเพลิง (tCO ₂)
	ระยะทางการเดินทางของผู้โดยสารใน 1 วัน VKT (คน-กม./วัน)						Fuel Economy (ลิตร/VKM)	Fuel Economy (L/TKM) (ลิตร/คน-กม.)	ปริมาณการใช้พลังงาน (l)	Conversion Factor (toe/m ³)	การใช้พลังงาน (ktoe)	ปริมาณพลังงานความร้อน (Energy Content)			
	ประเภทยานพาหนะ	ระยะทางรวม	เชื้อเพลิง	สัดส่วนแต่ละประเภทเชื้อเพลิง	ระยะทางแต่ละเชื้อเพลิง	Occupancy (คน/คัน)						Conversion Factor (MJ/ l)	Emission Factor (kgCO ₂ /TJ)	Carbon Emission per liter (tCO ₂ /l)	
	A	Reference	B	C = A x B	D	E	F = E / D	G = C x E / D	H	I = G x H	J	K	L = J x K	M = G x L	
1	เดินขี้น - เชียงของ	1,275,312.00	ดีเซล	100.00%	1,275,312.00	80	2.000	0.02500	31882.800	0.980	0.03125	36.43	74,100	0.00270	86.05
1.1	รถตู้มวลชน	0.00	ดีเซล	50.00%	-	5.2	0.171	0.03293	0.000	0.980	0.00000	36.43	74,100	0.00270	-
			CNG	50.00%	-	5.2	0.000	0.00000	0.000	0.510	0.00000	29.45	56,100	0.00165	-
1.2	รถทัวร์/ รถโค้ช	-471,848.94	ดีเซล	100.00%	(471,848.94)	25	0.237	0.00949	-4477.807	0.980	-0.00439	36.43	74,100	0.00270	(12.09)
1.3	เครื่องบิน	-105,588.57	เชื้อเพลิงอากาศยาน	100.00%	(105,588.57)	100	0.025	0.00025	-26.397	0.817	-0.00002	34.53	70,000	0.00242	(0.06)
1.4	รถยนต์นั่งส่วนบุคคล	-697,874.48	เบนซิน	3.87%	(27,007.74)	1.15	0.079	0.06887	-1860.150	0.860	-0.00160	31.48	69,300	0.00218	(4.06)
			แก๊สโซลีน 91	17.32%	(120,871.86)	1.15	0.074	0.06454	-7801.610	0.860	-0.00671	28.33	69,300	0.00196	(15.32)
			แก๊สโซลีน 95	10.72%	(74,812.14)	1.15	0.079	0.06880	-5147.404	0.860	-0.00443	28.33	69,300	0.00196	(10.11)
			E20	34.78%	(242,720.75)	1.15	0.067	0.05796	-14066.958	0.860	-0.01210	25.18	69,300	0.00175	(24.55)
			E85	4.70%	(32,800.10)	1.15	0.079	0.06854	-2248.043	0.860	-0.00193	4.72	69,300	0.00033	(0.74)
			ดีเซล	23.54%	(164,279.65)	1.15	0.080	0.06982	-11469.708	0.980	-0.01124	36.43	74,100	0.00270	(30.96)
			LPG	5.08%	(35,452.02)	1.15	0.088	0.07641	-2708.755	0.780	-0.00211	26.62	69,300	0.00184	(5.00)
รวมปริมาณการใช้พลังงานที่เปลี่ยนแปลงไป (l/d และ ktoe/d) และ CO ₂ ที่เปลี่ยนแปลงไป (tCO ₂ /day) ของการเดินทางของผู้โดยสาร									(17,924.03)		-0.0133			(16.82)	
เฉลี่ยการใช้พลังงานที่เปลี่ยนแปลงไป (ลิตร/คน/ปี และ ktoe/yr) ของการเดินทางของผู้โดยสาร									(6.54)		(4.85)				
เฉลี่ย CO ₂ ที่เปลี่ยนแปลงไป (MtCO ₂ /yr) ของการเดินทางของผู้โดยสาร														(0.01)	
อัตราการปล่อย CO ₂ (MtCO ₂ e/yr/passenger)														(0.0000)	

ประเภท	AS						I		ปริมาณการใช้พลังงาน			F			GHG ของแต่ละประเภทยานพาหนะรายเชื้อเพลิง (x10 ⁶ tCO ₂)
	ระยะทางการขนส่งสินค้าใน 1 ปี TKT (ล้านตัน-กม./ปี)						Fuel Economy (ลิตร/VKM)	Fuel Economy (L/TKM) (ลิตร/ล้านตัน-กม.)	ปริมาณการใช้พลังงาน (x10 ⁶ l) (ล้านลิตร)	Conversion Factor (toe/m ³)	การใช้พลังงาน (ktoe)	ปริมาณพลังงานความร้อน (Energy Content)			
	ประเภทยานพาหนะ	ระยะทางรวม	เชื้อเพลิง	สัดส่วนแต่ละประเภทเชื้อเพลิง	ระยะทางแต่ละเชื้อเพลิง	อัตราบรรทุก (Capacity) (ตัน)						Conversion Factor (MJ/ l)	Emission Factor (kgCO ₂ /TJ)	Carbon Emission per liter (tCO ₂ /l)	
	A	Reference	B	C = A x B	D	E	F = E / D	G = C x E / D	H	I = G x H	J	K	L = J x K	M = G x L	
2	เดินขี้น - เชียงของ	3.32	ดีเซล	100.00%	3.32	800	2.000	0.003	0.01	0.98	0.0000000	36.43	74,100	0.002699	0.0000
2.1	รถบรรทุก 4 ล้อ/ กระบะบรรทุก	-2.46	ดีเซล	100.00%	(2.46)	1.1	0.200	0.181	(0.45)	0.98	(0.0000004)	36.43	74,100	0.002699	(0.0012)
2.2	รถบรรทุกขนาดกลาง (6 ล้อ)	-0.30	ดีเซล	100.00%	(0.30)	2.7	0.200	0.075	(0.02)	0.98	(0.0000000)	36.43	74,100	0.002699	(0.0001)
2.3	รถบรรทุกขนาดใหญ่ (10 ล้อขึ้นไป)	-0.19	ดีเซล	100.00%	(0.19)	7.7	0.217	0.028	(0.01)	0.98	(0.0000000)	36.43	74,100	0.002699	(0.0000)
2.4	รถบรรทุกพ่วง	-0.37	ดีเซล	100.00%	(0.37)	15.0	0.257	0.017	(0.01)	0.98	(0.0000000)	36.43	74,100	0.002699	(0.0000)
รวมปริมาณการใช้พลังงานที่เปลี่ยนแปลงไป (ล้านลิตร/ปี และ ktoe/yr) และ CO ₂ ที่เปลี่ยนแปลงไป (tCO ₂ /yr) ของการขนส่งสินค้า									(0.47)		(0.46)			(0.0013)	
เฉลี่ยการใช้พลังงานที่เปลี่ยนแปลงไป (ล้านลิตร/ปี และ ktoe/yr) ของการขนส่งสินค้า									(0.47)		(0.46)				
เฉลี่ย CO ₂ ที่เปลี่ยนแปลงไป (MtCO ₂ /yr) ของการขนส่งสินค้า														(0.00)	
อัตราการปล่อย CO ₂ (MtCO ₂ e/yr/ล้านตัน-กม.)														(0.0004)	

เฉลี่ยการใช้พลังงานที่เปลี่ยนแปลงไป (ล้านลิตร/ปี และ ktoe/yr) ของการขนส่งทั้งหมด									(7.01)		(5.31)			
เฉลี่ย CO ₂ ที่เปลี่ยนแปลงไป (MtCO ₂ /yr) ของการขนส่งทั้งหมด														(0.007)

Table 5.4-4 Evaluation results of energy saving and GHG emission reduction

List of Routes	2573 BE (2030 CE)								
	Potential for Energy Reduction (Million Liters)			Potential for Energy Reduction (ktoe)			Potential to Reduce GHG (MtCO ₂ e)		
	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)
Construction of New Railway Line Project									
Den Chai-Chiang Khong	7.01			5.31			0.007		
Nakhon Sawan - Kamphaeng Phet - Tak - Mae Sot		11.60			8.69			0.0120	
Nakhon Sawan-Ban Phai			5.14			3.84			0.0050
Ban Phai - Nakhon Phanom	16.22			12.08			0.016		
Ban Phachi Junction - Nakhon Luang District		0.69			0.67			0.0019	
Surat Thani - Tha Nun	11.28			8.37			0.011		
Songkhla - Pakbara		2.34			2.13			0.0050	
Kanchanaburi - Ban Phu Nam Ron			0.88			0.85			0.0023
Kanchanaburi - Ban Phachi (Link Laem Chabang)		10.32			7.87			0.0110	
Ubon Ratchathani - Chong Mek			1.18			0.89			0.0012
Map Ta Phut - Rayong - Chanthaburi - Trat			13.53			10.04			0.0130
Chumphon - Ranong			2.59			1.96			0.0027
Thap Put - Krabi			3.35			2.49			0.0032
Surat Thani - Donsak			1.80			1.34			0.0020
Total	34.51	24.94	28.47	25.76	19.35	21.40	0.034	0.030	0.029
	87.92			66.51			0.09		

5.4.3 Energy use improvement or enhancement project (Improve)

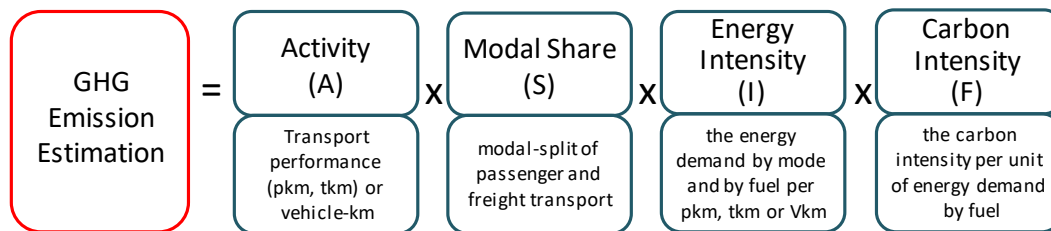
As for GHG emission reduction evaluation for individual projects, the energy use improvement or enhancement project (Improve), for example, procurement of 35 electric passenger vehicles including electric charging station construction was used to analyzed with details as follows:

Action Plan 1.1.3.2	Improvement of urban public passenger vehicles
Project 1.1.3.2-1	Procurement of 35 electric passenger vehicles including electric charging station construction
Reasons and Necessities	Improve urban public passenger vehicles to replace the existing diesel-driven vehicles that are defective and worn out over time of service, enhance quality and standards of service as well as the public bus reliability, promote use of public transport, reduce fuel use in transport sector according to the government policy, and mitigate global warming and pollution problems
Nature of Project	Most of current public buses above 60% are in service for more than 20 years. As a result, the buses are defective and worn out, and there are many broken vehicles leading to insufficient number of buses for the service. Therefore, Bangkok Mass Transit Authority (BMTA) plans to purchase additional public buses to replace the existing diesel-driven buses. According to the plan, 200 electric buses will be purchased as well as maintenance services. At an initial stage, the electric passenger buses will be purchased to replace the existing worn out passenger buses using internal combustion engine for 35 buses.
Objective of Project	Improve energy use efficiency of public buses in Bangkok
Indicator	Proportion of electric buses that are changes
Target Value	Proportion of energy use in public buses reduced by 30% in 2030
Budget	571.94 million baht
Source of Budget	Bureau of Budget
Main department	BMTA
Supporting department	DLT, OTP

Results of Project	
Amount of energy use reduction as of 2030	0.28 kilo ton oil equivalent (ktoe)
Amount of GHG emission reduction as of 2030	0.00192 million ton carbon dioxide equivalent (MtCO ₂ e)
Marginal Abatement Cost, baht/tCO ₂ e	-2,915,947.58

Evaluation Methods

The energy use and GHG emission reduction is evaluated based on Bottom-Up Method, which indirectly measures CO₂ mainly based on actual and measured travel demand using ASIF principle (Activity–Structure-Intensity-Fuel) as shown in the equation.



As for this evaluation, the passenger kilometer travel or ton kilometer travel (PKT, TKT) [A] changed between the base case and measure case is used for energy use and GHG emission reduction.

Hypothesis of Evaluation

Evaluation hypothesis for land transport are as follows:

- As a project on energy-saving and environmental friendly public transport systems such as procurement and rent of NGV buses as replacement for Bangkok transit services and procurement and rent of electric passenger vehicles including electric charging station construction, traveling distance was determined to be the same, only fuel consumption rate was different.
- Average distance for one NGV bus was 400 km/day/bus, and 250 km/day/bus for one EV bus (<https://www.voicetv.co.th/read/213210>)

Data used in the analysis

Data used for MRV evaluation based on Bottom-up method are:

(1) Travel demand in study areas (A and S)

- Number of passengers and freights changed between base case and measure case
 - Number of cars changed as of the project starting year = 35 cars/day
 - Average distance = 250 kilometer/car/day

(2) Energy use proportion of each transport mode (I)

- Total distance proportion classified by vehicle and fuel types

Vehicle type	Proportion of fuel used								Total fuel use classified by vehicle types
	Benzene 95	Gasohol 91	Gasohol 95	E20	E85	Diesel	LPG	CNG	
Personal vans/cars/pickups	3.87%	17.32%	10.72%	34.78%	4.70%	23.54%	5.08%	0.00%	100%
Personal motorcycles	45.08%	2.53%	2.24%	27.43%	0.00%	0.00%	0.00%	0.00%	77%
Taxi cars							23.83%	76.17%	100%
Public buses						63.76%		36.24%	100%
Public vans						50.00%		50.00%	100%

Source: Survey results of energy use reduction tracking project resulting from transport measures, OTP, 2018

- Fuel Economy (FE)

Fuel type	Benzene 95 (km/L)	Gasohol 91 (km/L)	Gasohol 95 (km/L)	E20 (km/L)	E85 (km/L)	Diesel B7 (km/L)	LPG (km/kg)	NGV/CNG (km/kg)	Electricity (km/kWh)
Cars ¹	12.63	13.47	12.64	15.00	12.69	12.45	11.38	12.56	0.16
4-wheel trucks/pickups ¹	13.50	12.98	11.75	17.63		12.96	12.02	14.04	
Taxi cars ¹	10.38						12.27	11.75	
Public vans	13.50	8.50	8.30	9.00		11.37	11.02	11.19	
Electric cars ²									0.066
Motorcycles	33.907	33.303	34.751	35.37					
Motor tricycles	12.98	16.83	27.25				15.75	15.86	
Public vans ³						5.84			0.45
Public buses ⁴					3.50	8.793	11.40	5.31	0.749
Passenger boats						3.00			
Freight transport boats						0.025			
Tour buses/Coach	4.00					4.215		3.70	
Airplanes (jet fuel)						40.00			
Dual track trains						2.00			
Medium trucks						5.011			
Large trucks						4.606		3.91	
Trailer trucks						3.886			

Source: Pollution Control Department, 2011

¹ Energy Policy and Planning Office, 2013

² Summary of electricity charges of electric train purple line (MRTA, 2016)

³ <http://www.nrcan.gc.ca/node/16745>

⁴ <https://www.thaipost.net/main/detail/10408>,

<https://chargedevs.com/newswire/nrel-report-battery-electric-buses-are-four-times-more-fuel-efficient-than-cng/>

(3) Amount of CO₂ emission classified by fuel use types (F)

- CO₂ emission rate

Vehicle Type	CO ₂ emission rate per vehicle traveling distance 1 km (gCO ₂ /หน่วย)							
	Fuel Type							
	Benzene 91, 95	Gasohol 91, 95	E20	E85	Diesel	LPG	CNG	Electricity
Motorcycles	64.62	57.98	49.60					
Service motorcycles	64.62	57.98	49.60					
Motor tricycles	168.79	89.51				107.24	211.73	
Taxi cars	211.07				215.79	137.66	285.90	
Minibus	162.29	159.53	99.53		195.49	140.51	239.12	
Public bus					286.17	148.18	628.15	
Public vans	162.29	234.86	194.96		222.87	153.34	299.97	
Electric cars	Source: Referred to international study hypothesis www.co2nnect.org							65
Private cars	173.54	151.11	116.95	26.54	203.43	148.43	267.27	118.53
Passenger boats					899.57			
Tour bus/coach	549.51				596.96		901.21	
Airplanes					60.425			
Dual track trains					1,360			
Medium trucks					502.13			
Large trucks					546.27		852.71	
Trailer trucks					647.46			
Public passenger buses					286.17	148.18	628.15	

Source: OTP, 2011 referred to model development data provided from the Pollution Control Department, IPCC and www.co2nnect.org

- Conversion factor and Energy Content

Conversion Factor (toe/m ³)						
CNG	LPG	diesel	bio diesel	petrol (benzene)	Electricity (1 MWh)	Jet fuel
0.51	0.78	0.98	0.78	0.86	0.0851	0.817

Conversion Factor (MJ/ unit)				
Benzene 95 (l)	Gasohol 91 (l)	Gasohol 95 (l)	E20 (l)	E85 (l)
31.48	28.33	28.33	25.18	4.72
Diesel B7 (l)	LPG (l)	NGV/CNG (l)	Electricity (kWh)	Jet fuel (l)
36.43	26.62	29.45	3.6	34.53

Emission Factor (kgCO ₂ /TJ)				
Benzene 95	Gasohol 91	Gasohol 95	E20	E85
69,300	69,300	69,300	69,300	69,300
Diesel B7	LPG	NGV/CNG	Electricity (kgCO ₂ /kWh)	Jet fuel
74,100	63,100	56,100	0.94	70,000

Source: Annual Report of Thailand Energy, Department of Alternative Energy Department and Efficiency <https://carbonpositivelife.com/co2-per-kwh-of-electricity/>

Table 5.4-5 Example of evaluation results of Energy saving and GHG emission reduction

AS					I	Energy consumption			F			CO ₂ Reduction (tCO ₂ e)	
Travel Distance in 1 Day VKT (people - km / day)					Fuel Economy* (liter/VKM)/ (kg/VKM)	Energy consumption (l)/(kg)	Conversion Factor (toe/m ³)	Energy consumption (ktoe)	Heat Energy Consumption (Energy Content)				
Vehicle type	Total Distance	Fuel	Proportion of Each Fuel	Distance of Each Fuel					Conversion Factor (MJ/ l)/ (MJ/kg)	Emission Factor (kgCO ₂ /TJ)	Carbon Emission per liter (tCO ₂ /l)/ (tCO ₂ /kg)		
Procurement of 35 electric buses including electric charging station construction													
Vehicle Type	A		B	C = A x B	D	E = C x D	F	G = E x F	H	I	J = H x I	K = E x J	
1 Diesel Bus	8,750	Diesel	100.00%	8,750.00	0.510	4,464.29	0.980	0.00438	36.43	74,100	0.00270	12.05	
2 EV Buses 35 Cars	8,750	Electric	100.00%	8,750.00	1.335	11,682.24				0.58		6.80	
Changing Energy Consumption (l / d and ktoe / d) and Changing CO ₂ (tCO ₂ e / day) of Passenger Travel						7,217.96						(5.25)	
Average of Changing Energy Consumption (million liters / year and ktoe / yr) of Passenger Travel						2.63							
Average of Changing CO ₂ (MtCO ₂ e / yr) of Passenger Travel												(0.00192)	

Note: * Information from BMTA (total fuel consumption / total distance traveled)

Chapter 6 Project Efficiency Evaluation on GHG Emission Reduction, and Economic, Social and Environmental Impact Analysis

6.1 Project Efficiency Evaluation Methods for GHG Emission Reduction

The project efficiency evaluation for GHG emission reduction is analysis of CO₂ emission reduction (tCO₂e) comparing between the base case and scenario case for each project using MRV method which is the most appropriate methods, according to the action plans and projects under the strategic operation plan of the Ministry of Transport in 2017 – 2021, for GHG emission reduction evaluation for individual projects are determined. Both MRV methods, i.e. Top-down and Bottom-up methods might be applied depending on each project's suitability, and it can be forecasted using traffic and energy models for CO₂ measurement in the target years. Investment fund, operation and maintenance fees, and Value of Time (VOT) benefits are evaluated. The project efficiency is Project Life Cycle Cost divided by the Project Life Cycle Carbon Reduction.

For the project efficiency evaluation for GHG emission reduction, individual project's GHG emission is evaluated in ton per carbon dioxide equivalent (tCO₂e) unit, both in baseline and mitigation scenarios, including GHG emission reduction from every project to be evaluated for investment fund until 2030.

6.2 GHG Emission Evaluation Based on Measurement, Reporting and Verification (MRV) Method

In the plans, projects and activities of agencies under the Ministry of Transport regarding GHG reduction are determined and classified into 3 groups as follows:

Group 1 - Existing projects and plans that are able to evaluate GHG emission reduction through the Measurement, Reporting and Verification (MRV)

Group 2 - Recommended projects and plans for additional operations

Group 3 - Added projects and measures with potential for GHG reduction, but unable to measure the reduction amount, and firstly, baseline data must be collected.

In these projects and plans, CO₂ reduction amount according to operation time period is measured, as shown in table **6.2-1**.

Table 6.2-1 GHG reduction estimation using Measurement, Reporting and Verification (MRV)

Action Plans and Projects		GHG potential (MtCO ₂ e)		
		Short (63- 64)	Medie m (65- 68)	Long (69- 73)
Group 1 - Existing projects and plans that are able to evaluate GHG emission reduction and perform the Measurement, Reporting and Verification (MRV)				
Measure 1.1.1	Travel Avoidance or Reduction (Avoid/Reduce)			
Action Plan 1.1.1.1	Development of Travel Demand Management (TDM) Mechanism			
Project 1.1.1.1-1	Parking fee collection measure in high-traffic areas		2.00	
Project 1.1.1.1-2	Road pricing measure in high-traffic areas			
Action Plan 1.1.1.2	Development of areas surrounding public transport stations (Transit Oriented Development, TOD)			
Project 1.1.1.2-1	Development of areas surrounding public transport stations (Transit Oriented Development, TOD)		0.9	
Measure 1.1.2	Shift of Transport Modes (Shift/Maintain)			
Action Plan 1.1.2.1	Infrastructure development to support the travel mode shift in railway transport systems			
Project 1.1.2.1-1	Construction of dual tracks for 32 lines	1.429	0.026	0.019
Project 1.1.2.1-2	Construction of mass transit electric train systems and suburb train systems for 20 lines (including extensions)	0.138	0.891	0.032
Project 1.1.2.1-3	New railway construction for 14 lines	0.034	0.030	0.032
Project 1.1.2.1-4	High-speed train + EEC for 4 lines	0.747	0.702	1.338
Action Plan 1.1.2.2	Infrastructure development to support the travel mode shift in water transport systems			
Project 1.1.2.2-1	Development of Single Rail Transfer Operator (SRTO) at Laem Chabang port, Phase 1 and 2	0.7935		
Project 1.1.2.2-2	Construction of Chao Praya and Nan river dams for water transport operation	0.0812		
Project 1.1.2.2-3	Enhancement of freight transport system via Pasak river	0.0478		
Project 1.1.2.2-4	Ferry development linking upper gulf of Thailand	0.0014		
Project 1.1.2.2-5	Laem Chabang Port development, Phase 3		0.4122	
Project 1.1.2.2-6	Mab Taphut industrial port development, Phase 3		0.0414	
Measure 1.1.3	Improvement and development of energy use efficiency in transport sector (Improve)			
Action Plan 1.1.3.1	Enhancement of energy use efficiency in private cars			
Project 1.1.3.1-1	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars	4.197		
Project 1.1.3.1-2	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for motorcycles	1.338		
Project 1.1.3.1-3	Annual car tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate)	1.535		
Project 1.1.3.1-4	Expansion of Electric vehicles	1.440		
Action Plan 1.1.3.2	Enhancement of urban public bus efficiency			
Project 1.1.3.2-1	Procurement of 35 electric buses including electric charging station construction	0.0019 2		
Project 1.1.3.2-2	Procurement of 1,453 hybrid buses	0.129		

Action Plans and Projects		GHG potential (MtCO _{2e})		
		Short (63-64)	Medium (65-68)	Long (69-73)
Project 1.1.3.2-3	Hybrid bus rent (7 years) for 400 buses	0.0354		
Action Plan 1.1.3.3	Enhancement of railway system efficiency			
Project 1.1.3.3-1	8 power cars modification (61-64)	0.009		
Project 1.1.3.3-2	12 power cars modification (61-64)	0.0136		
Project 1.1.3.3-3	Provision of diesel electric cars to replace GE diesel electric ones for 50 cars (61-64)	0.00964		
Action Plan 1.1.3.4	Enhancement of energy use efficiency in aviation			
Project 1.1.3.4-1	Runway constructions, line 3 and 4 of Suvarnabhumi Airport		0.077	
Action Plan 1.1.3.5	Promotion of logistic management for energy-saving			
Project 1.1.3.5-1	Promotion of Logistics and Transport Management (LTM) for energy-saving	0.19		
Project 1.1.3.5-2	Research and development of Logistics and Transport Management Application (LTMA) for energy-saving			
Total GHG emission reduction of Group 1		12.17	5.08	1.42
		18.67		
Group 2 - Recommended projects and plans for additional operations				
Measure 1.2.1	Travel Avoidance or Reduction (Avoid/Reduce)			
Measure 1.2.2	Travel mode shift (Shift/Maintain)			
Action Plan 1.2.2.1	Infrastructure development to promote travel mode shift in railway transport systems			
Project 1.2.2.1-1	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and vicinity		2.83	
Project 1.2.2.1-2	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla		0.72	
Action Plan 1.2.2.2	Development of travel mode shift promotion mechanism			
Project 1.2.2.2-1	Improvement of urban and outskirt public service via hybrid passenger vehicles		0.043	
Measure 1.2.3	Improvement and development of energy use efficiency in transport sector (Improve)			
Action Plan 1.2.3.1	Enhancement of energy use efficiency in private cars			
Project 1.2.3.1-1	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars based on strict tax measure		1.866	
Project 1.2.3.1-2	Promote disposal of deteriorated vehicles (old vehicles) from the system (more than 15 years of service or exceeding 200,000 km)			4.15
Project 1.2.3.1-3	Improvement of air conditioning systems in cars		1.00	
Project 1.2.3.1-4	Use of fuel mechanism to carry forward use of effective vehicles		2.056	
Action Plan 1.2.3.2	Improvement of urban public passenger vehicle efficiency			

Action Plans and Projects		GHG potential (MtCO ₂ e)		
		Short (63- 64)	Medie m (65- 68)	Long (69- 73)
Project 1.2.3.2-1	Replace air-conditioned passenger vans with 4,626 electric minibuses			0.0279
Project 1.2.3.2-2	Promote use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla			2.5
Project 1.2.3.2-3	Replace delivery motorcycles with electric motorcycles in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla			0.0006
Action Plan 1.2.3.3	Promotion of Logistic Management for energy-saving			
Project 1.2.3.3-1	Backhaul Management		0.06	
Project 1.2.3.3-2	Establish Distribution Center (DC)		0.241	
Project 1.2.3.3-3	Establish training center to train for energy-saving driving in 5 regions nationwide		0.31	
Action Plan 1.2.3.4	Development of Transportation Management System (TMS)			
Project 1.2.3.4-1	Development and promotion of Transportation Management System (TMS)		0.12	
Action Plan 1.2.3.5	Change of electric devices such as light bulbs in transport infrastructure			
Project 1.2.3.5-1	Shift to use of LED light bulbs in all ports/airports/highways		0.82	
Total GHG emission reduction of Group 2		0.00	10.07	6.68
		16.74		
Group 3 - Added projects and measures with potential for GHG reduction, but unable to measure the reduction amount, and firstly, baseline data must be collected.				
Measure 1.3.1	Travel Avoidance or Reduction (Avoid/Reduce)			
Measure 1.3.2	Travel mode shift (Shift/Maintain)			
Action Plan 1.3.2.1	Development of Travel Mode Shift Promotion Mechanism			
Project 1.3.2.1-1	Establish public transport promotion fund			
Project 1.3.2.1-2	Improve conditions of public bus service concession			
Project 1.3.2.1-3	Increase public bus service operating channels and provide priority to public buses in urban areas			
Project 1.3.2.1-4	Adjust a number of public bus trips and operation routes to connect to the railway systems (Feeder)			
Project 1.3.2.1-5	Provide real-time public transport service information via mobile application and improve provision of operating information on intelligent bus stops			
Project 1.3.2.1-6	Develop park and ride spots for railway transit customers (phase 2) to support transport demand management system			
Project 1.3.2.1-7	Develop an integral common-ticketing system for nationwide transport			
Project 1.3.2.1-8	Publicize information and data to the public to motivate them to use the service			
Action Plan 1.3.2.2	Infrastructure development to promote travel mode shift in water transport systems			
Project 1.3.2.2-1	Study and manage ship queuing			

Action Plans and Projects		GHG potential (MtCO ₂ e)		
		Short (63- 64)	Medie m (65- 68)	Long (69- 73)
Project 1.3.2.2-2	Establish Bangkok port's one stop service			
Project 1.3.2.2-3	Develop database and monitor shipping data and information			
Measure 1.3.3	Improvement and development of energy use efficiency in Transport sector (Improve)			
Action Plan 1.3.3.1	Enhance energy use efficiency in inter-city buses			
Project 1.3.3.1-1	Provide inter-city buses			
Project 1.3.3.1-2	Perform in accordance with the Eco-efficiency project according to memorandum of agreement, state enterprise evaluation, accounting year 2018			
Action Plan 1.3.3.2	Development of Training and Monitoring Systems for Eco-driving			
Project 1.3.3.2-1	Establish training center to train truck driving trainers (Training of Trainer) according to Eco-driving course in all regions nationwide			
Project 1.3.3.2-2	Develop On-board Diagnostic (OBD) technology and devices and database system for eco-driving evaluation among trucks			
Project 1.3.3.2-3	On-board Diagnostic (OBD) technology and devices for eco-driving evaluation among trucks			
Action Plan 1.3.3.3	Enhancement of truck transport management standards (Q Mark)			
Project 1.3.3.3-1	Enhance truck transport management standards to promote energy efficiency and GHG emission reduction			
Project 1.3.3.3-2	Recommend and encourage truck service operators to improve their operation quality according to truck transport standards (Q Mark)			
Project 1.3.3.3-3	Create marketing demands of truck transport standards (Q Mark)			
Project 1.3.3.3-4	Follow-up and give advices to truck service operators to perform in accordance with truck transport standards (Q Mark)			
Action Plan 1.3.3.4	Improvement of energy use and reduction of CO₂ in Cold Chain Logistics systems in Thailand			
Project 1.3.3.4-1	Study methods for energy use improvement and CO ₂ reduction for Cold Chain Logistics			
Project 1.3.3.4-2	Change of cooling substance used by trucks in Cold Chain Logistics systems to improve the energy use and reduce CO ₂			
Project 1.3.3.4-3	Pilot Project for cooling substance change in trucks in Cold Chain Logistics systems to improve the energy use and reduce CO ₂			
Action Plan 1.3.3.5	Logistics System Development			
Project 1.3.3.5-1	Sustainable logistics operations (Green Logistics) by private sectors			
Total GHG emission reduction of Group 3		12.17	15.15	8.10
		35.42		

According to table 6.2-1, it is found that the existing projects and plans, which are able to evaluate GHG emission reduction using the Measuring, Reporting and Valuation (MRV) (Group 1), are able to reduce the GHG emission for 18.67 MtCO₂e. The recommended projects and plans (group 2) are able to reduce the GHG emission at 16.74 MtCO₂e, while the GHG emission reduction in the added projects and measures (group 3) cannot be evaluated, since baseline data must be collected by responsible agencies as database for the following year's evaluation.

As a result, according to efficiency analysis of individual plans and projects based on the Measurement, Reporting and Verification (MRV) method through evaluation and comparison of energy use and GHG emission both in baseline and mitigation scenarios in the transport sector's action plans and projects as shown in **table 6.2-1**, it is found that the existing projects and plans in transport sector has potentials for GHG reduction of 18.67 MtCO₂e, and if the transport sector adds the operation plans as suggested in Group 2, it will be able to achieve the GHG reduction goal of 31 MtCO₂e as determined.

GHG Potentials of the transport sector's plans and projects for GHG emission reduction (Group 1) and recommended projects and plans (Group 2) can be shown as diagram as in **figure 6.2-1** classified by group color A-S-I; A (Avoid) in red, S (Shift) in blue and I (Improve) in green.

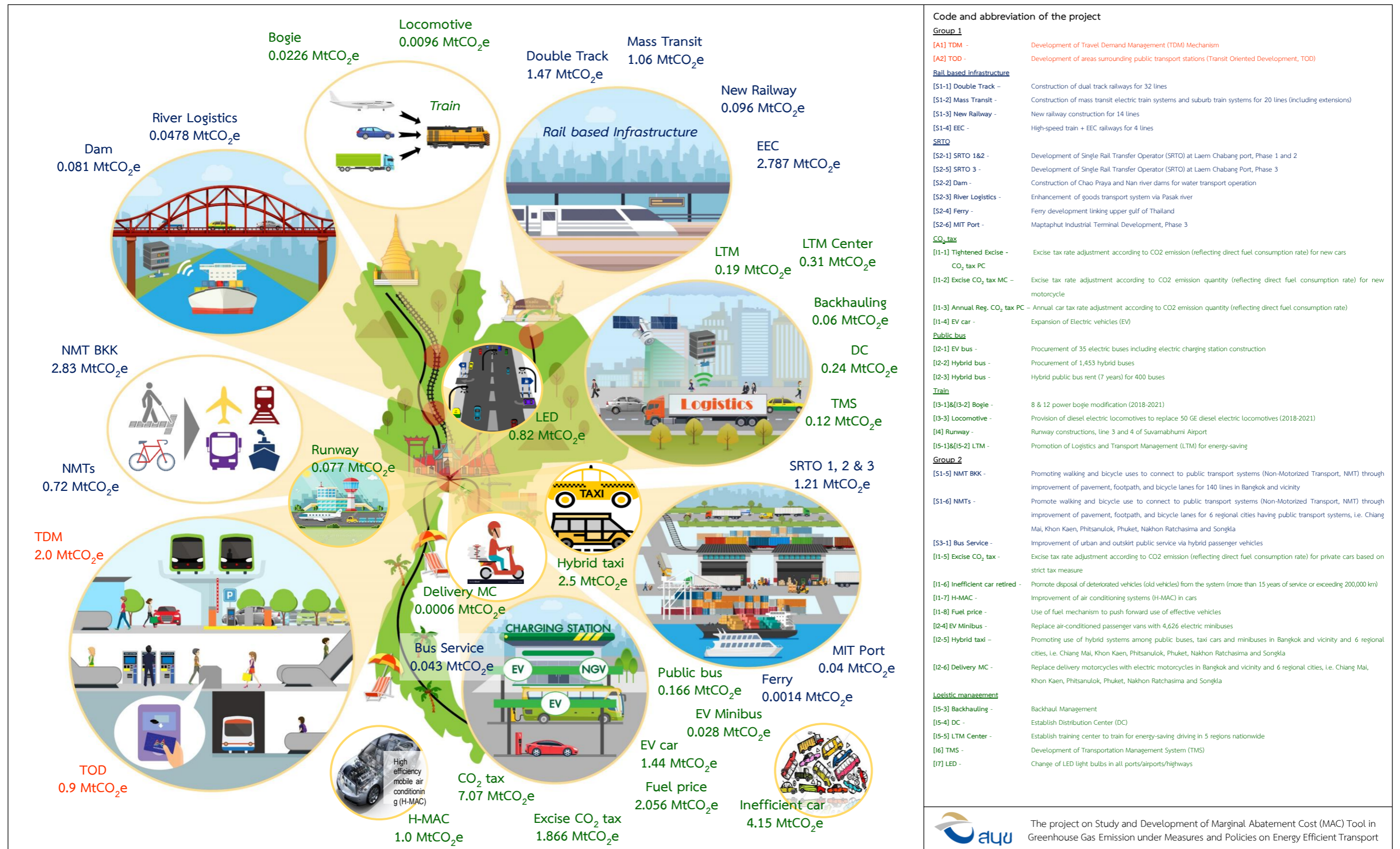


Figure 6.2-1 Potential for GHG emission reduction of plans and projects in the transport sector, Group 1 and Group 2

6.3 The Analysis of Economy, Society, and Environment Impacts

6.3.1 PESTLE Analysis

PESTEL analysis is used to analyze the economy, society, and environment impacts. The benefit of PESTEL is to analyze the external factor (uncontrolled factors). We will know the other factor affecting the project implementation and we will use it to plan the strategy in the future.

PESTEL analysis according to A-S-I Approach of projects and plans in overview transport sector, we can further analyze SWOT and TOWS to determine the framework being consistent with the guidelines of GHG reduction and use it as a tool for making decision to choose project implementation of GHG reduction by MACC model.

In PESTEL analysis according to projects and plans which is classified by A-S-I Approach, it is used to consider about the project efficiency and then it is used to compare with the costs of GHG emissions reduction of project. The PESTEL analysis is shown in **table 6.3.1-1**.

6.3.2 SWOT Analysis and TOWS Matrix

Prioritizing of projects and plans of GHG emission reduction in transport sector (NDC Action Plan) has been made by collecting project and plan information. The meeting with other agencies is conducted to initiate the discussion on the projects and plans related to GHG reduction. Also, integrated cooperation from relevant agencies by organizing training and discussion meeting in order to collect opinions, suggestions, and ideas or project operation plans of other agencies in the future. It needs to analyze Strengths, Weaknesses, Opportunities, and Threats (SWOT) in order to determine the framework being consistent with the guidelines of GHG reduction and use it as a tool for making decision to choose project implementation of GHG reduction. The related agencies can operate the project according to operation plan and it can be a guideline to request the budget and use it to support the operation of agencies' GHG reduction.

1) The Analysis of Strength, Weakness, Opportunity, Threat (SWOT)

The analysis of Strengths, Weaknesses, Opportunities, and Threats directly affects the implementation of overview country's GHG reduction, both internal and external factor. The analysis of Strengths, Weaknesses, Opportunities, and Threats comes from integrated opinion collection from focus group meeting at the Office of Transport and Traffic Policy and Planning by the experts, knowledgeable and experienced representatives of planning agencies and operational agencies from government and private sectors who are related to sustainable transportation system and the climate change. It also has additional in-depth analysis by Thai and foreign experts of consultants with working experience in Thailand and many countries. The result of this analysis is used as basic important data to determine the vision, mission, and objective and make a strategy in the future. The overview SWOT analysis is summarized as follows:

(1) Strengths

1) There is distinct the country's policy and strategy such as 20 years-National Strategy, the strategy of Ministry of Transportation in 2017-2021. The policies and strategies encourage and develop the transportation systems that reduce energy consumption, rely on clean energy and be environmentally friendly.

2) The agencies of government sector are ready for GHG emissions reduction, such as the preparation of the master plan for climate change (ONEP), the master plan for sustainable transportation system development and climate change problem decrease (OTP), the guidelines for the country's GHG reduction in 2021-2030 (ONEP), and action plan for energy conservation (EPPO).

3) There is both national and Ministry's operation plan to support the development of sustainable transport and being environmentally friendly. There is distinct developing plan of rail system transportation, including the accessibility plan.

(2) Weaknesses

1) The operation of GHG reduction is not the main responsibility of the Ministry. So, the government officials do not prepare for operation and planning. Also, as it is not the main responsibility of the Ministry, the budget request is difficult.

2) Since the government officials lack the effective data storage, they don't have the information of design, planning, and policy formulation related to monitoring and evaluating the reduction of GHG emissions.

3) The government officials are not alert to GHG. Their knowledge and understanding about GHG emissions, Measurement, Reporting, Verification, and MRV systems are not enough for their agencies to use. It, then, lacks the follow-up evaluation.

4) Due to the divided Administration structure, there is no a central agency to coordinate on central database and knowledge about the sustainable transportation and GHG reduction. The information connection lacks the integration between related agencies. There is redundant operation. Also, the education and research prior to the policy formulation don't have the quality. And the amount is insufficient to make the policy's results practical.

5) The executives and political sector's understanding about environmental and global warming problems is not enough. Thus, they are not alert to these problems and do not locate enough budget. The policies focus more on the advantage of industry sector and economy and lacks the responsibility to society and environment.

6) Due to the change of government, it lacks the continuity in policies enforcement. This interrupted the operation.

7) The current public transport system is still inefficient, delayed, and inconvenient, without the effective connection with railways transportation system, such as less and unsafe transport connection system of feeder and bicycle lane. It made the people use their own personal vehicle.

8) Because the people are not aware of the problem and don't have the environmental consciousness, they are not ready to change their own habits to reduce GHG emissions and do not cooperate enough with the government's environmental policy.

9) Traffic system management, the application of technology to help logistics system management and passengers travel (ITS) is not effective enough. It made the traffic jam and caused more pollution and GHG.

10) The government lacks the integrated area such as city planning integration or the development of the area for commercial public transportation system.

(3) Opportunities

1) There is international mechanism to support the reduction of climate change from abroad on knowledge and capital, e.g., Global Environment Fund (GEF). It made the transfer of technology which can help to reduce the emissions of GHG. Some international organizations have clearly specified the framework for reducing the GHG emissions (e.g., the International Civil Aviation Organization (ICAO)).

2) The government have more awareness of the importance of many continuous transportation modes. The government encourages the development of national sustainable transportation system and the reduction of personal vehicles and trucks, such as rail transportation development, joint ticket system policy to promote mass transportation, free trains and buses.

3) The government has Top-down policy to well encourage the reduction of energy use and has a plan to promote electric cars or technology to increase the automotive energy efficiency.

4) The private sector is active in supporting the climate change reduction projects. They have more understanding and are more interested in preventing the global warming problem.

(4) Threats

1) The uncertainty of current national cooperation agreement on GHG emissions reduction. The developed countries (a group of countries in Annex I) lack the sincerity in solving the global warming problem.

2) Political instability (Geopolitical) resulted in frequent changes in policies, goals, and master plans. It caused unclear and discontinuous development direction.

3) Because the oil prices are fluctuated and decreased, the people are not interested in reducing energy consumption as expected.

4) The technology of energy efficiency promoting that must be taken from foreign countries. So, it is high operation cost.

5) The calculation of CO₂ value is uncertain, it needs to implement the carbon price measure, carbon taxes measure, and it causes unclear excise tax operation

Table 6.3.1-1 PESTEL analysis based on A-S-I approach of plans and projects in transport sector

Factor	Measure 1 Avoid/Reduce	Measure 2 Shift/Maintain	(Measure 3 I Improve
Political Stability	<ul style="list-style-type: none"> There is distinct the country’s policy and strategy such as 20 years-National Strategy, the strategy of Ministry of Transportation in 2017-2021. The policies and strategies encourage and develop the transportation systems that reduce energy consumption, rely on clean energy and be environmentally friendly. Due to the change of government, it lacks the continuity in policies enforcement. This interrupted the operation. The executives and political sector’s understanding about environmental and global warming problems is not enough. Thus, they are not alert to these problems and do not locate enough budget. The policies focus more on the advantage of industry sector and economy and lacks the responsibility to society and environment. The uncertainty of current national cooperation agreement on GHG emissions reduction. The developed countries (a group of countries in Annex I) lack the sincerity in solving the global warming problem. Political instability (Geopolitical) resulted in frequent changes in 	<ul style="list-style-type: none"> There is distinct the country’s policy and strategy such as 20 years-National Strategy, the strategy of Ministry of Transportation in 2017-2021. The policies and strategies encourage and develop the transportation systems that reduce energy consumption, rely on clean energy and be environmentally friendly. There is both national and Ministry’s operation plan to support the development of sustainable transport and being environmentally friendly. There is distinct developing plan of rail system transportation, including, the accessibility plan. Due to the change of government, it lacks the continuity in policies enforcement. This interrupted the operation. The executives and political sector’s understanding about environmental and global warming problems is not enough. Thus, they are not alert to these problems and do not locate enough budget. The policies focus more on the advantage of industry sector and economy and lacks the responsibility to society and environment. The government have more awareness of the importance of many continuous transportation modes. The government encourages the development of national sustainable transportation system and the reduction of personal vehicles and trucks, such as rail transportation development, joint ticket system policy to promote mass transportation, free trains and buses. The uncertainty of current national cooperation agreement on GHG emissions reduction. The 	<ul style="list-style-type: none"> There is distinct the country’s policy and strategy such as 20 years-National Strategy, the strategy of Ministry of Transportation in 2017-2021. The policies and strategies encourage and develop the transportation systems that reduce energy consumption, rely on clean energy and be environmentally friendly. Due to the change of government, it lacks the continuity in policies enforcement. This interrupted the operation. The executives and political sector’s understanding about environmental and global warming problems is not enough. Thus, they are not alert to these problems and do not locate enough budget. The policies focus more on the advantage of industry sector and economy and lacks the responsibility to society and environment. The government has Top-down policy to well encourage the reduction of energy use and has a plan to promote electric cars or technology to increase the automotive energy efficiency. The uncertainty of current national cooperation agreement on GHG emissions reduction. The developed countries (a group of countries in Annex I) lack the sincerity in solving the global warming problem. Political instability (Geopolitical) resulted in frequent changes in policies, goals, and

Factor	Measure 1 Avoid/Reduce	Measure 2 Shift/Maintain	(Measure 3 I Improve
	<p>policies, goals, and master plans. It caused unclear and discontinuous development direction.</p> <ul style="list-style-type: none"> ● 	<p>developed countries (a group of countries in Annex I) lack the sincerity in solving the global warming problem.</p> <ul style="list-style-type: none"> ● Political instability (Geopolitical) resulted in frequent changes in policies, goals, and master plans. It caused unclear and discontinuous development direction. 	<p>master plans. It caused unclear and discontinuous development direction.</p>
Economic	<ul style="list-style-type: none"> ● Because the oil prices are fluctuated and decreased, the people are not interested in reducing energy consumption as expected. 	<ul style="list-style-type: none"> ● Because the oil prices are fluctuated and decreased, the people are not interested in reducing energy consumption as expected. 	<ul style="list-style-type: none"> ● Because the oil prices are fluctuated and decreased, the people are not interested in reducing energy consumption as expected.
Social	<ul style="list-style-type: none"> ● Because the people are not aware of the problem and don't have the environmental consciousness, they are not ready to change their own habits to reduce GHG emissions and do not cooperate enough with the government's environmental policy. 	<ul style="list-style-type: none"> ● Because the people are not aware of the problem and don't have the environmental consciousness, they are not ready to change their own habits to reduce GHG emissions and do not cooperate enough with the government's environmental policy. 	<ul style="list-style-type: none"> ● Because the people are not aware of the problem and don't have the environmental consciousness, they are not ready to change their own habits to reduce GHG emissions and do not cooperate enough with the government's environmental policy.
Technology	<ul style="list-style-type: none"> ● Traffic system management, the application of technology to help logistics system management and passengers travel (ITS) is not effective enough. It made the traffic jam and caused more pollution and GHG. 	<ul style="list-style-type: none"> ● The current public transport system is still inefficient, delayed, inconvenient, without the effective connection with railways transportation system, such as less and unsafe transport connection system of Feeder and bicycle lane. It made the people use their own personal vehicle. ● Traffic system management, the application of technology to help logistics system management and passengers travel (ITS) is not effective enough. It made the traffic jam and caused more pollution and GHG. 	<ul style="list-style-type: none"> ● The technology of energy efficiency promoting that must be taken from foreign countries. So, it is high operation cost.
Environment			<ul style="list-style-type: none"> ● The calculation of CO₂ value is uncertain, it needs to implement the carbon price measure, carbon taxes measure, it causes unclear excise tax operation

Factor	Measure 1 Avoid/Reduce	Measure 2 Shift/Maintain	(Measure 3 I Improve
<p>Legal</p>	<ul style="list-style-type: none"> ● The operation of GHG reduction is not the main responsibility of the Ministry. So, the government officials do not prepare for operation and planning. Also, as it is not the main responsibility of the Ministry, the budget request is difficult. ● The government lacks the integrated area, such as city planning integration or the development of the area for commercial public transportation system. 	<ul style="list-style-type: none"> ● The operation of GHG reduction is not the main responsibility of the Ministry. So, the government officials do not prepare for operation and planning. Also, as it is not the main responsibility of the Ministry, the budget request is difficult. ● The government lacks the integrated area, such as city planning integration or the development of the area for commercial public transportation system. 	<ul style="list-style-type: none"> ● The operation of GHG reduction is not the main responsibility of the Ministry. So, the government officials do not prepare for operation and planning. Also, as it is not the main responsibility of the Ministry, the budget request is difficult. ● The government lacks the integrated area, such as city planning integration or the development of the area for commercial public transportation system.

2) Analysis of relationship between strengths and opportunities, strengths and threats, weaknesses and opportunities, and weaknesses and threats (TOWS Matrix)

After the environmental conditions are measured through the analysis to identify strengths, weaknesses, opportunities and threats, and all data is analyzed in a form of relationship matrix called TOWS Matrix, which applies data from analysis of strengths, weaknesses, opportunities and threats to analyze relationship between strengths and opportunities, strengths and threats, weaknesses and opportunities, and weaknesses and threats to determine further strategies.

TOWS is a factor analysis tool for organization management based on a basic tool called SWOT. The TOWS will apply the SWOT data in deep analysis of external environment (threats and opportunities) and internal environment (strengths and weaknesses). This technique can be applied for analysis of agencies and organizations as well as analysis of working process and preparation of marketing campaign.

TOWS Matrix Analysis is applied as a guideline for determination of strategies for GHG reduction action plan from 2021 – 2030 in transport sector and prioritizing the projects as shown in **table 6.2.2-1**.

Table 6.2.2-1 TOWS matrix analysis

<p style="text-align: center;">Internal Factors</p> <p style="text-align: center;">External Factors</p>	<p>Strengths</p> <p>S1 Clear national policies and strategies</p> <p>S2 The government sector is ready for GHG emission reduction</p> <p>S3 Have national and ministerial action plans that promote development to sustainable and environmental friendly transport</p>	<p>Weaknesses</p> <p>W1 GHG reduction is not a ministry’s primary mission</p> <p>W2 Government authorities lack of effective data collection</p> <p>W3 Government authorities neglect and lack of knowledge and understanding on GHG emission and MRV systems</p> <p>W4 Lack of central agency to coordinate central database and knowledge on sustainable transport and GHG reduction and data connectivity</p> <p>W5 Administrators and political sector don’t understand environment and global warming issues.</p> <p>W6 interrupted policies because of change of administrations and government</p> <p>W7 Poor current public transport systems</p> <p>W8 The public is not aware of the problem as well as lack of environmental awareness.</p> <p>W9 Management of intelligent transportation system (ITS) is not sufficiently effective.</p> <p>W10 Government’s lack of area integral e.g. city planning or commercial Transit Oriented Development</p>
<p>Opportunities</p> <p>O1 International mechanism that support climate change mitigation is given both in fund and knowledge</p> <p>O2 Government is aware of importance of connected traveling modes, supporting sustainable national transport systems and reducing use of private cars and trucks</p> <p>O3 Government has top-down policy that supports less energy use</p> <p>O4 private sector actively supports climate change mitigation projects</p>	<p>Strengths-Opportunities (SO)</p> <p>S1O3 Clearly determine policies and agencies for energy use and GHG reduction</p> <p>S1O4 Promote GHG reduction in private sector more</p> <p>S2O4 Create network with private sector and business operators</p> <p>S3O3 Promote bottom-up action plans and activities for sustainable and environmental-friendly transport technology development</p>	<p>Weaknesses-Opportunities (WO)</p> <p>W1O1 Determine them as ministries’ main missions for appropriate budget allocation or request for help from international funds</p> <p>W2O2 Set data collection system regarding energy use and GHG reduction and clearly assign agencies for the system set-up</p> <p>W4O2 Appoint central agency for coordination, educating and linking data for sustainable transport system development</p> <p>W4O4 Search for a private sector’s representative that is well-prepared and willing to participate in the government’s GHG reduction operations and motivate for participation</p> <p>W7O2 Study data from foreign countries e.g. study trip or inviting foreign experts for knowledge support</p> <p>W7O4 Let private sector to act as representative for system development and moving forward transport mode change such as providing concession rights or designing business Champaign</p> <p>W8O2 Create public participation system such as giving privilege or points for participating in government activities</p> <p>W9O2 Use IT systems to develop traveling efficiency enhancement</p> <p>W10O2 Use Transit Oriented Development and city planning for sustainable transport development</p>

<p style="text-align: center;">Internal Factors</p> <p style="text-align: center;">External Factors</p>	<p>Strengths</p> <p>S1 Clear national policies and strategies</p> <p>S2 The government sector is ready for GHG emission reduction</p> <p>S3 Have national and ministerial action plans that promote development to sustainable and environmental friendly transport</p>	<p>Weaknesses</p> <p>W1 GHG reduction is not a ministry's primary mission</p> <p>W2 Government authorities lack of effective data collection</p> <p>W3 Government authorities neglect and lack of knowledge and understanding on GHG emission and MRV systems</p> <p>W4 Lack of central agency to coordinate central database and knowledge on sustainable transport and GHG reduction and data connectivity</p> <p>W5 Administrators and political sector don't understand environment and global warming issues.</p> <p>W6 interrupted policies because of change of administrations and government</p> <p>W7 Poor current public transport systems</p> <p>W8 The public is not aware of the problem as well as lack of environmental awareness.</p> <p>W9 Management of intelligent transportation system (ITS) is not sufficiently effective.</p> <p>W10 Government's lack of area integral e.g. city planning or commercial Transit Oriented Development</p>
<p>Threats</p> <p>T1 Uncertainty of national agreement and cooperation for GHG emission reduction among developed countries (country group Annex I)</p> <p>T2 Unstable international politics (Geopolitical)</p> <p>T3 Fluctuated and reduced oil prices</p> <p>T4 Imported energy enhancement technologies</p> <p>T5 Uncertain calculation of CO₂ amount</p>	<p>Strengths-Threats (ST)</p> <p>S2T2 Continuously study international conditions and adjust to Thailand context</p> <p>S3T4 Study and test sustainable transport development technologies that are suitable for Thailand and apply them as action plans for departments</p>	<p>Weaknesses-Threats (WT)</p> <p>W1T2 Determine clear ministerial policies and strategies</p> <p>W1T4 Government allocates budget for GHG reduction at top priority especially for technology development and energy efficiency promotion measures</p> <p>W2T3 Set database that is able to collect and analyze data considering dynamic marketing factors</p> <p>W3T4 Train to develop staff and officers' proficiency systematically and continuously</p> <p>W3T8 Motivate to promote knowledge and technology for energy efficiency and gas reduction</p> <p>W4T2 Clear determination of central agency</p> <p>W7T4 Train to develop knowledge and technology from foreign countries and apply them to Thailand's context appropriately</p> <p>W8T3 Organize members and give privilege to motivate reduction of energy use and GHG</p>

Chapter 7 Comparison of Economic, Social and Environmental Impacts

For comparison of economic, social and environmental impacts, an analysis tool called Multi-Criteria Analysis (MCA) or sometime called Multi-Criteria Decision Analysis (MCDA) is used. The tool is used for making complex decisions or issues with multiple factors.

As for prioritizing factors for project selection, priority data is analyzed to acquire priorities of both primary and secondary factors based on Analytic Hierarchy Process (AHP) technique using Pair-Wise Comparison Method to obtain main factors' weight for each aspect. The principle is to compare the pair-wise factors for decision making within each hierarchy of the structure, and check consistency of the evaluators' decision-making through calculation for Multi-Criteria Analysis (MCA).

The Hierarchy structure can be shown as in **figure 7-1**.

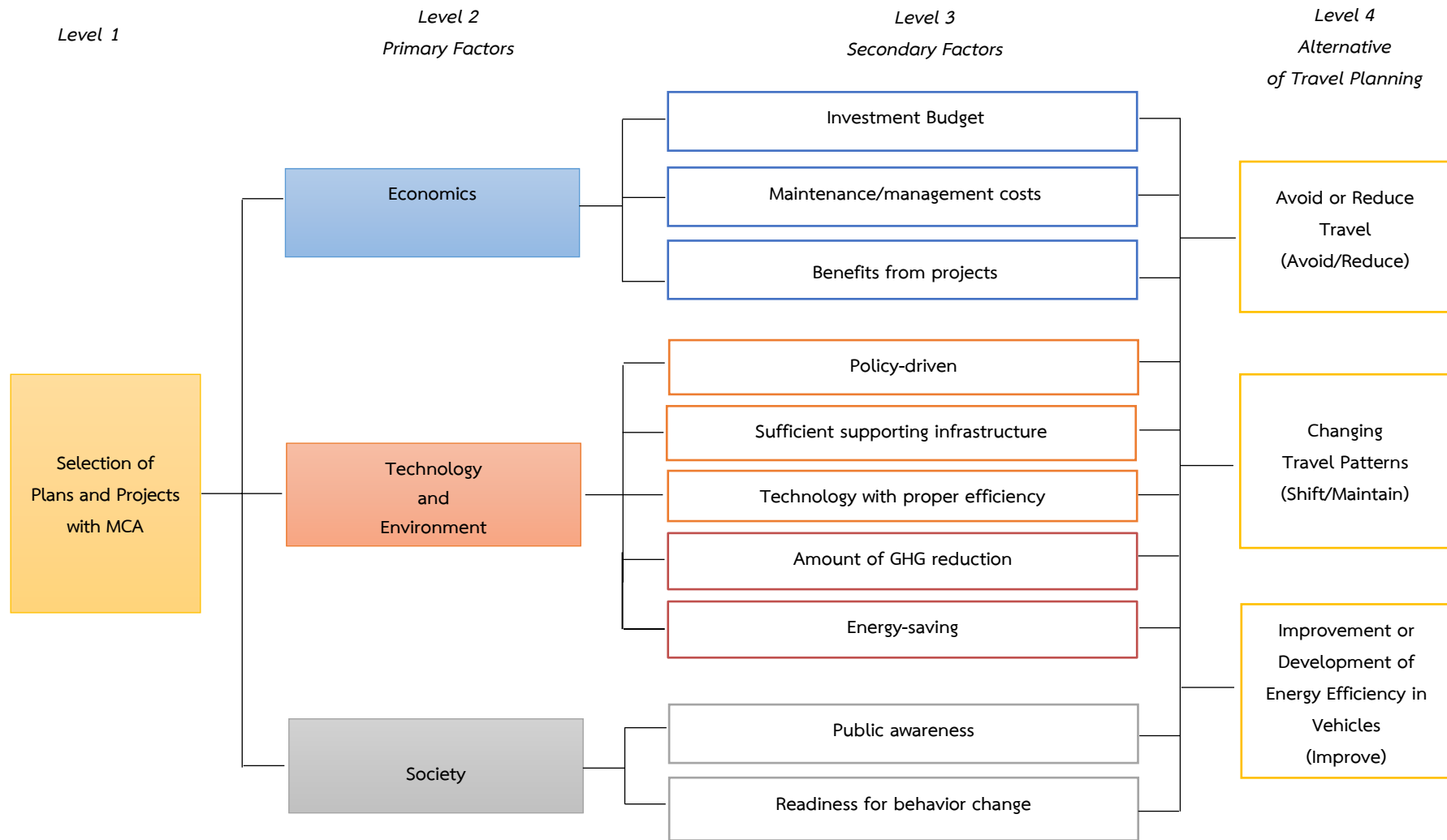


Figure 7-1 Decision hierarchy to select plans and projects in GHG emission reduction in transport sector

Table 7-1 Average priority weight of main and supporting factors for project selection decision

Project Selection	Primary Factors	Priority Weight	Secondary Factors	Secondary Factor Weight	Priority Weight
	Economic	0.429	Investment Budget	0.454	0.195
Maintenance/management costs			0.225	0.097	
Benefits from projects			0.321	0.137	
Technology and Environment	0.429	Policy-driven	0.429	0.184	
		Sufficient supporting infrastructure	0.143	0.061	
		Technology with proper efficiency	0.143	0.061	
		Amount of GHG reduction	0.143	0.061	
		Energy-saving	0.143	0.061	
Social	0.143	Public awareness	0.500	0.071	
		Readiness for behavior change	0.500	0.071	
Total		1.000		1.000	

According to table 7-1, it is found that the priority weight of economic and technology and environmental primary factors is the highest (0.429), followed by social factors (0.143), since investment factors and policy-driven certainty should be the first priority. In addition, public awareness and readiness for behavior change should be considered for benefits of investment in GHG reduction appropriately.

Table 7-2 Scoring criteria for secondary factors in project selection

Project selection	Primary Factors	Secondary Factors	Score	Scoring Criteria		
				Avoid/Reduce	Shift/Maintain	Improve
Economic		Investment Budget	0.195	0.25	1.00	0.25
		Maintenance/management costs	0.097	0.25	1.00	0.75
		Benefits from projects	0.137	0.75	1.00	0.75
Technology and Environment		Policy-driven	0.184	0.25	1.00	1.00
		Sufficient supporting infrastructure	0.061	0.25	0.75	0.75
		Technology with proper efficiency	0.061	0.00	0.50	0.50
		Amount of GHG reduction	0.061	0.75	0.50	1.00
		Energy-saving	0.061	0.75	0.50	1.00
Social		Public awareness	0.071	0.25	0.75	0.50
		Readiness for behavior change	0.071	0.25	0.75	0.75
Total			1.000			
Utility Score				0.32	0.83	0.63

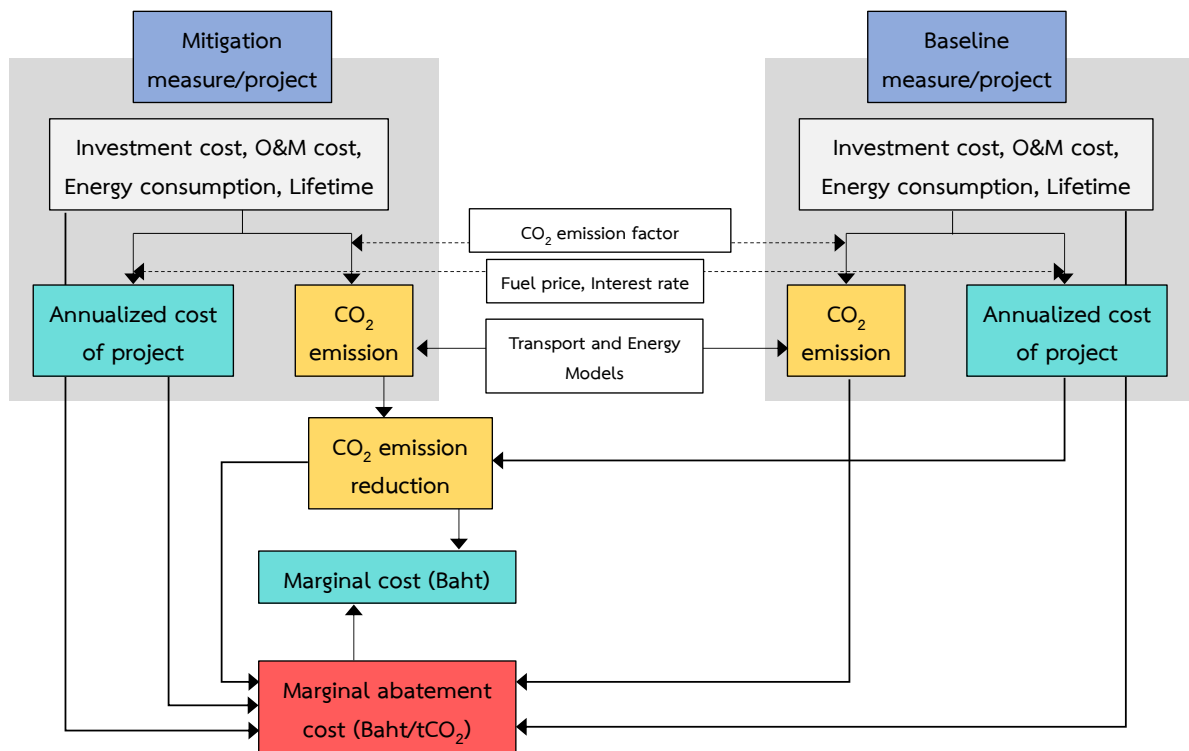
According to the table, it is found that the Shift/Maintain method has the highest utility (0.83), followed by the Improve method (0.63) and the Avoid/Reduce method (0.32), respectively. Therefore, the Shift/Maintain method is suitable, worth the investment, and able to reduce the GHG the best. However, project selection using the analysis tool called Multi-Criteria Analysis (MCA), is a method that is able to analyze multiple factors, and there is another analysis tool for the project decision-making especially GHG reduction projects, called Marginal Abatement Cost Curve (MACC), which is covered in Chapter 10.

Chapter 8 Marginal Abatement Cost (MAC) Analysis of GHG Emission Reduction for Transport Sector's Projects and Plans

8.1 The Guidelines of Marginal Abatement Cost (MAC) Analysis

Marginal Abatement Cost (MAC) analysis of GHG emission reduction is evaluating cost per unit of CO₂ emission reduction in the plans and projects related to sustainable development of the agencies under the Ministry of Transportation. It evaluates the amount of project base's GHG emissions in term of THB/project lifetime in 2020 and 2030.

The calculation of Marginal Abatement Cost (baht/tCO₂e) can be calculated by converting it to levelized cost in baseline and mitigation scenarios. Then, calculating the differences of both cases.



Note: Applied from Japan Scenarios and Actions towards Low-Carbon Societies (LCSs), NIES, Kyoto University, Mizuho Information, June 2008

Figure 8.1-1 Marginal Abatement Cost analysis concept

For the operation of agency's GHG reduction in Thailand, the other measures and policies have been defined in the purpose of GHG reduction. The tools used to evaluate and present the operation's result is Marginal Abatement Cost Curve (MACC). MACC is used to evaluate the cost of GHG emission reduction in form of Net Cost (Cost-Benefit). In case of comparing the measures with base case, that difference is called "Incremental cost".

In the analysis of incremental cost of GHG emissions reduction, it evaluates in terms of the amount of CO₂ emission reduction, tCO₂e vs. Marginal abatement cost (baht/tCO₂e). Each evaluated project is compared and presented graphically for distinct comparison.

8.2 The Evaluation of Marginal Abatement Cost (MAC)

Marginal Abatement Cost (MAC) is the evaluation of the costs of GHG emissions reduction in form of Net Cost (Cost-Benefit). In case of comparing the measures with base case, that difference is called "Incremental cost".

The analysis of incremental cost for GHG emissions reduction is a comparison between "mitigation costs" and "non-GHG policy case" or it is called "base case" by comparing in form of Net Cost that is the benefit deduction arising from GHG reduction in mitigation.

For the evaluation of Marginal Abatement Cost (MAC), the cost evaluated into 5 topics as follows:

- 1) Travel expenses
 - a. Travel expenses of passengers and freights for base case
 - b. Travel expenses and freights for measure case
- 2) Construction budget and project operation
- 3) Operation and maintenance cost
 - a. Operation and maintenance cost for base case
 - b. Operation and maintenance cost for measure case
- 4) Value of Time (VOT)
- 5) Value of Energy Saving

In the analysis of economic projects, in this regard, for example, the project of mass transport railway and suburb train as a model to analyze and evaluate the cost of GHG emissions reduction (Marginal Abatement Cost, MAC) because the projects in transport sector which are important in GHG reduction are mainly the projects of rail-based public transportation system. The details of analysis are as follows:

8.2.1 The Evaluation of GHG Emissions Reduction Costs

1) Travel expenses of projects

For the evaluation of travel expenses of projects, it can divide into passengers or freights. It considers as the travel expenses of passengers and freights for base case and the travel expenses and freights for measure case as the following details:

1.1) The travel expenses of passenger and freight for base case

The travel expenses of passengers and freights for base case is travel expense of passengers and freights in case of no measures implemented. To analyze, we take the cost of passenger travel (baht/person/km.) or the cost of freight (baht/ton-km.) multiplied by the number of passengers or freights and average distance (km.) as the equation below:

1.1.1) The travel expense of passengers for base case

The cost of passenger travel (baht/person/km.) is based on Kagoshima Regional Economic Research Institute (2018) (Table 8.2.1-1) and use the number of passengers and average distance in considered project base.

In this context, “the number of passengers”, we use the number of passengers that have been changed after operating this project or implementing this measure by considering if the number of passengers that have been changed not use any various train services or measures, in normal circumstances, how much the travel expense costs. The equation calculated as follows:

$$\text{Travel expense of passengers in base case} = \text{Travel costs in base case (baht/person/km.)} \times \text{the number of passengers (person)} \times \text{average distance (km.)}$$

- The travel costs of passengers comprise travel costs of passengers who use public bus and private car as following details:

Table 8.2.1-1 Travel cost of passengers using public transport

Category	Express bus	VIP bus	Ordinary train	HSR train	Plane
	Baht / trip	Baht / trip	Baht / trip	Baht / trip	Baht / trip
Distance (km)	700	700	700	700	700
Time (minutes)	720	570	900	180	120
Cost (baht)	1450	876	300	1200	2000
Transportation costs (baht / person / km)	2.07	1.25	0.43	1.71	2.86

Source: Kagoshima Regional Economic Research Institute (2561)

For the travel costs of passengers who use private car, it needs to know the travel speed because travel expenses are classified by vehicle speed. Mostly private car's speed is 20-60 km/hour or average speed is 40 km./hour. Therefore, the travel cost of private cars is 6.002 baht /pcu-km.

Table 8.2.1-2 The cost of using private car

Unit: (baht / PCU-km)

Speed (km / h)	10	20	30	40	50	60	70	80	90	100	
VOC (baht / PCU-km)	12.99	7.94	6.33	5.59	5.18	4.97	4.88	4.87	4.94	5.09	
	6.002										

The calculation of passenger travel expenses in base case is based on “the project of mass transport railway and suburb trains” as an example for calculation. The details are as follows:

- The number of passengers and freights changed from base case and measure case.
 The number of passengers changed as of 2030 = 4,875,483 person-time/day
 The amount of freights changed as of 2030 = - million ton-km./year
- Travel proportion and unit change (passenger car unit (pcu))

Project of Shift mode Type	Coach Bus/ Coach/ Bus	Airplane	Private car			
Travel Proportion	37.00	8.28	54.72			
Water Project	Bus		Private car	Train	Ship	
Travel Proportion	36.27%		47.78%	9.74%	6.21%	
Type of Vehicle	Public Van	Coach Bus/ Coach/ Bus	Airplane	Private car	Taxi	Motorcycle/ Tricycle
Occupancy (person/car)	5.2	25.1	100	1.15	1.15	1.1
Unit Conversion (pcu/car)	1.5	2.1	5	1	1.5	0.333

- Total distance and average distance
 Total distance = 430 kilometer
 Average distance = 120.95 kilometer

The calculation result of passenger travel expenses in base case is considered from the number of passengers classified by travel proportion of “shift mode” of passengers in each vehicle. Then, it calculates the travel expenses separated in each kind of vehicle as **table 8.2.1-3** shown below:

Table 8.2.1-3 The calculation results of passenger travel expenses in base case

No.	Type of Vehicle	Proportion of Mode shift ¹	Passenger (person-time/day)	Average distance of passenger travel (km.)	Cost of Travel ² (baht/person/km.)	Travel Expenses of Passengers (million baht)
Type of Passenger Travel			A	B	C	D = A x B x C
1.1	Coach bus/ Coach/ Bus	37.00%	1,803,928.74	120.95	2.07	164,963.58
1.2	Airplane	8.28%	403,690.00	120.95	2.86	50,918.86
1.3	Private car	54.72%	2,667,864.34	120.95	6.002	706,900.80
Total		100.00%	4,875,483.08			922,783.24

Source: ¹ Master Plan of railways network development supporting the special economic zone for tourism and area development, The Office of Transport and Traffic Policy and Planning (OTP) (2018)

² Kagoshima Regional Economic Research Institute (2018)

From the **table 8.2.1-3**, we found that the travel expenses of passengers of “the project of mass transport railway and suburb train” as of 2573, it costs 922,783.24 million baht for base case. Or in case these number of passengers do not take any mass transportation system service, all travel expense is 922,783.24 million baht.

1.1.2) The freight expenses for base case





The cost of freight (baht/ton/km.) is based on study on Travel Demand Survey (TDS) and freight movement database for National Transportation System Planning (OTP., 2018) and use the number of freights and average distance in considered project base.

“The number of freights”, in this case, we use the number of passengers that have been changed after operating this project or implementing this measure by considering if the number of freights that have been changed not use any freight services by various trains or other measures, in normal circumstances, how much the freight expenses cost. The equation calculated as follows:

$\text{Freight Expenses in base case} = \text{Freight costs in base case (baht/ton-Km.)} \times \text{the number of freights (ton-km.)} \times \text{average distance (km.)}$

The cost of freights is used freights by land as base case (the train construction has not been operated yet.) as **table 8.2.1-4** shown below:

Table 8.2.1-4 Cost of freight

Modes of Freight	Freight volume (Tons per year)	Freight Proportion (%)	Freight Cost (Baht / ton - km)
 Land	699,743,964	86.897	1.384
 Rail	9,678,384	1.202	0.713
 Water	95,775,615	11.894	0.518
 Air	60,784	0.008	20.000
Total	805,258,747	100.00	

Source: Study of travel demand survey and database update of freight movement for planning the national transportation system, OTP (2561 BE)

The calculation of freight expense in base case will use the double-tracks railways construction project as an example to calculate since the double-tracks railways are used for freight. The details of information are as follows:

- The number of passengers and freights changed from base case and measure case
 The number of passengers changed as of 2030 = 274,378 person-time/day
 The amount of freights changed as of 2030 = 8,306 Million ton-km./year
- The proportion of travel

Train Project	4 wheels-Truck/ Pick-up Truck	Medium sized-Truck (6 wheels)	Large sized- Truck (10 wheels up)	Trailer	
Proportion (%)	63.47%	12.09%	7.58%	16.86%	
Load (ton/car)	2	9.5	15	28	
Freight Project (Lamchabang and Mabtapud)	4 wheels-Truck/ Pick-up Truck	Medium sized-Truck (6 wheels)	Large sized- Truck (10 wheels up)	Trailer	Train
Proportion (%)	0.00%	0.00%	0.00%	85.00%	15.00%
Load (ton/car)	2	9.5	15	28	800
Shipping Project (Pasak river and Nan river)	4 wheels-Truck/ Pick-up Truck	Medium sized-Truck (6 wheels)	Large sized- Truck (10 wheels up)	Trailer	Cargo ship
Proportion (%)	30.14%	15.73%	9.41%	28.75%	15.97%
Load (ton/car)	2	9.5	15	28	2,000

- Total distance and average distance

Total distance = 3,148.71 Km.

Average distance = 1,385.43 Km.

The calculation results of freight expenses in base case, it is considered from the amount of freights transported by land. The cost of freight is 1.384 baht/ton-km. as the details in **table 8.2.1-5**.

Table 8.2.1-5 The calculation result of freight expenses in base case

Vehicle type	Product Amount (Million tons - km / year)	Freight Cost (Baht / ton - km)	freight expenses by Truck (Million Baht)
Construction of dual tracks	A	B	C = A x B
Freight Transported by Land	8,306	1.384	11,494.94

From **table 8.2.1-5**, it is found that the freight expense of double-tracks railways project in 2030, it costs 11,494.94 million baht in base case or in case the trucks do not take a service of double-tracks railways, all freight expense is 11,494.94 Million Baht/year.

1.2) The travel expenses of passenger and freight in measure case

The travel expenses of passengers and freights in Measure case is the expenses of passenger travel and freight in the condition of measures implemented. The analysis principle is similar to the expense calculation of passenger travel and freight in base case. It takes the cost of passenger travel (Baht/person/km.) or freight cost (Baht/ton-km.) multiplied by the number of passengers or freights and average distance (km.). But, changing the cost of travel or freight to the cost of measure used as the equation below:

1.2.1) The travel expenses of passengers in measure case

The cost of passenger travel (Baht/person/km.) is based on Kagoshima Regional Economic Research Institute (2018) (**Table 8.2.1-1**) and use the number of passengers and average distance in considered project base.

In this case, “the number of passengers”, we take the number of passengers that have been changed after operating this project or implementing this measure by considering if this number of passengers that have been changed use railways services or other measures, how much the travel expenses decrease or change. The equation is calculated as follows:

$$\begin{aligned}
 \text{Travel expense of passengers in measure case} = & \text{Cost of travel in measure case} \\
 & (\text{Baht/person/km.}) \times \text{the number of} \\
 & \text{passengers (person)} \times \text{average distance} \\
 & (\text{km.})
 \end{aligned}$$

The calculation of travel expenses of passengers in measure case, “the project of mass transport railway and suburb train” is used as a calculation example.

The calculation result of travel expense of passengers in measure case, it considers the number of passengers classified by travel proportion in Shift mode in each vehicle. Then, it calculates travel expenses classified by each vehicle, as the details shown in **table 8.2.1-6**.

Table no. 8.2.1-6 The calculation result of passenger travel expenses in measure case

No.	Type of Vehicle	Proportion of Shift mode ¹	Passenger (person-time/day)	Average distance of Passenger Travel (km.)	Cost of Travel ² (Baht/Person/km.)	Travel Expenses of Passengers (Million Baht)
<u>Type of Passenger Travel</u>			A	B	C	D = A x B x C
1.1	Coach Bus/ Coach/ Bus	37.00%	1,803,928.74	120.95	1.71	136,521.58
1.2	Airplane	8.28%	403,690.00	120.95	1.71	30,551.32
1.3	Private car	54.72%	2,667,864.34	120.95	1.71	201,904.35
	Total	100.00%	4,875,483.08			368,977.26

Source: ¹ Master Plan of railways network development supporting the special economic zone for tourism and area development, The Office of Transport and Traffic Policy and Planning (OTP) (2018)

² Kagoshima Regional Economic Research Institute (2018)

Based on **table 8.2.1-6**, it is found that the travel expenses of passengers in “the project of mass transport railway and suburb train” in 2030 is 368,977.26 million baht in Mitigation or in case this number of passengers using the service of public transportation system, all travel expenses is 368,977.26 million baht.

1.2.2) The freight expenses in measure case

The cost of freight (baht/ton-km.) is based on the study of Travel Demand Survey (TDS) and freight movement database for National Transportation System Planning (OTP., 2018) (**table 8.2.1-4**) and use the number of freights and average distance in considered project base.

“The number of freights”, in this case, we take the number of freights that have been changed after operating this project or implementing this measure by considering if this number of freights changed taking a freight service by railways or the other measures, how much the freight expenses cost. The equation is calculated as follows:

$\text{Freight Expenses in measure case} = \text{Cost of Freight in measure case (baht/ton-Km.)} \times \text{the number of freights (ton-km.)} \times \text{average distance (km.)}$

The calculation of freight expense in measure case, “the double-tracks railways construction project” is used as a calculation example because double track railways is for freight transport.

The calculation result of freight expense in measure case, it considers the number of freights changed to be transported by railways which is 0.713 baht/Ton-km in freight cost as the details shown in **table 8.2.1-7**.

Table 8.2.1-7 The calculation result of freight travel expenses in measure case

Vehicle type	Freight amount (Million ton-km/yr)	Freight travel cost (Baht/ton-km.)	Travel expenses of freight (Million Baht)
Double track project	A	B	$C = A \times B$
Freight travel on road	8,306	0.713	5,921.89

From **table 8.2.1-7**, it is found that the freight expenses of double track railway in 2030, it is 5,921.89 Million Baht in measure case or in case this number of freight truck using the service of double-tracks railways, all transport expenses are decreased to 5,921.89 million baht.

2) The budget of construction and project operation

The budget of construction and project operation is a construction budget or project operation in measure case. This budget is based on the action plan according to the Ministry of Transportation's strategy of 2017-2021 and the agencies that are responsible of the project/in measure case.






3) Operation and maintenance cost

3.1) Operation and maintenance cost in Shift mode project

3.1.1) Base case

The operation and maintenance cost of road system is based on the information of PSC project study of Motorways Bangpain-Korat (road+structure) in 2017. The railway system is based on the information of Mass Rapid Transit Authority of Thailand in 2017 and the study on appropriateness of high-speed train construction, Bangkok – Hua-Hin, in 2017. For water system, it is based on the information of Industrial Estate Authority of Thailand and Commercial Port of Sahathai Terminal Public Company Limited. The yearly operation and maintenance cost is divided by service distance or the number of freights as table **8.2.1-8**.

Table 8.2.1-8 Maintenance costs of other system

				
Road ¹ (Million Baht/km.)	Rail (Urban Train) ² (Million Baht/km.)	Rail (Highspeed Train) ³ (Million Baht/km.)	Freight Port ⁴ (Baht/ton)	Commercial Port ⁵ (Baht/ton)
5.05	24.5	12.414	25,211	25,888

Source: ¹ PSC of Motorways Bangpain-Korat (Road+Structure), in 2017, ² Mass Rapid Transit Authority of Thailand, 2017, ³ the study on appropriateness of high-speed train construction, Bangkok – Hua-Hin, ⁴ Industrial Estate Authority of Thailand, 2011, ⁵ Sahathai Terminal Public Company Limited, 2016

From **table 8.2.1-8**, to analyze the operation and maintenance cost for base case is the maintenance cost for road using. The value of 5.05 Million Baht/km is multiplied by average travel distance.

For measure case, the analysis of this case is similar to base case. But, changing the maintenance cost from road to railway. The operation and maintenance cost of passengers in the project of mass transport railways and suburb train in 2030 as the detail shown in **table 8.2.1-9**

Table 8.2.1-9 The operation and maintenance cost of passengers in 2573 BE (2030 CE)

Operation and Maintenance Cost for base case (Million Baht)	Operation and Maintenance Cost for measure case (Million Baht)	Incremental Costs for Operation and Maintenance (Million Baht)
A	B	C = B - A
<i>Construction of Mass Transit Electric Train Systems and Suburb Train Systems</i>		
610.80	3,002.95	-2,392.15

From **table 8.2.1-9**, we found that the operation and maintenance cost in base case of passengers in in the project of mass transport railways and suburb train in 2030, it costs 610.80 Million Baht. And the operation and maintenance cost in measure case of freights in the project of mass transport railways and suburb train in 2030, it costs 3,002.95 Million Baht. Therefore, if there is a construction of mass transport railways and suburb train, the incremental expense of operation and maintenance will be -2,392.15 Million Baht.

3.2) The operation and maintenance of Improve mode project

The Improve mode project, it calculates the travel expense or travel cost and the operation and vehicle maintenance costs. For base case, it is the same type of fuel. For measure case, it will change to improved fuel or new fuel. The cost of car use and car maintenance in each type of vehicle, it is shown in **table 8.2.1-14**.

Table 8.2.1-14 Travel expense or travel cost and operation and maintenance costs

Vehicle Type	Upfront Price (Baht)	Operating Cost (Baht)	Maintenance Cost (Baht)	Savage Value (Baht)	NPC (Baht)	NPC per distance (Baht/km)
<i>City Buses</i>						
NGV						24.04
<i>Private Car</i>						
ICE-Large	1,500,000	613,812	33,712	-111,890	2,035,635	6.85
ICE-Mid	936,000	635,734	33,712	-69,819	1,535,627	5.17
ICE-Small	644,000	540,739	33,712	-48,038	1,170,413	3.94
HEV	1,400,000	409,208	98,937	-104,430	1,803,715	6.07
PHEV	1,867,000	313,300	105,459	-139,265	2,146,494	7.23
EREV	2,283,000	237,852	260,899	-170,296	2,611,455	8.79
BEV	2,053,000	186,336	391,348	-153,139	2,477,545	8.34

For the analysis of operation and maintenance cost in Improve mode project, the number of vehicles is multiplied by the cost of car use and car maintenance in each vehicle type, both base case and measure case. For the analysis, 400 Hybrid rental cars project is an example as shown in table 8.2.1-15.

Table 8.2.1-15 Operation and maintenance cost of vehicle in 2573 BE (2030 CE)

Amount of Vehicle (Bus(es))	Average Distance (Km / year)	Operation and Maintenance Cost of Vehicle (Baht/Km)	Operation and Maintenance Cost of Vehicle (Baht/Million Baht)
<i>Hybrid bus rent (7 years) for 400 buses</i>			
<i>Base case</i>			
400	91,250	2.071	75.61
<i>Mitigation</i>			
400	91,250	6.07	221.56

From table 8.2.1-15, it is found that for the project of 400 Hybrid rental cars, in case of unchanging to Hybrid system, the expenses of car use and maintenance is 75.61 Million. If changing, the expenses of car use and maintenance will be up to 221.56 Million Baht.

4) Value of Time (VOT)

The value of travel time saving Value of Time (VOT) is evaluated from the decreased expenses because of travel mode changing to public transportation. It will make the value of time better. For this study, the amount of changed passenger travel and freight (Baseline - Mitigation) are evaluated. It specifies the changed passengers and freights to change all modes of travel to the proportion according to each vehicle

The expense of travel time saving takes the travel time of all kinds of vehicle, e.g., private cars, motorcycles, taxis, non-airconditioned buses and airconditioned buses. It is based on the information of Master Plan of mass transit in Bangkok and nearby provinces (M-MAP) 2008. And the value of time is predicted in 2030 by using the growth rate at 2.5% and the consumer price index (CPI) between 2008-2015 at 2.07% as shown in table 8.2.1-16.

Table 8.2.1-16 Value of travel time

Vehicle Type	Value of Travel Time (Baht / car - hour)	
	2551 BE (2008 CE)	2573 BE (2030 CE)
Private car	121.88	261.9
motorcycle	54.25	116.6
Taxi	122.7	263.7
Bus not air conditioned	1,412.71	3,035.6
Air-conditioned buses	1,374.62	2,953.8
Average per PCU (baht / PCU-hour)	200.49	430.8

Source: Mass Transit Master Plan in Bangkok and Metropolitan Area (M-MAP), OTP 2008

From **table 8.2.1-16**, it will use the value of time (VOT) from the study of Master Plan of mass transit in Bangkok and nearby provinces (M-MAP) (OTP, 2008) which is 261.9 Baht/pcu-hour. Then, it will calculate the amount of total travel and value of travel time (Baseline - Mitigation) in 2030.

The analysis of value of time (VOT), it must find the number of vehicles (pcu/km./year and car-km./year) first (**table 8.2.1-17** and **table 8.2.1-18**). Then, it will be multiplied by value of time (VOT), the amount of passenger travel and freights of double tracks train project in 2030 as shown in **table 8.2.1-19**.

Table 8.2.1-17 Amount of total travel and value of travel time (Baseline - Mitigation) in 2573 BE (2030 CE)

Vehicle type	Travel proportion (%)	Number of Passengers (People - Travel / Year)	Occupancy (People / cars)	Number of Vehicle (Cars / km / year)	pcu unit conversion (pcu / car)	Travel Volume (pcu / km / year)
		A	B	$C = A / B / \text{distance}$	D	$E = C \times D$
Tour Bus / Coach / Bus	37.00	37,054,772	25.1	1,066	2.1	2,238
Plane	8.28	8,292,257	100	60	5.0	299
Private car	54.72	54,801,004	1.15	34,396	1.0	34,396
Total	100.00	100,148,033				36,933

Table 8.2.1-18 The amount of freight changes (Baseline - Mitigation) in 2573 BE (2030 CE)

Vehicle type	Travel proportion (%)	Increased number of freights (Million tons - km / year)	Weight of Truck (Tons / cars)	Conversion of pcu (pcu/cars)	Freight Demand (pcu / km / year)
		A	B	C	$D = A / B \times C / \text{distance}$
4-wheel truck / pickup truck	63.47	5,271.55	2	2.5	4,756,239.94
Medium truck (6 wheels)	12.09	1,004.30	9.5	2.5	190,763.50
Large trucks (10 wheels or more)	7.58	629.15	15	2.5	75,686.49
Tow truck	16.86	1,400.60	28	2.5	90,263.36
Total	100.00	8,305.59			5,112,953.29

The calculation of vehicle operating cost (VOC) is shown in **table 8.2.1-19**.

Table 8.2.1-19 Value of travel time savings (vehicle operating cost, VOC) in 2573 BE (2030 CE)

Passenger Amount (pcu / km / year)	Freight Amount (pcu / km / year)	Total Travel Amount (pcu / km / year)	Average Travel Speed (km / hour)	Value of Travel Time (Baht / car - hour)	Total Cost (Million baht)
A	B	$C = A + B$	D	E	$F = C / D \times E$
Construction of dual tracks					
36,933	5,112,953	5,149,876.01	25.5	261.9	52.89

From **table 8.2.1-19**, we found that the value of time (VOT) of double tracks train construction project in 2030 is 52.89 Million Baht.

5) The Value of energy saving

The value of energy saving is evaluated from the amount of changed passenger travel and freight (Baseline – Mitigation) by specifying the changed passengers and freights change all travel modes as the proportion according to each vehicle by using the amount of energy use that can be reduced (Million liters) which can be evaluated from the principle of Measurement, Reporting and Verification, MRV in each project.

In the valuation of energy saving, it uses the prices of Benzene gasoline 95 and Diesel gasoline of refinery including the marketing costs by averaging previous 3 years based on the Energy Policy and Planning Office, the Ministry of Energy which is baht/liter 18.213 and baht/liter 17.475 (as of November 6th, 2018) respectively. It, then, calculates the value of energy saving of project in 2030 as shown in Figure **8.2.1-9**

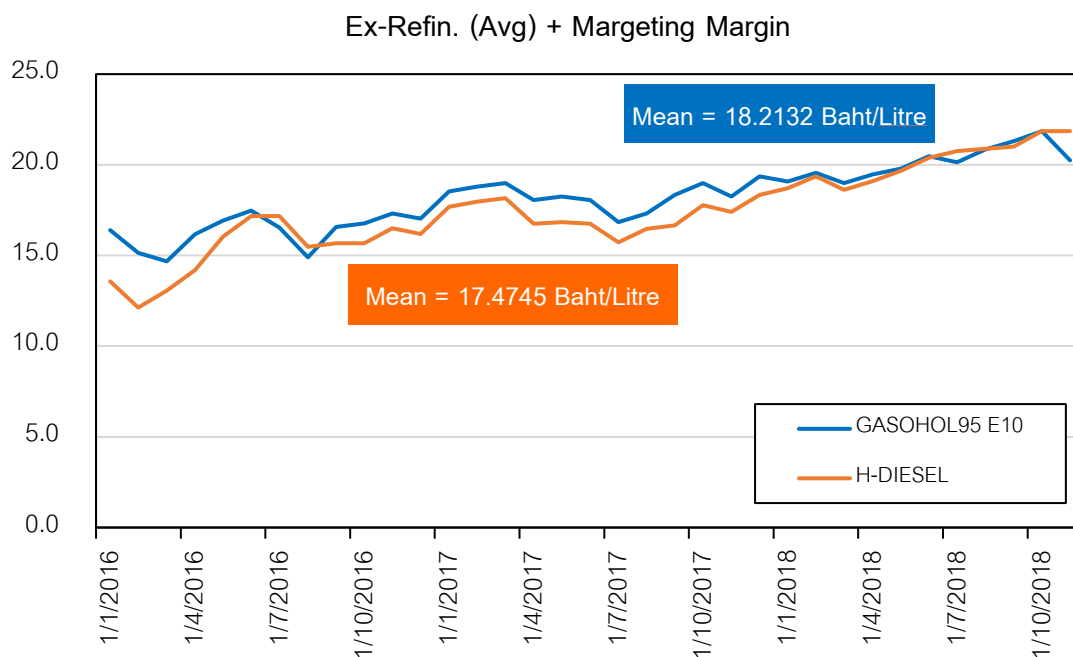


Figure 8.2.1-9 Averaging previous 3-yr prices of benzene and diesel of refinery including the marketing costs

Value of energy saving of the project in 2030 can be calculated as in **Table 8.2.1-20**

Table 8.2.1-20 Value of energy saving in 2573 BE (2030 CE)

Reduced Energy Consumption (Million liters)	Oil Price (Baht / liter)	Value of Energy Saving (Energy Saving) (Million Baht)
<i>Construction of Mass Transit Electric Train Systems and Suburb Train Systems</i>		
936.34	18.213	16,362.07

From **table 8.2.1-20**, we found that for the project of mass transport railway and suburb trains construction, the value of energy saving in 2030 is 16,362.07 Million Baht.

8.2.2 The Evaluation of Incremental Costs of Project

The current value of cost (by considering from all kinds of costs from evaluation) comprise 1) travel expenses of passenger and freight in base case and measure case, 2) the construction and operation budget in measure case in 2030 (because of the number of predicted passengers and freights as of 2030), 3) operation and maintenance cost in base case and measure case, 4) the value of time (VOT), and 5) the value of energy saving.

8.2.2.1) The project of shift mode

The valuation of the project costs and benefits as of 2030 is an evaluation of cost in reducing GHG emissions in the form of net cost (cost-benefit) or Marginal Abatement Cost (MAC) in case of comparing between measure case and base case. That difference is called “incremental cost”. The result of incremental cost evaluation of project, mass transport railway and suburb trains construction, the project expenses as of 2030 is shown in **table 8.2.2-1**.

Table 8.2.2-1 Cost evaluation in construction of Mass Transit Electric Train in 2573 BE (2030 CE)

Travel Expenses (Million Baht)				Operation and Maintenance Fee (Million Baht)			
Passenger		Freight		Passenger		Freight	
Base case	Measure case	Base case	Measure case	Base case	Measure case	Base case	Measure case
922,783.24	368,977.26	-	-	610.80	3,002.95	-	-
Budget for construction or operation (Million baht)			Value of Saving Tavel Time (VOT) (Million Baht)		Value of Energy Saving (Million Baht)		
828,953.80			-77.21		-16,362.07		

The budget funds have not been included with the above cost because each year, various figures have been put in the budget and that money must be converted to current economic value. So, it must be separated from the cost for analyzing.

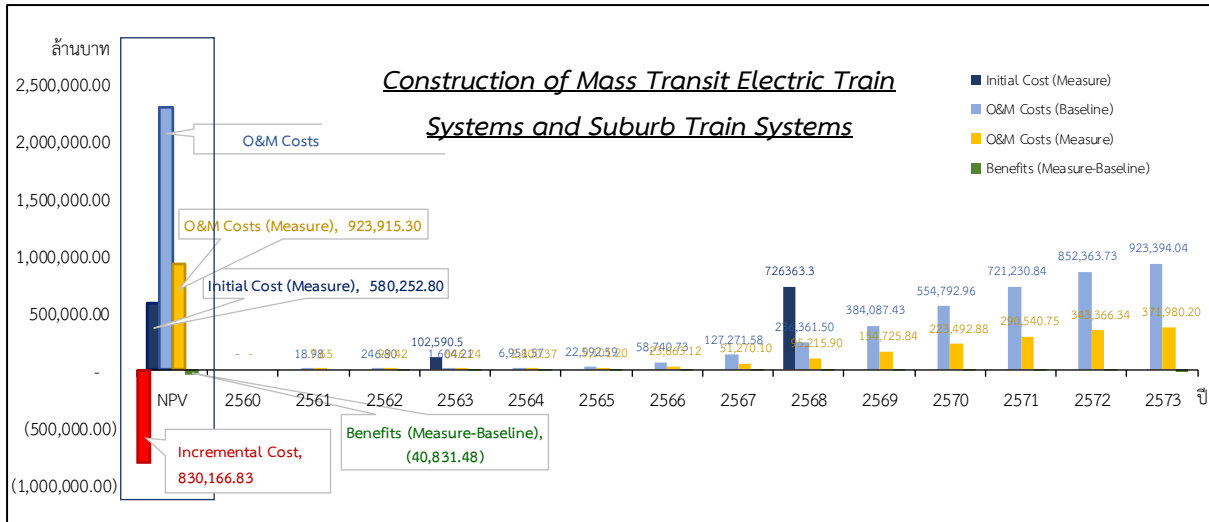


Figure 8.2.3-1 Analysis of Marginal Abatement Cost of construction of Mass Transit Electric Train Systems and Suburb Train Systems

From Figure 8.2.3-1, it was found that the marginal abatement costs of the mass transit and suburban rail projects were 830,166.83 million baht.

8.2.2.2) The project of improve mode

For Improve mode project, 400 Hybrid rental cars project is an example for analyzing as in table 8.2.2-2.

Table 8.2.2-2 Expenses of hybrid bus rent (7 years) for 400 buses in 2573 BE (2030 CE)

Travel Expenses (Million Baht)				Operation and Maintenance Fee (Million Baht)			
Passenger		Freight		Passenger		Freight	
Base case	Measure case	Base case	Measure case	Base case	Measure case	Base case	Measure case
-	-	-	-	75.61	221.56	-	-
Budget for construction or operation (Million baht)			Value of Saving Tavel Time (VOT) (Million Baht)		Value of Energy Saving (Million Baht)		
4,208.81			-		-229.09		

From the above expenses, analyzed and converted into the present economic value, as shown in Figure 8.2.3-1. The incremental cost of the project is the incremental cost in the red bar of the graph which will be used to analyze the cost of increasing GHG reduction per unit.



Figure 8.2.3-2 Analysis of incremental cost of 400 Hybrid Bus Rental Project

As Figure 8.2.3-2, the incremental cost of 400 Hybrid Bus Rental Project was 3,439.38 Million Baht.

For the other projects which have been selected as the project of GHG reduction in transport sector, the details of calculation are shown in table 8.2.2-3.

Figure 8.2.2-3 Calculation of Marginal Abatement Cost of GHG emission reduction in transport sector

Code of Project	Initials	Project name	Amount of GHG Emission Reduction (MtCO ₂ e)	Energy Consumption Reduction		Average distance of travel (km.)	Amount of Passenger Change (People - travel per day)	Amount of Freight Change (Million tons - km / year)	Amount of Car Change (cars)	Construction and Operation of the Project Budget (Million Baht)	Travel Expenses (Million Baht)				Operation and Maintenance Fee (Million Baht)				Value of Save Travel Time (VOT) (Million Baht)	Value in Energy Consumption Reduction (Energy Saving) (Million Baht)
				(Million Liters)	(ktoe)						Passenger		Freight		Passenger		Freight			
											Base case	Measure case	Base case	Measure case	Base case	Measure case	Base case	Measure case		
[S1-1]	Double Track	Dual Tracks	1.47	853.64	725.68	1,385.43	274,378.17	8,305.59		463,015.00	594,854.94	59,463.57	11,494.94	5,921.89	6,996.43	34,397.52			52.89	14,916.93
[S1-2]	Mass Transit	mass transit electric train systems and suburb train systems	1.06	936.34	826.72	120.95	4,875,483.08			828,953.80	922,783.24	368,977.26	-	-	610.80	3,002.95			77.21	16,362.07
[S1-3]	New Railway	New railway	0.10	87.92	66.51	1,417.80	134,418.00	42.17		501,690.00	298,228.11	29,811.82	58.37	30.07	7,159.89	35,201.14			0.44	1,536.43
[S1-4]	EEC	High-speed train + EEC	2.79		648.45	1,534.20	240,440.00			1,538,379.00	577,251.23	230,815.39	-	-	7,747.71	19,045.56			0.30	-
[S2-1]	SRTO 1&2	Development of Single Rail Transfer Operator (SRTO) at Laem Chabang port, Phase 1 and 2	1.09	285.120	279.42	267.00		32,299.06		981.50	-	-	44,701.90	23,029.23	-	-	1,348.35	6,629.08	94.87	4,982.33
[S2-2]	Dam	Construction of Chao Praya and Nan river dams for water transport operation	0.08	30.070	29.47	477.00		1,467.96		6,422.80	-	-	2,031.65	760.40	-	-	2,408.85	38,002.43	14.53	525.46
[S2-3]	River Logistics	Enhancement of freight transport system via Pasak river	0.05	17.720	17.36	477.00		864.91		2,162.90	-	-	1,197.04	448.02	-	-	2,408.85	22,390.78	8.56	309.65
[S2-4]	Ferry	Ferry development linking upper gulf of Thailand	0.00	0.610	0.53	116.00	36,404.22	-		591.70	5,692.18	660.58	-	-			-	-	0.58	10.66
[S2-5]	SRTO 3	Laem Chabang Port development, Phase 3	0.41	148.110	145.15	267.00		12,259.59		155,834.00	-	-	16,967.27	8,741.09	-	-	1,348.35	6,629.08	36.01	2,588.15
[S2-6]	MIT Port	Mab Taphut industrial port development, Phase 3	0.04	14.870	14.57	332.00		1,230.70		10,154.00	-	-	1,703.29	877.49	-	-	1,676.60	8,242.90	2.91	259.85
[S1-5]	NMT BKK	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and vicinity	2.83	544.00	731.00	1,000				450.00									-	9,506.13
[S1-6]	NMTs	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of	0.72	1,933	354.00	390				200.00									-	33,778.21

Code of Project	Initials	Project name	Amount of GHG Emission Reduction (MtCO _{2e})	Energy Consumption Reduction		Average distance of travel (km.)	Amount of Passenger Change (People - travel per day)	Amount of Freight Change (Million tons - km / year)	Amount of Car Change (cars)	Construction and Operation of the Project Budget (Million Baht)	Travel Expenses (Million Baht)				Operation and Maintenance Fee (Million Baht)				Value of Save Travel Time (VOT) (Million Baht)	Value in Energy Consumption Reduction (Energy Saving) (Million Baht)
				(Million Liters)	(ktoe)						Passenger		Frieght		Passenger		Frieght			
											Base case	Measure case	Base case	Measure case	Base case	Measure case	Base case	Measure case		
		pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla																		
[S3-1]	Bus Service	Improvement of urban and outskirt public service via hybrid passenger vehicles	0.04	15.870	13.68	15	24,000,000		21,343,874	100.00	1,620.36	745.71			75.75	75.75			14.61428	277.32
[I1-1]	Tightened Excise CO ₂ tax PC	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars	4.20	1,923.85	1,433.40	22,000.00			2,300,677	100.00									0.00107	35,039.45
[I1-2]	Excise CO ₂ tax MC	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for motorcycles	1.34	613.32	456.97	17,820.00			3,021,525	80.00									0.00058	11,170.55
[I1-3]	Annual Reg. CO ₂ tax PC	Annual car tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate)	1.54	703.62	524.25	22,000.00			2,300,677	50.00									0.00107	12,815.24
[I1-4]	EV car	Expansion of Electric vehicles	1.44		210.56	22,000.00			16,290,000	200.00					1,852,824.6	2,988,889.2			0.00760	10,712.66
[I1-5]	Excise CO ₂ tax	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars based on strict tax measure	1.87	855.35	637.30	22,000			275,660	20.00									0.00013	15,578.65
[I1-6]	Inefficient car retired	Promote disposal of deteriorated vehicles (old vehicles) from the	4.15	1,902.3	1,417.35	20,000			1,225,000	30.00					126,665.0	204,330.0			0.00063	34,647.06

Code of Project	Initials	Project name	Amount of GHG Emission Reduction (MtCO _{2e})	Energy Consumption Reduction		Average distance of travel (km.)	Amount of Passenger Change (People - travel per day)	Amount of Freight Change (Million tons - km / year)	Amount of Car Change (cars)	Construction and Operation of the Project Budget (Million Baht)	Travel Expenses (Million Baht)				Operation and Maintenance Fee (Million Baht)				Value of Save Travel Time (VOT) (Million Baht)	Value in Energy Consumption Reduction (Energy Saving) (Million Baht)
				(Million Liters)	(ktoe)						Passenger		Freight		Passenger		Freight			
											Base case	Measure case	Base case	Measure case	Base case	Measure case	Base case	Measure case		
		system (more than 15 years of service or exceeding 200,000 km)																		
[1-7]	H-MAC	Improvement of air conditioning systems in cars	1.00	458.39	341.53					30.00									8,348.69	
[1-8]	Fuel price	Use of fuel mechanism to carry forward use of effective vehicles	2.06							10.00									-	
[12-1]	EV bus	Procurement of 35 electric buses including electric charging station construction	0.00		0.28	146,000			35	571.94				10.59	122.84			0.000000062	27,430.64	
[12-2]	Hybrid bus	Procurement of 1,453 hybrid buses	0.13	47.62	41.05	91,250			1,453	11,624.00				274.64	804.80			0.00000	832.14	
[12-3]	Hybrid bus	Hybrid bus rent (7 years) for 400 buses	0.04	13.11	11.30	91,250			400	4,208.81				75.61	221.56			0.0000001126	229.09	
[12-4]	EV Minibus	Replace air-conditioned passenger vans with 4,626 electric minibuses	0.03		4.08	30,000			4,626	465.00				950.64	1,157.43			0.00000	1,487,989.97	
[12-5]	Hybrid taxi	Promote use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla	2.50	936.05	806.86	22,000			63,492	25,130.00				7,221.58	8,478.72			0.00003	16,357.01	
[12-6]	Delivery MC	Replace delivery motorcycles with electric motorcycles in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla	0.00	0.28	0.21	3,650.00			64,405.51	4,400.00				1,215.36	1,960.57			0.00006	4.89	
[13-1]&[13-2]	Bogie	8 and 12 power cars modification (2018 - 2021)	0.02	2.030	3.180	113,880			8	266.28								0.00000	35.47	

Code of Project	Initials	Project name	Amount of GHG Emission Reduction (MtCO _{2e})	Energy Consumption Reduction		Average distance of travel (km.)	Amount of Passenger Change (People - travel per day)	Amount of Freight Change (Million tons - km / year)	Amount of Car Change (cars)	Construction and Operation of the Project Budget (Million Baht)	Travel Expenses (Million Baht)				Operation and Maintenance Fee (Million Baht)				Value of Save Travel Time (VOT) (Million Baht)	Value in Energy Consumption Reduction (Energy Saving) (Million Baht)
				(Million Liters)	(ktoe)						Passenger		Freight		Passenger		Freight			
											Base case	Measure case	Base case	Measure case	Base case	Measure case	Base case	Measure case		
[13-3]	Locomotive	Provision of diesel electric cars to replace GE diesel electric ones for 50 cars (2018 - 2021)	0.01	3.040	4.770	113,880			12	6,561.50									0.00000	53.12
[14]	Runway	Runway constructions, line 3 and 4 of Suvarnabhumi Airport	0.08	3.570	3.500	113,880			50	13,686.57									0.00000	62.38
[17]	LED	Shift to use of LED light bulbs in all ports/airports/highways	0.82	24.544	0.0021					100.00									-	428.89
[15-1]&[15-2]	LTM	Promotion of Logistics and Transport Management (LTM) for energy-saving	0.19		60.4					80.00									-	3,073.02
Total			31.78*	12,354.34	9,809.53															

Note: * Exclude TOD and TDM and Logistic Management projects, due to inadequate information for marginal cost estimation.

8.2.3 The Evaluation of Costs in Reducing GHG Emissions per Unit (MAC)

The evaluation of costs in reducing GHG emissions per unit as of 2030 in Baht/tCO₂e is an evaluation of cost in reducing GHG emissions in form of net cost (cost-benefit), called Marginal Abatement Cost (MAC) (Million Baht) in case of comparing between measure case and base case. Then, it is divided by the amount of GHG emission reduction (MtCO₂e) and converted to the current economic value as shown in table 8.2.3-1.

Table 8.2.3-1 Marginal Abatement Cost for GHG emissions reduction, Net Present Value (NPV)

Marginal Abatement Cost (MAC) (Million Baht)	Amount of GHG Emission Reduction (MtCO ₂ e)	Marginal Abatement Cost for GHG Emissions Reduction Per Unit (Baht/tCO ₂ e)
<i>Construction of Mass Transit Electric Train Systems and Suburb Train Systems [Shift Mode]</i>		
-830,166.83	6.00	-138,477
<i>Hybrid Bus Rent (7 years) for 400 Buses [Improve Mode]</i>		
3,439.83	0.42	8,100

From table 8.2.3-1, the MAC of mass transport railways and suburb train project in 2030, it costs -830,166.83 Million Baht. And the amount of GHG emissions reduction of double tracks train construction project in 2030, it costs 6.00 Million Ton CO₂ (MtCO₂e). So, the MAC of GHG emission reduction per unit is -138,477 Baht/Ton CO₂ (Baht/tCO₂e).

For other projects that have been selected as the GHG reduction project of the transport sector, the calculation details can be found in Table 8.2.3-2

Table 8.2.3-2 Marginal Abatement Cost (MAC) of GHG emission reduction of projects as NPV

Project code	Short name	Project name	CO ₂ emission reduction	Marginal Cost	Marginal Abatement cost	
			MtCO ₂ e	Million Baht	Baht/tCO ₂ e	
1	[S1-1]	Double Track	Dual Tracks	14.52	(930,164.09)	(64,083)
2	[S1-2]	Mass Transit	mass transit electric train systems and suburb train systems	6.00	(830,166.83)	(138,477)
3	[S1-3]	New Railway	New railway	0.6500	(196,825.41)	(302,808)
4	[S1-4]	EEC	High-speed train + EEC	9.397	(52,343.04)	(5,570)
5	[S2-1]	SRTO 1&2	Development of Single Rail Transfer Operator (SRTO) at Laem Chabang port, Phase 1 and 2	9.40	(52,343.04)	(5,570)
6	[S2-2]	Dam	Construction of Chao Praya and Nan river dams for water transport operation	0.44	90,330.55	203,447
7	[S2-3]	River Logistics	Enhancement of freight transport system via Pasak river	0.37	49,142.78	132,460

Project code	Short name	Project name	CO ₂ emission reduction	Marginal Cost	Marginal Abatement cost	
			MtCO ₂ e	Million Baht	Baht/tCO ₂ e	
8	[S2-4]	Ferry	Ferry development linking upper gulf of Thailand	0.01	(12,026.60)	(1,045,791)
9	[S2-5]	SRTO 3	Laem Chabang Port development, Phase 3	2.04	91,640.90	44,845
10	[S2-6]	MIT Port	Mab Taphut industrial port development, Phase 3	0.12	20,478.11	171,007
11	[S1-5]	NMT BKK	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and vicinity	7.83	(23,258.50)	(2,972)
12	[S1-6]	NMTs	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla	1.83	(83,740.78)	(45,885)
13	[S3-1]	Bus Service	Improvement of urban and outskirt public service via hybrid passenger vehicles	0.22	(2,819.17)	(13,112)
14	[I1-1]	Tightened Excise CO ₂ tax PC	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars	22.72	(86,943.74)	(3,827)
15	[I1-2]	Excise CO ₂ tax MC	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for motorcycles	7.44	(27,676.02)	(3,718)
16	[I1-3]	Annual Reg. CO ₂ tax PC	Annual car tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate)	8.37	(31,786.98)	(3,798)
17	[I1-4]	EV car	Expansion of Electric vehicles	7.80	2,795,294.29	358,371
18	[I1-5]	Excise CO ₂ tax	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars based on strict tax measure	7.63	(38,678.21)	(5,069)
19	[I1-6]	Inefficient car retired	Promote disposal of deteriorated vehicles (old vehicles) from the system (more than 15 years of service or exceeding 200,000 km)	11.13	106,867.21	9,606
20	[I1-7]	H-MAC	Improvement of air conditioning systems in cars	3.00	(20,712.76)	(6,904)
21	[I1-8]	Fuel price	Use of fuel mechanism to carry forward use of effective vehicles	11.18	7.84	1
22	[I2-1]	EV bus	Procurement of 35 electric buses including electric charging station construction	0.02	(67,058.02)	(2,915,948)

Project code	Short name	Project name	CO ₂ emission reduction	Marginal Cost	Marginal Abatement cost	
			MtCO ₂ e	Million Baht	Baht/tCO ₂ e	
23	[I2-2]	Hybrid bus	Procurement of 1,453 hybrid buses	1.54	10,320.43	6,691
24	[I2-3]	Hybrid bus	Hybrid bus rent (7 years) for 400 buses	0.42	3,801.88	8,953
25	[I2-4]	EV Minibus	Replace air-conditioned passenger vans with 4,626 electric minibuses	0.51	(3,691,654.41)	(7,310,207)
26	[I2-5]	Hybrid taxi	Promote use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla	7.50	(20,495.70)	(2,733)
27	[I2-6]	Delivery MC	Replace delivery motorcycles with electric motorcycles in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla	0.00	4,816.86	2,408,430
28	[I3-1]& [I3-2]	Bogie	8 and 12 power cars modification (2018 - 2021)	0.25	165.49	666
29	[I3-3]	Locomotive	Provision of diesel electric cars to replace GE diesel electric ones for 50 cars (2018 - 2021)	0.11	6,117.10	57,687
30	[I4]	Runway	Runway constructions, line 3 and 4 of Suvarnabhumi Airport	0.51	10,568.84	20,805
31	[I7]	LED	Shift to use of LED light bulbs in all ports/airports/highways	6.56	(986.92)	(150)
32	[I5-1]& [I5-2]	LTM	Promotion of Logistics and Transport Management (LTM) for energy-saving	1.71	(7,566.87)	(4,425)

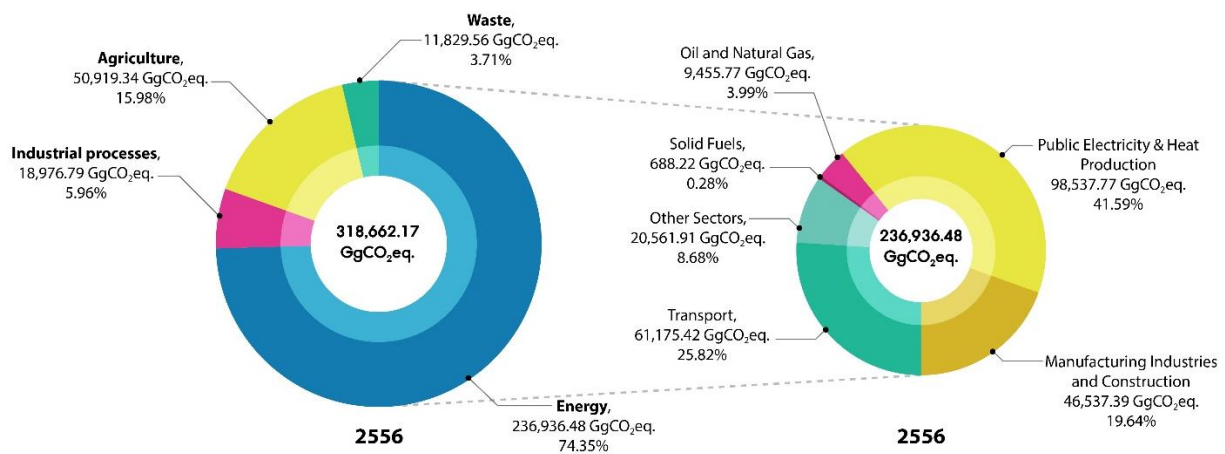
Note: Negative numbers or numbers in parentheses () are projects that have a value that benefits from project operations.

From **table 8.2.3-1**, the MAC in transport sector of current year (NPV), it is found that the figures are in both positive and negative. The negative numbers are the projects that have benefits from the operation. The above information will be used to prioritize the project and further create the incremental cost analysis tools to reduce the emission of GHG per unit.

Chapter 9 The Formulation of Action Plan for Transport Sector

9.1 Transport Sector's NDC Action Plan 2021 - 2030

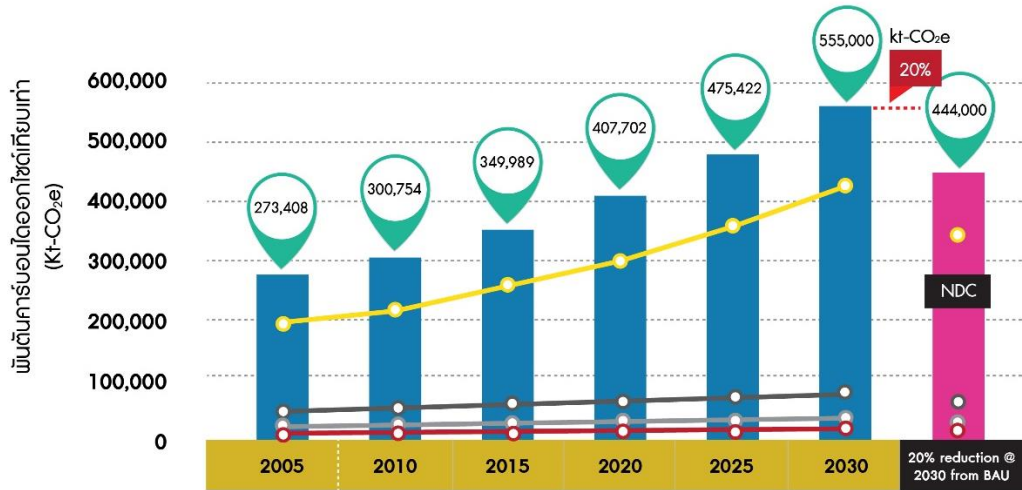
Today, there is greater global awareness of the impacts of climate change, triggered by an increase in greenhouse gas (GHG) emissions resulting primarily from man-made activities especially burning of fossil fuels which is the key source of CO₂ emission in the air. As the Second Biennial Update Report of Thailand, Office of Natural Resources and Environmental Policy and Planning reported to United Nations Framework Convention on Climate Change (UNFCCC) was found that energy consumption has been increasing accordingly to economic growth and is the cause of air pollution and GHG problems. In Thailand, total CO₂ emissions from all sectors was 318,662 GgCO₂e or 318.66 MtCO₂e and 61,175 GgCO₂e or 61.175 MtCO₂e from transport sector, 25.82% of total GHG emissions of energy sector or 19.2% of total GHG emissions of Thailand as shown in Figure 9.1-1.



Source: Second Biennial Update Report of Thailand, Office of Natural Resources and Environmental Policy and Planning, 2560

Figure 9.1-1 CO₂ emission by sector, 2556

Based on GHG emissions of Thailand as Business as usual (BAU), it was found that GHG emissions increased from 273,408 kt-CO₂e in 2005 to 555,000 kt-CO₂e or 555 MtCO₂e in 2030 or annual growth rate of 2.8 (Figure 9.1-2).



รวม	273,408	300,754	349,989	407,702	475,422	555,000	444,000
สงเสียด	12,878	13,011	14,489	16,135	17,968	20,010	16,008
เกษตรกรรม	46,294	52,316	57,554	63,316	69,656	76,630	61,304
กระบวนการอุตสาหกรรมและการใช้ผลิตภัณฑ์	19,555	21,408	23,737	26,304	29,148	32,360	25,888
พลังงาน	194,681	214,019	254,209	301,947	358,650	426,000	340,800

Source: data from Office of Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment, 2560

Figure 9.1-2 Forecast of GHG emission of Thailand (Thailand’s INDC) in all economic sectors

As potential estimation in GHG reduction as a hypothesis of PDP2015 at GDP annual Growth Rate of 3.94 and POP annual Growth Rate of 0.03, all economic sectors were amounted to reduce GHG to 111 MtCO₂e in 2030 or 20% from BAU.

Thailand’s Emission Reduction Pledges

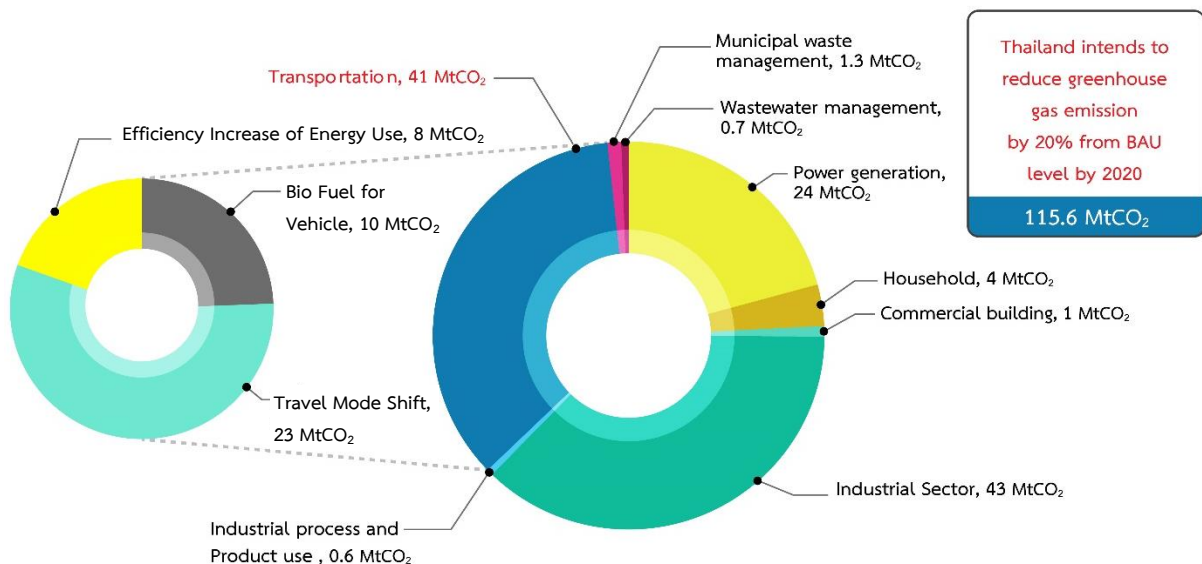
Since Thailand became a member of the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, Thailand has been working with many countries to maintain the concentration level of the amount of GHG in the atmosphere and are ready to adapt ourselves for the effect from climate change to be consistent with the continuous development on sustainable economy and society. On October 1st, 2015, Thailand submitted the proposals of the Intended Nationally Determined Contributions (INDCs) on GHG emission reduction in 2020 to the Secretariat of the United Nations Framework Convention on Climate Change. The goal is to reduce GHG emission in Thailand after 2020 in the range of 20 - 25% below the business-as-usual (BAU).

In the 21st Conference of the Parties to the UNFCCC or COP21 on November 30th, 2015, in Paris, France, the Prime Minister shared a statement in the COP21 meeting in order to express his intention that “Thailand has an intention to reduce GHG emissions in the range of 20 – 25% below the business-as-usual (BAU) in 2030. The Paris Agreement entered into force on November 4th, 2016.

For the operation to achieve the goal of GHG emissions reduction at 20% within 2030, the Committee formulated the plan for GHG emission reduction of the country. The Office of Natural Resources and Environmental Policy and Planning (ONEP) as the secretary of the Committee approved the draft of Thailand’s Nationally Determined Contribution Roadmap on Mitigation 2021 – 2030: NDC Roadmap 2021 - 2030 on Energy and Transport sector, Industrial Process and Product sector and Waste Management sector through 5 Committee Meetings. The conclusion was that Energy and Transport sector, Industrial Process and Product sector and Waste Management sector have operational readiness plans capacities to operate and support on GHG emission reduction with the GHG reduction potentials in total of 115.6 Million Ton CO₂ in 2030. It is complied with the target of GHG emission reduction at 111 Million Ton CO₂ or 20% from the business-as-usual (BAU).

Later, on May 23rd 2017, the cabinet resolution agreed on the (draft) of Thailand’s Nationally Determined Contribution Roadmap on Mitigation 2021 – 2030 (NDC Roadmap 2021 - 2030) which is an operational framework that leads to achieve the country’s GHG reduction target of 20% or 111 Million Ton CO₂ (MtCO_{2e}) in 2030 by 3 main sectors (15 measures); Energy and Transport sector, Industrial Process and Product sector, and Waste Management sector that are prompt and have potentials to reduce GHG emission of 115.6 Million Ton CO₂ (MtCO_{2e}) in 2030 and assigned the related agencies to formulate NDC Action Plans for the agencies in order to achieve the determined target according to the draft of NDC Roadmap 2021 - 2030.

The transportation in energy and transport sector have total potentials to reduce GHG emission of 41 MtCO_{2e} in 2030 comprising of a measure to increase the energy efficiency in transportation of 31 MtCO_{2e} and a measure of biofuels use for vehicles of 10 MtCO_{2e} as in **figure 9.1-1**



Source: Office of Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment, 2017

Figure 9.1-1 Proportion of GHG reduction in 2573 BE (2030 CE) (MtCO_{2e})

Concept and Process

Transport Sector's NDC Action Plan 2021 – 2030 was formulated to support the operation of the NDC Roadmap 2021 - 2030. In transport sector, the Office of Transport and Traffic Policy and Planning (OTP) is a key focal point for Thailand GHG emission reduction in the range of 20% - 25% below the business-as-usual (BAU) in 2030. Target for GHG reduction in transport sector is 41 MtCO_{2e}; energy use efficiency enhancement measure at 31 MtCO_{2e} and biofuel use measure for vehicles at 10 MtCO_{2e}.

Prioritizing of projects and plans of GHG emission reduction in transport sector (NDC Action Plan) has been made by collecting project and plan information. The meeting with other agencies is conducted to initiate the discussion on the projects and plans related to GHG reduction. Also, integrated cooperation from relevant agencies by organizing training and discussion meeting in order to collect opinions, suggestions, and ideas or project operation plans of other agencies in the future. It needs to analyze Strengths, Weaknesses, Opportunities, and Threats (SWOT) in order to determine the framework being consistent with the guidelines of GHG reduction and use it as a tool for making decision to choose project implementation of GHG reduction. The related agencies can operate the project according to operation plan and it can be a guideline to request the budget and use it to support the operation of agencies' GHG reduction.

The Analysis of Strength, Weakness, Opportunity, Threat (SWOT)

The analysis of Strengths, Weaknesses, Opportunities, and Threats directly affects the implementation of overview country's GHG reduction, both internal and external factor. The analysis of Strengths, Weaknesses, Opportunities, and Threats comes from integrated opinion collection from focus group meeting at the Office of Transport and Traffic Policy and Planning by the experts, knowledgeable and experienced representatives of planning agencies and operational agencies from government and private sectors who are related to sustainable transportation system and the climate change. It also has additional in-depth analysis by Thai and foreign experts of consultants with working experience in Thailand and many countries. The result of this analysis is used as basic important data to determine the vision, mission, and objective and make a strategy in the future. The overview SWOT analysis is summarized as follows:

(1) Strengths

1) There is distinct the country's policy and strategy such as 20 years-National Strategy, the strategy of Ministry of Transportation in 2017-2021. The policies and strategies encourage and develop the transportation systems that reduce energy consumption, rely on clean energy and be environmentally friendly.

2) The agencies of government sector are ready for GHG emissions reduction, such as the preparation of the master plan for climate change (ONEP), the master plan for sustainable transportation system development and climate change problem decrease (OTP), the guidelines for the country's GHG reduction in 2021-2030 (ONEP), and action plan for energy conservation (EPPO).

3) There is both national and Ministry's operation plan to support the development of sustainable transport and being environmentally friendly. There is distinct developing plan of rail system transportation, including, the accessibility plan.

(2) Weaknesses

1) The operation of GHG reduction is not the main responsibility of the Ministry. So, the government officials do not prepare for operation and planning. Also, as it is not the main responsibility of the Ministry, the budget request is difficult.

2) Since the government officials lack the effective data storage, they don't have the information of design, planning, and policy formulation related to monitoring and evaluating the reduction of GHG emissions.

3) The government officials are not alert to GHG. Their knowledge and understanding about GHG emissions, Measurement, Reporting, Verification, and MRV systems are not enough for their agencies to use. It, then, lacks the follow-up evaluation.

4) Due to the divided Administration structure, there is no a central agency to coordinate on central database and knowledge about the sustainable transportation and GHG reduction. The information connection lacks the integration between related agencies. There is redundant operation. Also, the education and research prior to the policy formulation don't have the quality. And the amount is insufficient to make the policy's results practical.

5) The executives and political sector's understanding about environmental and global warming problems is not enough. Thus, they are not alert to these problems and do not locate enough budget. The policies focus more on the advantage of industry sector and economy and lacks the responsibility to society and environment.

6) Due to the change of government, it lacks the continuity in policies enforcement. This interrupted the operation.

7) The current public transport system is still inefficient, delayed, and inconvenient, without the effective connection with railways transportation system, such as less and unsafe transport connection system of Feeder and bicycle lane. It made the people use their own personal vehicle.

8) Because the people are not aware of the problem and don't have the environmental consciousness, they are not ready to change their own habits to reduce GHG emissions and do not cooperate enough with the government's environmental policy.

9) Management of Intelligent Traffic System (ITS), the application of technology to help logistics system management and passengers travel is not effective enough. It made the traffic jam and caused more pollution and GHG.

10) The government lacks the integrated area such as city planning integration or the development of the area for commercial public transportation system.

(3) Opportunities

1) There is international mechanism to support the reduction of climate change from abroad on knowledge and capital, e.g., Global Environment Fund (GEF). It made the transfer of technology which can help to reduce the emissions of GHG. Some international organizations have clearly specified the framework for reducing the GHG emissions (e.g., the International Civil Aviation Organization (ICAO)).

2) The government have more awareness of the importance of many continuous transportation modes. The government encourages the development of national sustainable transportation system and the reduction of personal vehicles and trucks, such as rail transportation development, joint ticket system policy to promote mass transportation, free trains and buses.

3) The government has Top-down policy to well encourage the reduction of energy use and has a plan to promote electric cars or technology to increase the automotive energy efficiency.

4) The private sector is active in supporting the climate change reduction projects. They have more understanding and are more interested in preventing the global warming problem.

(4) Threats

1) The uncertainty of current national cooperation agreement on GHG emissions reduction. The developed countries (a group of countries in Annex I) lack the sincerity in solving the global warming problem.

2) Political instability (Geopolitical) resulted in frequent changes in policies, goals, and master plans. It caused unclear and discontinuous development direction.

3) Because the oil prices are fluctuated and decreased, the people are not interested in reducing energy consumption as expected.

4) The technology of energy efficiency promoting that must be taken from foreign countries. So, it is high operation cost.

5) The calculation of CO₂ value is uncertain, it needs to implement the carbon price measure, carbon taxes measure, and it causes unclear excise tax operation

Analysis of relationship between strengths and opportunities, strengths and threats, weaknesses and opportunities, and weaknesses and threats (TOWS Matrix)

After the environmental conditions are measured through the analysis to identify strengths, weaknesses, opportunities and threats, and all data is analyzed in a form of relationship matrix called TOWS Matrix, which applies data from analysis of strengths, weaknesses, opportunities and threats to analyze relationship between strengths and opportunities, strengths and threats, weaknesses and opportunities, and weaknesses and threats to determine further strategies.

TOWS is a factor analysis tool for organization management based on a basic tool called SWOT. The TOWS will apply the SWOT data in deep analysis of external environment (threats and opportunities) and internal environment (strengths and weaknesses). This technique can be applied for analysis of agencies and organizations as well as analysis of working process and preparation of marketing campaign. TOWS concept is shown as Figure 9.1-4.



Figure 9.1-4 TOWS Analysis Concept

TOWS Matrix Analysis is applied as a guideline for determination of strategies for GHG reduction action plan from 2021 – 2030 in transport sector and prioritizing the projects as shown in Table 9.1-1.

Table 9.1-1 TOWS matrix analysis

<p style="text-align: center;">Internal Factors</p> <p style="text-align: center;">External Factors</p>	<p>Strengths</p> <p>S1 Clear national policies and strategies</p> <p>S2 The government sector is ready for GHG emission reduction</p> <p>S3 Have national and ministerial action plans that promote development to sustainable and environmental friendly transport</p>	<p>Weaknesses</p> <p>W1 GHG reduction is not a ministry’s primary mission</p> <p>W2 Government authorities lack of effective data collection</p> <p>W3 Government authorities neglect and lack of knowledge and understanding on GHG emission and MRV systems</p> <p>W4 Lack of central agency to coordinate central database and knowledge on sustainable transport and GHG reduction and data connectivity</p> <p>W5 Administrators and political sector don’t understand environment and global warming issues.</p> <p>W6 interrupted policies because of change of administrations and government</p> <p>W7 Poor current public transport systems</p> <p>W8 The public is not aware of the problem as well as lack of environmental awareness.</p> <p>W9 Management of intelligent transportation system (ITS) is not sufficiently effective.</p> <p>W10 Government’s lack of area integral e.g. city planning or commercial Transit Oriented Development</p>
<p>Opportunities</p> <p>O1 International mechanism that support climate change mitigation is given both in fund and knowledge</p> <p>O2 Government is aware of importance of connected traveling modes, supporting sustainable national transport systems and reducing use of private cars and trucks</p> <p>O3 Government has top-down policy that supports less energy use</p> <p>O4 private sector actively supports climate change mitigation projects</p>	<p>Strengths-Opportunities (SO)</p> <p>S1O3 Clearly determine policies and agencies for energy use and GHG reduction</p> <p>S1O4 Promote GHG reduction in private sector more</p> <p>S2O4 Create network with private sector and business operators</p> <p>S3O3 Promote bottom-up action plans and activities for sustainable and environmental-friendly transport technology development</p>	<p>Weaknesses-Opportunities (WO)</p> <p>W1O1 Determine them as ministries’ main missions for appropriate budget allocation or request for help from international funds</p> <p>W2O2 Set data collection system regarding energy use and GHG reduction and clearly assign agencies for the system set-up</p> <p>W4O2 Appoint central agency for coordination, educating and linking data for sustainable transport system development</p> <p>W4O4 Search for a private sector’s representative that is well-prepared and willing to participate in the government’s GHG reduction operations and motivate for participation</p> <p>W7O2 Study data from foreign countries e.g. study trip or inviting foreign experts for knowledge support</p> <p>W7O4 Let private sector to act as representative for system development and moving forward transport mode change such as providing concession rights or designing business Champaign</p> <p>W8O2 Create public participation system such as giving privilege or points for participating in government activities</p> <p>W9O2 Use IT systems to develop traveling efficiency enhancement</p> <p>W10O2 Use Transit Oriented Development and city planning for sustainable transport development</p>

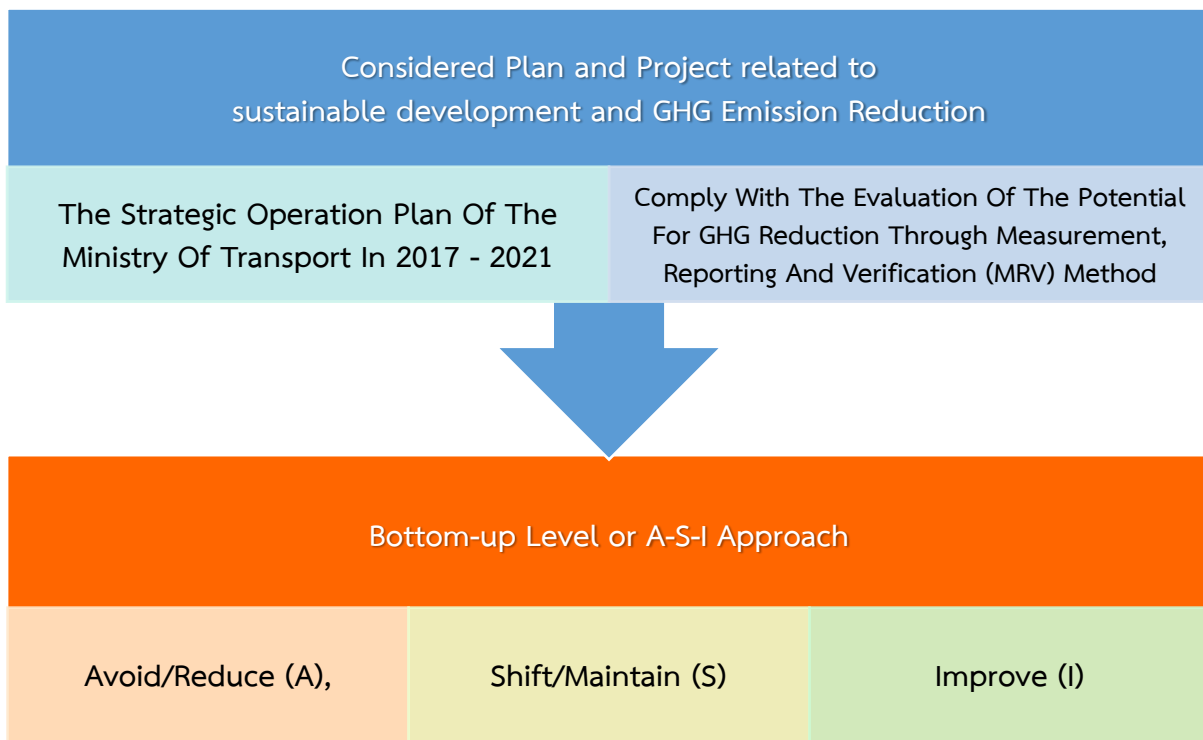
<p style="text-align: center;">Internal Factors</p> <p style="text-align: center;">External Factors</p>	<p>Strengths</p> <p>S1 Clear national policies and strategies</p> <p>S2 The government sector is ready for GHG emission reduction</p> <p>S3 Have national and ministerial action plans that promote development to sustainable and environmental friendly transport</p>	<p>Weaknesses</p> <p>W1 GHG reduction is not a ministry’s primary mission</p> <p>W2 Government authorities lack of effective data collection</p> <p>W3 Government authorities neglect and lack of knowledge and understanding on GHG emission and MRV systems</p> <p>W4 Lack of central agency to coordinate central database and knowledge on sustainable transport and GHG reduction and data connectivity</p> <p>W5 Administrators and political sector don’t understand environment and global warming issues.</p> <p>W6 interrupted policies because of change of administrations and government</p> <p>W7 Poor current public transport systems</p> <p>W8 The public is not aware of the problem as well as lack of environmental awareness.</p> <p>W9 Management of intelligent transportation system (ITS) is not sufficiently effective.</p> <p>W10 Government’s lack of area integral e.g. city planning or commercial Transit Oriented Development</p>
<p>Threats</p> <p>T1 Uncertainty of national agreement and cooperation for GHG emission reduction among developed countries (country group Annex I)</p> <p>T2 Unstable international politics (Geopolitical)</p> <p>T3 Fluctuated and reduced oil prices</p> <p>T4 Imported energy enhancement technologies</p> <p>T5 Uncertain calculation of CO₂ amount</p>	<p>Strengths-Threats (ST)</p> <p>S2T2 Continuously study international conditions and adjust to Thailand context</p> <p>S3T4 Study and test sustainable transport development technologies that are suitable for Thailand and apply them as action plans for departments</p>	<p>Weaknesses-Threats (WT)</p> <p>W1T2 Determine clear ministerial policies and strategies</p> <p>W1T4 Government allocates budget for GHG reduction at top priority especially for technology development and energy efficiency promotion measures</p> <p>W2T3 Set database that is able to collect and analyze data considering dynamic marketing factors</p> <p>W3T4 Train to develop staff and officers’ proficiency systematically and continuously</p> <p>W3T8 Motivate to promote knowledge and technology for energy efficiency and gas reduction</p> <p>W4T2 Clear determination of central agency</p> <p>W7T4 Train to develop knowledge and technology from foreign countries and apply them to Thailand’s context appropriately</p> <p>W8T3 Organize members and give privilege to motivate reduction of energy use and GHG</p>

Process of Transport Sector's NDC Action Plan 2021 – 2030

The step of NDC action plan formulation is as follows:

1. Considering plans and projects related to sustainable development and GHG emission reduction

From the strategic operation plan of the Ministry of Transport in 2017 - 2021, it classifies the type of transport system and responsible agencies and budgets for investment. For the selection, it reviews the project and plan related to sustainable development and the reduction of the amount of GHG emissions of the strategic operation plan of the Ministry of Transport in 2017 - 2021. For the strategic issue 1, it is “throughout and environmentally friendly”; strategy 1.2, develop the service of fundamental public transportation to be comprehensive and accessible; strategy 1.3, increase the flexibility and connection between modes of transportation; strategy 1.5, promote and develop the transportation systems that reduce energy consumption, rely on clean energy, and be environmentally friendly. And for the strategic issue 3, “Efficiency and Capability”; strategy 3.1, develop the transportation infrastructure to support the country’s economic development because these 2 strategic issues considerably involve sustainable development and reduction of GHG emissions.



To classify the projects, it is classified by the level, type and criterion as follows:

1.1.1 The level of project for investment evaluation

- 1) By land – Rural Roads, National Highways, Intercity Motorways, Expressways, Local Highways, etc.
- 2) By railway – Suburb trains, Airport rail link trains, Metro, Double-track trains, etc.
- 3) By water – Cruise ports, Ferries, Ports
- 4) By air – Airports

1.1.2 The type of project for investment evaluation

- 1) Infrastructure
- 2) directing
- 3) policies and plans
- 4) business
- 5) promoting

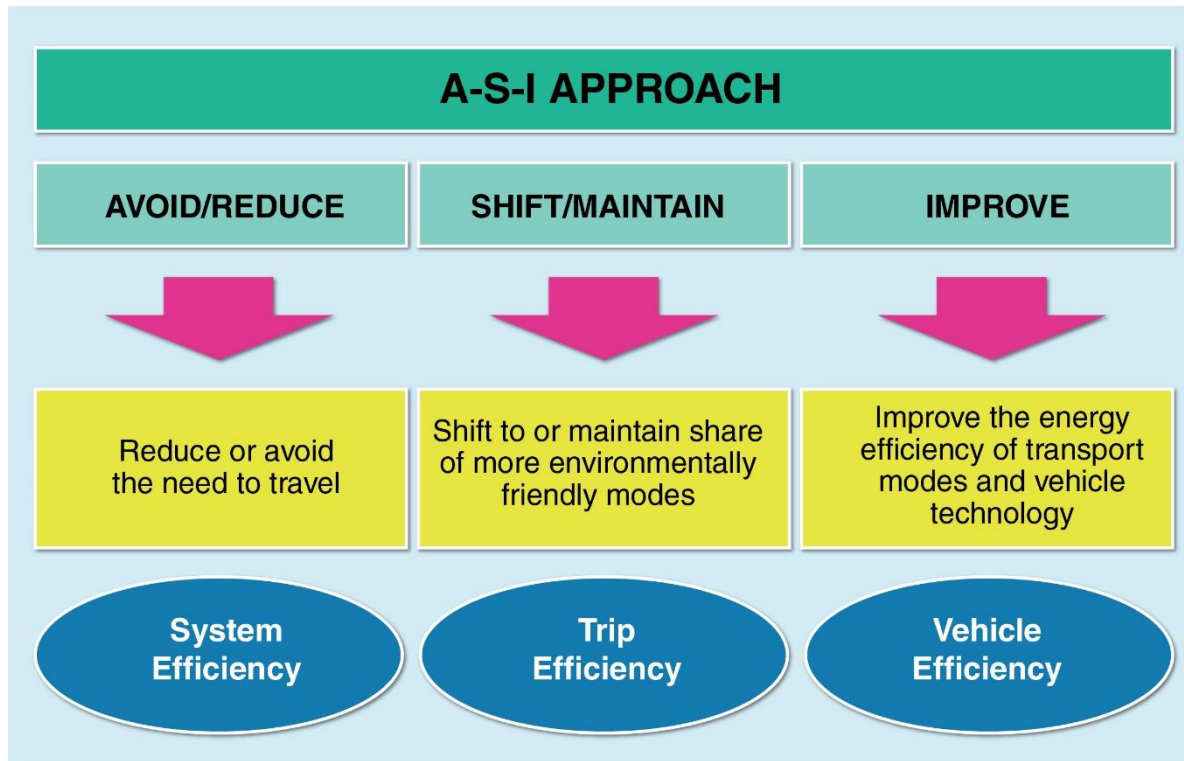
1.1.3 The criterion for project classification for investment evaluation

- 1) The project is related to freight.
- 2) The project is related to the travel of passengers or public transportation system.

2. The project grouping using A-S-I approach

A-S-I Approach or “avoid-shift-improve” principle is an important principle used to change and create the sustainable transport system of the projects and plans in transport.

In many countries, the A-S-I principle is used for the systematic transportation planning. The A-S-I principle or Avoid/Reduce (A) is to reduce or avoid the needs of travel by increasing or improving the efficiency of system. Shift/Maintain (S) is to change or use the environmentally friendly modes of travel by increasing or improving the efficiency of travel. Improve (I) is to improve energy efficiency in transportation and automotive technology by increasing or improving the efficiency of vehicle as shown in **Figure 9.1-5**



Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (giz) GmbH

Figure 9.1-5 A-S-I approach

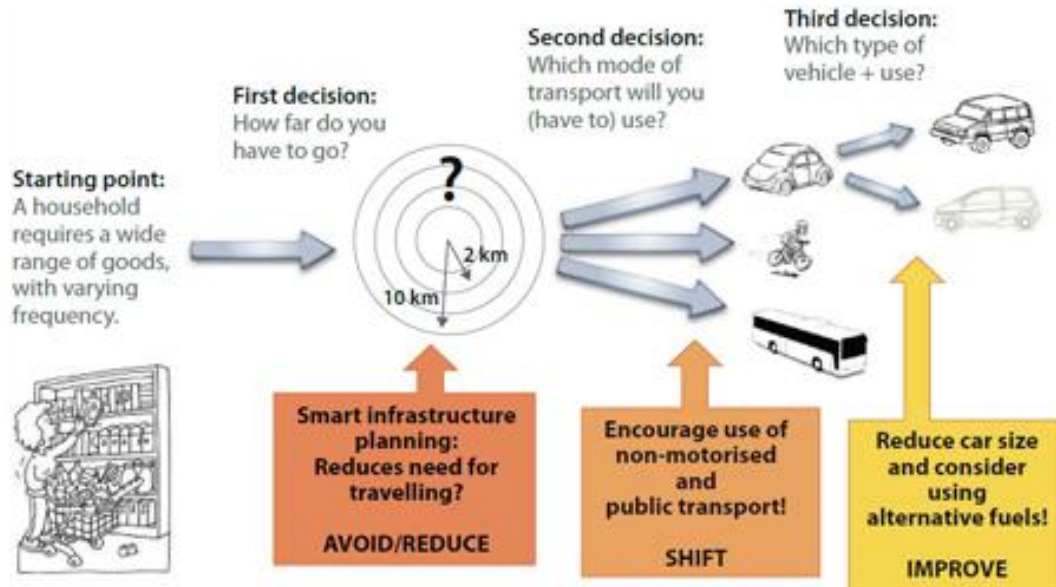
A-S-I principle is consisted of 3 parts;

(1) **Avoid/Reduce** – This policy is to encourage the people to avoid the travel or reduce unnecessary travel distance by appropriate integrating between city planning and transportation planning, such as developing the functional areas in the form of compact areas, promoting the work-at-home measure, building a government centers or shopping center in the area, etc.

(2) **Shift/Maintain** – This policy is to encourage the people to change from personal vehicle use to more efficient and environmentally friendly transportation modes, such as public transportation and non-engine transportation (travel by bicycle and on foot).

(3) **Improve** – This policy is to focus on automotive development and using the same infrastructure for more efficiency, such as automotive energy saving technology, alternative energy using, Gasohol oil use promoting, and electric cars and bicycles use promoting.

A-S-I approach can be illustrated as in Figure 9.1-6. People/households start to require a wide range of goods and need transports. First decision is how far do they have to go? They need to plan for travelling. In this step, it needs smart infrastructure planning or the supported system to avoid/reduce need for travelling. Second decision is which mode of transport will you have to use? In this step, it needs to encourage use of non-motorized and public transport to shift mode. Third decision is which type of vehicle use? It needs to reduce car size and consider using alternative fuels. These three decision steps are called A-S-I approach and use to move forward sustainable transport, reduce energy consumption and environmentally friendly.



Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (giz) GmbH

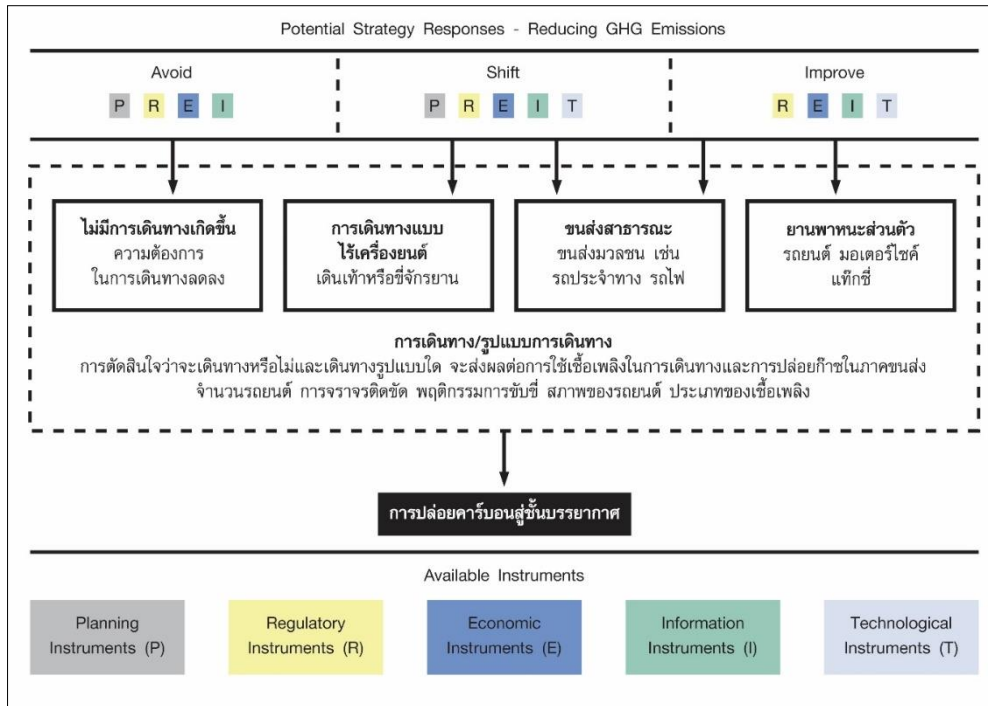
Figure 9.1-6 Mechanism of A-S-I approach

A-S-I approach is a principle for effective and sustainable transport system development to reduce energy consumption in transport sector, reduce traffic problem, build good society and reduce GHG to the atmosphere leading to sustainable economic growth. If rearrange the paradigm of A-S-I approach by adding the fourth component “Cross-cuttings”, sustainable transport can have co-benefits in various dimension such as road safety, people health, air pollution, climate change, energy dependence and equality, etc. These components are driving sustainable transport system development with relative targets.

According to the Master Plan for Sustainable Transport System Development and Climate Change Mitigation (OTP, 2012), five instruments were proposed for sustainable transport implementation. Each country has various instruments regarding measure/project/technology which are appropriate to their owns. The five instruments are as follows:

- (1) Planning Instrument; P
- (2) Regulatory Instrument; R
- (3) Economic Instrument; E
- (4) Information Instrument; I
- (5) Technology Instrument; T

The five instruments are linked to A-S-I approach leading to eco-friendly transport as shown in Figure 9.1-7.



Source: The Master Plan for Sustainable Transport System Development and Climate Change Mitigation (OTP, 2012)

Figure 9.1-7 Procedure leading to eco-friendly transport

Classifying projects by MRV evaluation can be grouped into Avoid/Reduce (A), Shift/ Maintain (S) and Improve (I). the objective of classification was to systematically divide project group for GHG analysis and calculation such as rail-based projects for shift mode analysis or energy efficiency for improve analysis. (Figure 9.1-8)

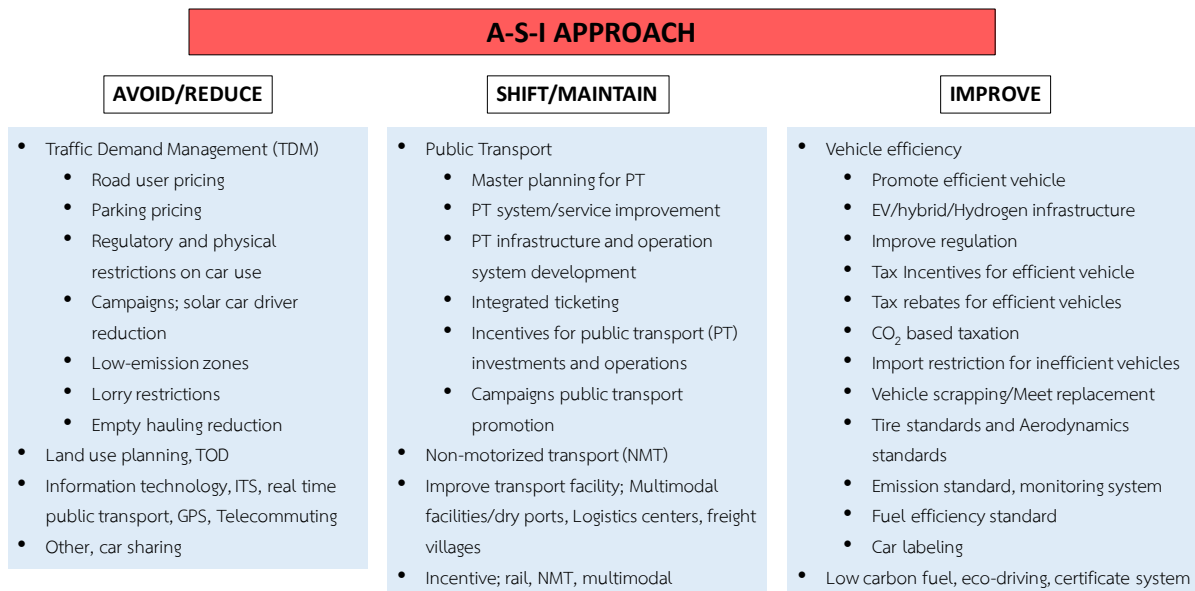


Figure 9.1-8 Activity classification by A-S-I approach

3. The criterion of the project and plan selection

The criterion of the project and plan selection is summarized as the following details:

- 1) It is the project and plan related to sustainable transportation development. Most of them are the projects in strategy 1, the development of basic transportation systems to link thoroughly and be environmentally friendly. And in strategy 3, the development of transportation systems to increase the competitiveness and drive the country's economic development.
- 2) It is the project and plan related to GHG reduction according to evaluation method of Measurement, Reporting and Verification (MRV) in bottom-up level and A-S-I Approach.
- 3) It is the project and plan related to freight and passenger travels and public transportation system.
- 4) It is the project and plan with clearly defined budgets and responsible agencies.

Vision

To drive and promote GHG reduction under the Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021 – 2030 (NDC Roadmap 2021 – 2030) in order to achieve GHG reduction target in the transport sector

Mission

1. To support and promote operations according to related transport agencies' action plans which is consistent with the NDC Roadmap 2021 – 2030
2. To determine procedures for GHG reduction in the transport sector so that related agencies obtain clear procedures
3. To develop supporting mechanism for GHG reduction and Measurement, Reporting and Verification (MRV) mechanism through promoting cooperation and integral of GHG reduction measures in all agencies

Strategies

Transport Sector's NDC Action Plan 2021 – 2030 aims to encourage related agencies to perform the GHG reduction measures in order to achieve to goals of Nationally Determined Contribution (NDC) by 2030. The strategies are determined into 4 sections as follows:

- | | |
|------------|--|
| Strategy 1 | Support and promote actions regarding relevant agencies in transport sector |
| Strategy 2 | Develop and improve laws promoted the GHG reduction |
| Strategy 3 | Develop Measurement, Reporting and Verification (MRV) system |
| Strategy 4 | Rise public participation and enhance capacities of all agencies in GHG emission reduction |

Moreover, the strategies are classified into 3 groups according to the Avoid, Shift, and Improve measure, which focuses on development of sustainable and effective transport systems to reduce energy use in transport sector and traffic problems, create friendly cities and reduce GHG emission to the atmosphere leading to sustainable and stable economic growth.

In the action plan, projects and activities acquired from all of the GHG reduction projects are classified into 3 groups as follows:

Group 1- Existing projects and plans that are able to evaluate GHG emission reduction through the Measurement, Reporting and Verification (MRV)

Group 2 - Recommended projects and plans for additional operations

Group 3 - Added projects and measures with potential for GHG reduction, but unable to measure the reduction amount, and firstly, baseline data must be collected.

Duration of operation for the plans is divided into 3 phases, i.e.

Short-term from 2020 - 2021 (1 – 2 year(s))

Medium-term from 2022 – 2025 (4 years)

Long-term from 2026 – 2030 (5 years)

Strategic flowchart of Transport Sector's NDC Action Plan 2021 - 2030 as shown in **Figure 9.1-9** and framework of Transport Sector's NDC Action Plan 2021 - 2030 as shown in **Figure 9.1-10**.

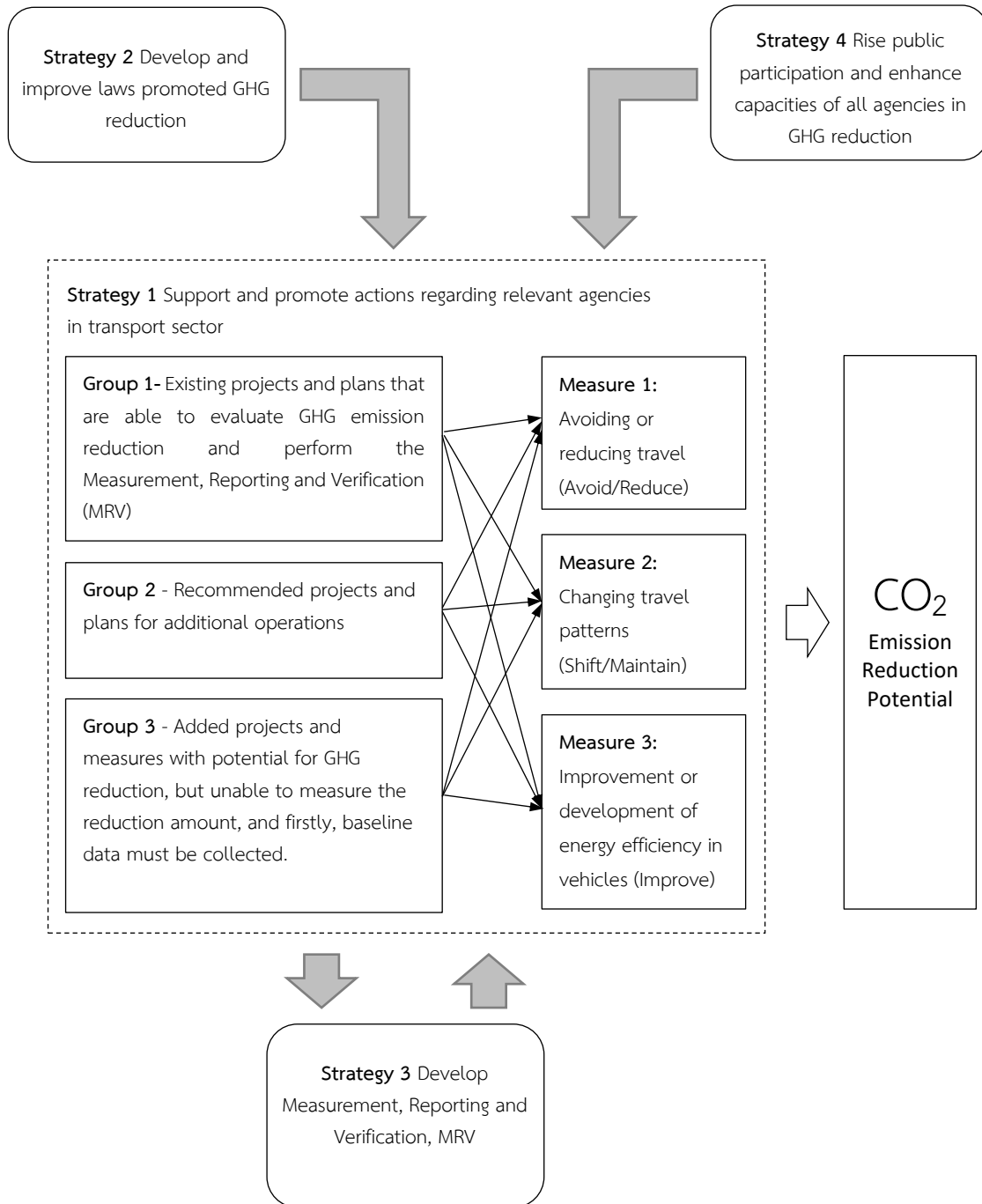
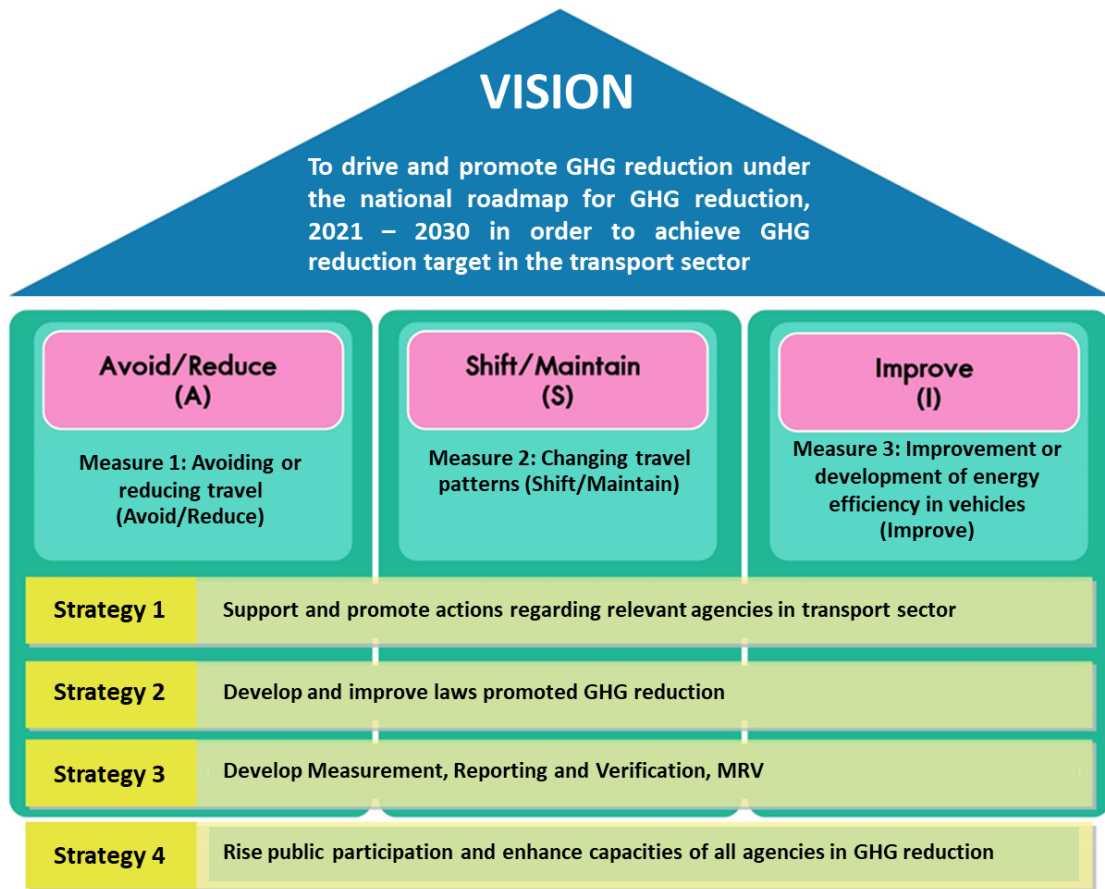


Figure 9.1-9 Strategic framework of Transport Sector's NDC Action Plan 2021 - 2030



ရូပုံ 9.1-10 Structure of Transport Sector's NDC Action Plan 2021 – 2030

Strategy 1 Support and promote actions regarding relevant agencies in transport sector

<u>Group 1</u>	Existing projects and plans that are able to evaluate GHG emission reduction through the Measurement, Reporting and Verification (MRV)
Measure 1.1.1	Travel Avoidance or Reduction (Avoid/Reduce)
Action Plan 1.1.1.1	Development of Travel Demand Management (TDM) Mechanism
Project 1.1.1.1-1	Parking fee collection measure in high-traffic areas
Project 1.1.1.1-2	Road pricing measure in high-traffic areas
Action Plan 1.1.1.2	Development of areas surrounding public transport stations (Transit Oriented Development, TOD)
Project 1.1.1.2-1	Development of areas surrounding public transport stations (Transit Oriented Development, TOD)
Measure 1.1.2	Shift of Transport Modes (Shift/Maintain)
Action Plan 1.1.2.1	Infrastructure development to support the travel mode shift in railway transport systems
Project 1.1.2.1-1	Construction of dual tracks for 32 lines
Project 1.1.2.1-2	Construction of mass transit electric train systems and suburb train systems for 20 lines (including extensions)
Project 1.1.2.1-3	New railway construction for 14 lines
Project 1.1.2.1-4	High-speed train + EEC for 4 lines
Action Plan 1.1.2.2	Infrastructure development to support the travel mode shift in water transport systems
Project 1.1.2.2-1	Development of Single Rail Transfer Operator (SRTO) at Laem Chabang port, Phase 1 and 2
Project 1.1.2.2-2	Construction of Chao Praya and Nan river dams for water transport operation
Project 1.1.2.2-3	Enhancement of freight transport system via Pasak river
Project 1.1.2.2-4	Ferry development linking upper gulf of Thailand
Project 1.1.2.2-5	Laem Chabang Port development, Phase 3
Project 1.1.2.2-6	Mab Taphut industrial port development, Phase 3

Measure 1.1.3	Improvement and development of energy use efficiency in transport sector (Improve)
Action Plan 1.1.3.1	Enhancement of energy use efficiency in private cars
Project 1.1.3.1-1	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars
Project 1.1.3.1-2	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars
Project 1.1.3.1-3	Annual car tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate)
Project 1.1.3.1-4	Expansion of Electric vehicles
Action Plan 1.1.3.2	Enhancement of urban public bus efficiency
Project 1.1.3.2-1	Procurement of 35 electric buses including electric charging station construction
Project 1.1.3.2-2	Procurement of 1,453 hybrid buses
Project 1.1.3.2-3	Hybrid bus rent (7 years) for 400 buses
Action Plan 1.1.3.3	Enhancement of railway system efficiency
Project 1.1.3.3-1	8 power cars modification (61-64)
Project 1.1.3.3-2	12 power cars modification (61-64)
Project 1.1.3.3-3	Provision of diesel electric cars to replace GE diesel electric ones for 50 cars (61-64)
Action Plan 1.1.3.4	Enhancement of energy use efficiency in aviation
Project 1.1.3.4-1	Runway constructions, line 3 and 4 of Suvarnabhumi Airport
Action Plan 1.1.3.5	Promotion of logistic management for energy-saving
Project 1.1.3.5-1	Promotion of Logistics and Transport Management (LTM) for energy-saving
Project 1.1.3.5-2	Research and development of Logistics and Transport Management Application (LTMA) for energy-saving

Table 9.1-2 Project and plan details in Group 1 under Strategy 1






Project / Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)			
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support					
Strategy 1	Support and promote actions regarding relevant agencies in transport sector																		
Group 1	Existing projects and plans that are able to evaluate GHG emission reduction through the Measurement, Reporting and Verification (MRV)																	3,249,937.26	18.67
Measure 1.1.1	Travel Avoidance or Reduction (Avoid/Reduce)																	1,000.00	2.90
Action Plan 1.1.1.1	Development of Travel Demand Management (TDM) Mechanism																	600.00	2.00
Project 1.1.1.1-1	Parking fee collection measure in high-traffic areas															BMA DLT	OTP TTP	100.00	2.00
Project 1.1.1.1-2	Road pricing measure in high-traffic areas															BMA DLT	OTP TTP	500.00	
Action Plan 1.1.1.2	Development of areas surrounding public transport stations (Transit Oriented Development, TOD)																	400.00	0.9
Project 1.1.1.2-1	Development of areas surrounding public transport stations (Transit Oriented Development, TOD)															BMA DLT	OTP SRT DPT	400.00	0.9
Measure 1.1.2	Shift of Transport Modes (Shift/Maintain)																	3,211,508.20	6.79
Action Plan 1.1.2.1	Infrastructure development to support the travel mode shift in railway transport systems																	3,035,361.30	5.42
Project 1.1.2.1-1	Construction of dual tracks for 32 lines															SRT		463,015.00	1.47
Project 1.1.2.1-2	Construction of mass transit electric train systems and suburb train systems for 20 lines (including extensions)															MRTA/SRT		532,277.30	1.06
Project 1.1.2.1-3	New railway construction for 14 lines															SRT		501,690.00	0.09

Project / Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)	
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support			
Project 1.1.2.1-4	High-speed train + EEC for 4 lines													SRT		1,538,379.00	2.79
Action Plan 1.1.2.2	Infrastructure development to support the travel mode shift in water transport systems														176,146.90	1.38	
Project 1.1.2.2-1	Development of Single Rail Transfer Operator (SRTO) at Laem Chabang port, Phase 1 and 2												PORT		981.50	0.7935	
Project 1.1.2.2-2	Construction of Chao Praya and Nan river dams for water transport operation												MD		6,422.80	0.0812	
Project 1.1.2.2-3	Enhancement of freight transport system via Pasak river												MD		2,162.90	0.0478	
Project 1.1.2.2-4	Ferry development linking upper gulf of Thailand												MD		591.70	0.001	
Project 1.1.2.2-5	Laem Chabang Port development, Phase 3												PORT		155,834.00	0.4122	
Project 1.1.2.2-6	Mab Taphut industrial port development, Phase 3												I-EA-T	PORT	10,154.00	0.041	
Measure 1.1.3	Improvement and development of energy use efficiency in transport sector (Improve)														37,429.06	8.59	
Action Plan 1.1.3.1	Enhancement of energy use efficiency in private cars														430.00	8.51	
Project 1.1.3.1-1	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars														100.00	4.197	
Activity 1.1.3.1-1.1	Excise tax collection According to the amount of CO ₂ emissions announced on 2017												Excise Department	OIE			
Activity 1.1.3.1-1.2	The database of fuel consumption rates of new cars (from Eco-sticker) and cars in the system (from observation)												OTP	OIE DLT TISI			
Activity 1.1.3.1-1.3	Education to improve the rate of taxation, increase concentration, and understand the stakeholders.												Excise Department	OTP OIE			

Project / Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)	
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support			
Activity 1.1.3.1-1.4	Excise tax declaration rate (Revised edition)		■					■					Excise Department				
Activity 1.1.3.1-1.5	Enforcement of Excise Tax Rates (Revised edition)					■					■		Excise Department				
Project 1.1.3.1-2	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars	←—————→													80.00	1.34	
Activity 1.1.3.1-2.1	Labeling of fuel consumption data of new motorcycles	■											OIE	Excise Department TISI			
Activity 1.1.3.1-2.2	Creating a database of fuel consumption rates of new motorcycles and motorcycles in the system (from observation)	■	■	■	■	■	■	■	■	■	■	■	OTP	OIE DLT TISI			
Activity 1.1.3.1-2.3	Study of appropriate taxation rates and understanding with stakeholders	■					■				■		Excise Department	OTP OIE			
Activity 1.1.3.1-2.4	Excise tax declaration rate (Revised edition)		■					■					Excise Department				
Activity 1.1.3.1-2.5	Enforcement of excise tax rates (Revised edition)					■					■		Excise Department				
Project 1.1.3.1-3	Annual car tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate)	←—————→													50.00	1.54	
Activity 1.1.3.1-3.1	Study of annual car tax rates according to the appropriate CO ₂ emissions (61)												DLT	OIE TISI OTP			
Activity 1.1.3.1-3.2	Public relations and understanding with stakeholders and annual car tax rates according to CO ₂ emissions (62-63)	■											DLT	OIE TISI OTP			
Activity 1.1.3.1-3.3	Announcement of annual car tax rates according to the amount of CO ₂ emissions		■										DLT	OIE TISI OTP			

Project / Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)	
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support			
Activity 1.1.3.1-3.4	Enforcement of annual car tax rates according to the amount of CO ₂ emissions													DLT	OIE TISIOTP		
Project 1.1.3.1-4	Expansion of Electric vehicles	↔														200.00	1.44
Activity 1.1.3.1-4.2	The study of the impact of the expansion of electric vehicles													OTP	TISI OIE		
Activity 1.1.3.1-4.3	Feasibility study of charging stations													EPPO	OIE TISIOTP		
Activity 1.1.3.1-4.4	Announcement of the policy to promote the use of electric vehicles (EV)													DLT	OIE TISI OTP EPPO		
Action Plan 1.1.3.2	Enhancement of urban public bus efficiency	↔														16,404.75	0.17
Project 1.1.3.2-1	Procurement of 35 electric buses including electric charging station construction	↔														571.94	0.0019
Activity 1.1.3.2-1.1	Comparative study of financial value from various types of buses													BMTA	OTP EPPO		
Activity 1.1.3.2-1.2	Drafting the scope of work and details of the specific features and prices of electric buses with repair and maintenance of buses Including drafting the scope of work and details of the construction features of the charging station with maintenance of the station and conduct procurement													BMTA	OTP		
Activity 1.1.3.2-1.3	Try to run 35 electric buses with data on energy usage.													BMTA	OTP		
Project 1.1.3.2-2	Procurement of 1,453 hybrid buses	↔											BMTA	BB OTP DLT	11,624.00	0.129	
Activity 1.1.3.2-2.1	Drafting the scope of work and specifying the specific characteristics of the hybrid bus purchase (Hybrid)													BMTA	OTP		

Project / Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support		
Activity 1.1.3.2-2.2	Car procurement												BMTA	OTP		
Activity 1.1.3.2-2.3	Perform the operation												BMTA	DLT		
Project 1.1.3.2-3	Hybrid bus rent (7 years) for 400 buses	←—————→											BMTA	BB	4,208.81	0.035
Activity 1.1.3.2-3.1	Drafting the scope of work and specifying the characteristics of the hybrid car rental (Hybrid)												BMTA	OTP		
Activity 1.1.3.2-3.2	Car rental operation												BMTA	OTP		
Activity 1.1.3.2-3.3	Perform the operation												BMTA	DLT		
Action Plan 1.1.3.3	Enhancement of railway system efficiency	←—————→													6,827.74	0.032
Project 1.1.3.3-1	8 power cars modification (61-64)	←—————→													133.12	0.009
Activity 1.1.3.3-1.1	Drafting the scope of work and specifying the specific characteristics of the electric car bogie modification of 8 cars (61)												SRT	OTP		
Activity 1.1.3.3-1.2	Car modification of 8 cars (61) and operating												SRT	OTP		
Project 1.1.3.3-2	12 power cars modification (61-64)	←—————→													133.12	0.0136
Activity 1.1.3.3-2.1	Drafting the scope of work and specifying details of the specific features of the 12 electric car bogie modification (62)												SRT	OTP		
Activity 1.1.3.3-2.2	Car modification of 12 cars (63-64) and operating												SRT	OTP		
Project 1.1.3.3-3	Provision of diesel electric cars to replace GE diesel electric ones for 50 cars (61-64)	←—————→											SRT	OTP	6,561.50	0.010

Project / Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support		
Activity 1.1.3.3-1	Drafting the scope of work and specifying specific specifications for the supply of diesel electric vehicles (61)												SRT	OTP		
Activity 1.1.3.3-2	Procurement operations												SRT	OTP		
Activity 1.1.3.3-3	Perform the operation												SRT	OTP		
Action Plan 1.1.3.4	Enhancement of energy use efficiency in aviation														13,686.57	0.077
Project 1.1.3.4-1	Runway constructions, line 3 and 4 of Suvarnabhumi Airport												AOT	OTP	13,686.57	0.077
Action Plan 1.1.3.5	Promotion of logistic management for energy-saving														80.00	0.19
Project 1.1.3.5-1	Promotion of Logistics and Transport Management (LTM) for energy-saving												OTP	EPPO	60.00	0.19
Project 1.1.3.5-2	Research and development of Logistics and Transport Management Application (LTMA) for energy-saving												OTP	EPPO	20.00	
Total Group 1														3,249,937.26	18.67	

Note: * Excise tax rate improvement and annual car tax rates the proportion of new cars per vehicle in the system of personal cars 8.20%, pickup trucks 4.71% and motorcycles 9.77%

** Runway construction, routes 3 and 4 were used to evaluate the specific activities in Suvarnabhumi Airport. Not including airline activities

Existing projects and plans that are able to evaluate GHG emission reduction through the Measurement, Reporting and Verification (MRV) (Group 1) have potentials to reduce GHG of 18.67 MtCO₂e but not meet the target for GHG reduction in transport sector of 31 MtCO₂e. Therefore, it needs to add more projects/plans/measures which do not exist in the Action Plan of Ministry of Transport's Strategies 2017 – 2021 and are unoperated to meet the determined target. Those projects/plans/measures should enhance projects and plans of Group 1 to increase efficiency in GHG reduction.

For example, Action Plan 1.1.2.1 Infrastructure development to support the travel mode shift in railway transport systems (Group 1) consists of Construction of dual tracks for 32 lines, Construction of mass transit electric train systems and suburb train systems for 20 lines (including extensions), New railway construction for 14 lines and High-speed train + (Eastern Economic Corridor, EEC) for 4 lines. All projects are infrastructure development for Shift/Maintain mode which have potentials to reduce GHG of 5.42 MtCO₂e. Increasing people needs of railway system, the Government should promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and vicinity as in Action Plan 1.2.2.1 (Group 2) which can have more potentials to reduce GHG of 2.83 MtCO₂e.

Action Plan 1.1.3.1 Enhancement of energy use efficiency in private cars; Excise tax rate adjustment according to CO₂ emission amount (reflecting direct fuel consumption rate) for cars which is for improve mode have potentials to reduce GHG of 4.197 MtCO₂e. If the Government considers Excise tax rate adjustment according to CO₂ emission amount (reflecting direct fuel consumption rate) for cars based on strict tax measure, it can increase potentials of 1.87 MtCO₂e

Action Plan 1.1.2.2 Infrastructure development to support the travel mode shift in water transport systems (Group 1) consists of Development of Single Rail Transfer Operator (SRTO) at Laem Chabang port, Phase 1, 2 and 3 and Mab Taphut industrial port development Phase 3 which are for Shift/Maintain mode and have potentials to reduce GHG of 0.06 MtCO₂e including Development of Distribution Center (DC) can increase GHG reduction of 0.24 MtCO₂e and Establishment of Transportation Management System (TMS) as in Action Plan 1.2.3.4 can increase GHG reduction of 0.12 MtCO₂e.

Recommended projects and plans of Group 2 can be illustrated as follows:

Group 2	Recommended projects and plans for additional operations
----------------	---

Measure 1.2.1	Travel Avoidance or Reduction (Avoid/Reduce)
Measure 1.2.2	Travel mode shift (Shift/Maintain)
Action Plan 1.2.2.1	Infrastructure development to promote travel mode shift in railway transport systems
Project 1.2.2.1-1	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and vicinity
Project 1.2.2.1-2	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla
Action Plan 1.2.2.2	Development of travel mode shift promotion mechanism
Project 1.2.2.2-1	Improvement of urban and outskirt public service via hybrid passenger vehicles
Measure 1.2.3	Improvement and development of energy use efficiency in transport sector (Improve)
Action Plan 1.2.3.1	Enhancement of energy use efficiency in private cars
Project 1.2.3.1-1	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars based on strict tax measure
Project 1.2.3.1-2	Promote disposal of deteriorated vehicles (old vehicles) from the system (more than 15 years of service or exceeding 200,000 km)
Project 1.2.3.1-3	Improvement of air conditioning systems in cars
Project 1.2.3.1-4	Use of fuel mechanism to carry forward use of effective vehicles
Action Plan 1.2.3.2	Improvement of urban public passenger vehicle efficiency
Project 1.2.3.2-1	Replace air-conditioned passenger vans with 4,626 electric minibuses
Project 1.2.3.2-2	Promote use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla

- Project 1.2.3.2-3 Replace delivery motorcycles with electric motorcycles in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla
- Action Plan 1.2.3.3 Promotion of Logistic Management for energy-saving**
- Project 1.2.3.3-1 Backhaul Management
- Project 1.2.3.3-2 Establish Distribution Center (DC)
- Project 1.2.3.3-3 Establish training center to train for energy-saving driving in 5 regions nationwide
- Action Plan 1.2.3.4 Development of Transportation Management System (TMS)**
- Project 1.2.3.4-1 Development and promotion of Transportation Management System (TMS)
- Action Plan 1.2.3.5 Change of electric devices such as light bulbs in transport infrastructure**
- Project 1.2.3.5-1 Shift to use of LED light bulbs in all ports/airports/highways

Table 9.1-3 Project and plan details in Group 2 under Strategy 1

Project /Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)				
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support						
Strategy 1	Support and promote actions regarding relevant agencies in transport sector																			
Group 2	Recommended projects and plans for additional operations																31,619.00	16.74		
Measure 1.2.2	Travel mode shift (Shift/Maintain)																750.00	3.59		
Action Plan 1.2.2.1	Infrastructure development to promote travel mode shift in railway transport systems																650.00	3.55		
Project 1.2.2.1-1	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and vicinity														BMA DOH/DRR	OTP/PSM OT	450.00	2.83		
Project 1.2.2.1-2	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla																DOH./DRR DLA	OTP/PSM OT	200.00	0.72
Action Plan 1.2.2.2	Development of travel mode shift promotion mechanism																		100.00	0.043
Project 1.2.2.2-1	Improvement of urban and outskirt public service via hybrid passenger vehicles																DLT DLA	MOT	100.00	0.043
Measure 1.2.3	Improvement and development of energy use efficiency in transport sector (Improve)																30,869.00	13.15		
Action Plan 1.2.3.1	Enhancement of energy use efficiency in private cars																90.00	9.07		
Project 1.2.3.1-1	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars based on strict tax measure																20.00	1.866		

Project /Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)	
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support			
Activity 1.2.3.1-1.1	Excise tax collection According to the amount of CO ₂ emissions announced on 2017												Excise Department				
Activity 1.2.3.1-1.2	Creating a database of fuel consumption rates of new cars (from Eco-sticker) and cars in the system. (from observation)												OTP	OIE DLT TISI			
Activity 1.2.3.1-1.3	Education to improve the rate of taxation, increase concentration, and understand stakeholders.												Excise Department	OTP OIE			
Activity 1.2.3.1-1.4	Excise tax declaration rate (Revised edition)												Excise Department				
Activity 1.2.3.1-1.5	Enforcement of excise tax rates (Revised edition)												Excise Department				
Project 1.2.3.1-2	Promote disposal of deteriorated vehicles (old vehicles) from the system (more than 15 years of service or exceeding 200,000 km)															30.00	4.15
Activity 1.2.3.1-2.1	A study of deteriorating vehicle specifications (old cars), conditions, impacts, and measures to support sales of degraded vehicles from the system.												DLT	OIE TISI OTP CGD			
Activity 1.2.3.1-2.2	A study of the process of eliminating degraded cars (old cars) and handling used industrial parts												PCD	TISI OIE			
Activity 1.2.3.1-2.3	Public relations and understanding with stakeholders												DLT	OIE TISI OTP			
Activity 1.2.3.1-2.4	Announcement of support policies for the sale of degraded cars from the system (2 nd car)												DLT	OIE TISI OTP			
Activity 1.2.3.1-2.5	Admission to join the 2 nd car project												DLT	OIE TISI OTP			
Project 1.2.3.1-3	Improvement of air conditioning systems in cars															30.00	1.00
Activity 1.2.3.1-3.1	baseline and support data for evaluation through measurement, report and verification (MRV) (61)												OTP	DEDE			

Project /Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)			
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support					
Activity 1.2.3.1-3.2	Establish standards for energy efficiency testing in vehicles with air conditioning systems (61-62)													DEDE	TISI DLT EGAT				
Activity 1.2.3.1-3.3	Study the possibility of issuing tax incentives. To convince manufacturers to develop and install high-performance air-conditioning systems (62-63)													DEDE	BOI				
Activity 1.2.3.1-3.4	Establish rules for the private sector to enter the process of using high efficiency air conditioning systems													DEDE	TISI DLT EGAT				
Project 1.2.3.1-4	Use of fuel mechanism to carry forward use of effective vehicles																10.00	2.056	
Activity 1.2.3.1-4.1	The study of the effects of using price mechanisms to drive fuel consumption from high-performance vehicles													EPPO	OTP				
Activity 1.2.3.1-4.2	Public relations and understanding with stakeholders													EPPO	OTP				
Activity 1.2.3.1-4.3	Announcement of price mechanism													EPPO	OTP				
Action Plan 1.2.3.2	Improvement of urban public passenger vehicle efficiency																29,995.00	2.53	
Project 1.2.3.2-1	Replace air-conditioned passenger vans with 4,626 electric minibuses													BMTA Private Bus	DLT			465.00	0.0279
Activity 1.2.3.2-1.1	Comparative study of economics and environmental value from electric bus operation and the mechanism of changing cars													EPPO	OTP				
Activity 1.2.3.2-1.2	Public relations and understanding with stakeholders													EPPO	OTP				
Activity 1.2.3.2-1.3	Conduct a pilot project to change the air-conditioned van to 4,626 electric mini buses (100 shared cars) (65)													EPPO	Customs DLT				

Project /Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)	
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support			
Activity 1.2.3.2-1.4	Announcement of guidelines and conditions for changing vehicles													EPPO	OTP Customs		
Activity 1.2.3.2-1.5	Announcement for participation in the project													EPPO	OTP DLT		
Activity 1.2.3.2-1.6	Operate the bus (67)													EPPO	OTP		
Project 1.2.3.2-2	Promote use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla													BMTA Private Bus DLA	DLT	25,130.00	2.5
Project 1.2.3.2-3	Replace delivery motorcycles with electric motorcycles in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla													Entrepreneur	DLT	4,400.00	0.001
Action Plan 1.2.3.3	Promotion of Logistic Management for energy-saving															634.00	0.611
Project 1.2.3.3-1	Backhaul Management															104.00	0.06
Activity 1.2.3.3-1.1	Development of Application and Platform for the management of empty transport of trucks in real time													DLT	OTP DEDE	39.00	
Activity 1.2.3.3-1.2	Promotion and dissemination of application usage for the management of empty transportation with domestic transport operators													DLT	OTP DEDE	65.00	
Project 1.2.3.3-2	Establish Distribution Center (DC)													DLT	OTP DEDE	500.00	0.241
Project 1.2.3.3-3	Establish training center to train for energy-saving driving in 5 regions nationwide													OTP	EPPO	30.00	0.31
Action Plan 1.2.3.4	Development of Transportation Management System (TMS)															50.00	0.12

Project /Activity	Action Plan	Timeline											Agency		Budget Million Baht	CO ₂ Reduction (MtCO ₂ e)	
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support			
Project 1.2.3.4-1	Development and promotion of Transportation Management System (TMS)				↔									OTP	DEDE Entrepreneur	50.00	0.12
Action Plan 1.2.3.5	Change of electric devices such as light bulbs in transport infrastructure			↔												100.00	0.82
Project 1.2.3.5-1	Shift to use of LED light bulbs in all ports/airports/highways			↔										PORT MD AOT DOA EXAT	DEDE EPPO	100.00	0.82
Total Group 2															31,619.00	16.74	

According to evaluation of potential for GHG reduction through Measurement, Reporting and Verification (MRV) methods using comparative analysis of energy consumption and GHG emission in baseline and mitigation scenarios, it was found that the existing projects and plans in the strategic operation plan of the Ministry of Transport in 2017 – 2021 have potentials to reduce GHG in total of 18.67 MtCO₂e (Group 1). If Ministry of Transport implements the Recommended projects and plans of Group 2, GHG will be reduced to 16.74 MtCO₂e, totally 35.42 MtCO₂e. This will meet the target of GHG reduction in transport sector of 31 MtCO₂e as determined.

Additionally, Transport Sector's NDC Action Plan 2021 – 2030 proposes the added projects and measures (Group 3) which have potentials for GHG reduction, but unable to measure the reduction amount, due to baseline data must be collected by relevant agencies for the next year.

Added projects and measures with potential for GHG reduction of Group 3 can be illustrated as follows:

Group 3

Added projects and measures with potential for GHG reduction, but unable to measure the reduction amount, and firstly, baseline data must be collected.

Measure 1.3.1	Travel Avoidance or Reduction (Avoid/Reduce)
Measure 1.3.2	Travel mode shift (Shift/Maintain)
Action Plan 1.3.2.1	Development of Travel Mode Shift Promotion Mechanism
Project 1.3.2.1-1	Establish public transport promotion fund
Project 1.3.2.1-2	Improve conditions of public bus service concession
Project 1.3.2.1-3	Increase public bus service operating channels and provide priority to public buses in urban areas
Project 1.3.2.1-4	Adjust a number of public bus trips and operation routes to connect to the railway systems (Feeder)
Project 1.3.2.1-5	Provide real-time public transport service information via mobile application and improve provision of operating information on intelligent bus stops
Project 1.3.2.1-6	Develop park and ride spots for railway transit customers (phase 2) to support transport demand management system
Project 1.3.2.1-7	Develop an integral common-ticketing system for nationwide transport
Project 1.3.2.1-8	Publicize information and data to the public to motivate them to use the service
Action Plan 1.3.2.2	Infrastructure development to promote travel mode shift in water transport systems
Project 1.3.2.2-1	Study and manage ship queuing
Project 1.3.2.2-2	Establish Bangkok port's one stop service
Project 1.3.2.2-3	Develop database and monitor shipping data and information
Measure 1.3.3	Improvement and development of energy use efficiency in Transport sector (Improve)
Action Plan 1.3.3.1	Enhance energy use efficiency in inter-city buses
Project 1.3.3.1-1	Provide inter-city buses
Project 1.3.3.1-2	Perform in accordance with the Eco-efficiency project according to memorandum of agreement, state enterprise evaluation, accounting year 2018
Action Plan 1.3.3.2	Development of Training and Monitoring Systems for Eco-driving

- Project 1.3.3.2-1 Establish training center to train truck driving trainers (Training of Trainer) according to Eco-driving course in all regions nationwide
- Project 1.3.3.2-2 Develop On-board Diagnostic (OBD) technology and devices and database system for eco-driving evaluation among trucks
- Project 1.3.3.2-3 On-board Diagnostic (OBD) technology and devices for eco-driving evaluation among trucks
- Action Plan 1.3.3.3 Enhancement of truck transport management standards (Q Mark)**
- Project 1.3.3.3-1 Enhance truck transport management standards to promote energy efficiency and GHG emission reduction
- Project 1.3.3.3-2 Recommend and encourage truck service operators to improve their operation quality according to truck transport standards (Q Mark)
- Project 1.3.3.3-3 Create marketing demands of truck transport standards (Q Mark)
- Project 1.3.3.3-4 Follow-up and give advices to truck service operators to perform in accordance with truck transport standards (Q Mark)
- Action Plan 1.3.3.4 Improvement of energy use and reduction of CO₂ in Cold Chain Logistics systems in Thailand**
- Project 1.3.3.4-1 Study methods for energy use improvement and CO₂ reduction for Cold Chain Logistics
- Project 1.3.3.4-2 Change of cooling substance used by trucks in Cold Chain Logistics systems to improve the energy use and reduce CO₂
- Project 1.3.3.4-3 Pilot Project for cooling substance change in trucks in Cold Chain Logistics systems to improve the energy use and reduce CO₂
- Action Plan 1.3.3.5 Logistics System Development**
- Project 1.3.3.5-1 Sustainable logistics operations (Green Logistics) by private sectors

Table 9.1-4 Project and plan details in Group 3 under Strategy 1

Project/ Activity	Action Plan	Timeline											Agency		Budget Million	CO ₂ Reduction (MtCO ₂ e)		
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support				
Strategy 1	Support and promote actions regarding relevant agencies in transport sector																	
Group 3	Added projects and measures with potential for GHG reduction, but unable to measure the reduction amount, and firstly, baseline data must be collected.																44,108.00	
Measure 1.3.2	Travel Avoidance or Reduction (Avoid/Reduce)																41,560.00	0.00
Action Plan 1.3.2.1	Travel mode shift (Shift/Maintain)														41,485.00	0.00		
Project 1.3.2.1-1	Development of Travel Mode Shift Promotion Mechanism												OTP	DLT MOF	30.00			
Project 1.3.2.1-2	Establish public transport promotion fund												DLT	OTP	25.00			
Project 1.3.2.1-3	Improve conditions of public bus service concession												DLT	BMTA OTP	100.00			
Project 1.3.2.1-4	Increase public bus service operating channels and provide priority to public buses in urban areas												BMTA BUS	BMTA OTP	30.00			
Project 1.3.2.1-5	Adjust a number of public bus trips and operation routes to connect to the railway systems (Feeder)												DLT	BMTA BMA	600.00			
Project 1.3.2.1-6	Provide real-time public transport service information via mobile application and improve provision of operating information on intelligent bus stops												MRTA	OTP	40,000.00			
Project 1.3.2.1-7	Develop park and ride spots for railway transit customers (phase 2) to support transport demand management system												MRTA BMTA BUS SRT	OTP DLT	600.00			
Project 1.3.2.1-8	Publicize information and data to the public to motivate them to use the service												DLT	BMA	100.00			

Project/ Activity	Action Plan	Timeline											Agency		Budget Million	CO ₂ Reduction (MtCO ₂ e)			
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support					
Action Plan 1.3.2.2	Infrastructure development to promote travel mode shift in water transport systems			←→														75.00	0.00
Project 1.3.2.2-1	Study and manage ship queuing			←→										PORT	DEDE	30.00			
Project 1.3.2.2-2	Establish Bangkok port's one stop service					←→								PORT		15.00			
Project 1.3.2.2-3	Develop database and monitor shipping data and information			←→										MD	OTP	30.00			
Measure 1.3.3	Improvement and development of energy use efficiency in Transport sector (Improve)															2,548.00	0.00		
Action Plan 1.3.3.1	Enhance energy use efficiency in inter-city buses	←→													-	0			
Project 1.3.3.1-1	Provide inter-city buses	←→																	
Activity 1.3.3.1-1.1	Drafting the scope of work and specifying the details of the specific features of renting and buying buses between cities													The Transport	BB				
Activity 1.3.3.1-1.2	Procurement and bus rental													The Transport	BB				
Activity 1.3.3.1-1.3	Operate the bus													The Transport	BB				
Project 1.3.3.1-2	Perform in accordance with the Eco-efficiency project according to memorandum of agreement, state enterprise evaluation, accounting year 2018	←→																	
Activity 1.3.3.1-2.1	Collect data and prepare evaluation guidelines (61)													The Transport	OTP				
Activity 1.3.3.1-2.2	Evaluation													The Transport	OTP				
Action Plan 1.3.3.2	Development of Training and Monitoring Systems for Eco-driving	←→													1,885.00	0			

Project/ Activity	Action Plan	Timeline											Agency		Budget Million	CO ₂ Reduction (MtCO ₂ e)		
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support				
Project 1.3.3.2-1	Establish training center to train truck driving trainers (Training of Trainer) according to Eco-driving course in all regions nationwide	←→												DLT DEDE	DSD BusThai	650.00		
Project 1.3.3.2-2	Develop On-board Diagnostic (OBD) technology and devices and database system for eco-driving evaluation among trucks	←→												DLT DEDE	NSTDA Private Company	65.00		
Project 1.3.3.2-3	On-board Diagnostic (OBD) technology and devices for eco-driving evaluation among trucks			←→											DLT	NSTDA Private Company	1,170.00	
Action Plan 1.3.3.3	Enhancement of truck transport management standards (Q Mark)	←→															377.00	0
Project 1.3.3.3-1	Enhance truck transport management standards to promote energy efficiency and GHG emission reduction	←→							←→					DLT	OTP	52.00		
Project 1.3.3.3-2	Recommend and encourage truck service operators to improve their operation quality according to truck transport standards (Q Mark)	←→													DLT	OTP	130.00	
Project 1.3.3.3-3	Create marketing demands of truck transport standards (Q Mark)	←→													DLT	OTP	130.00	
Project 1.3.3.3-4	Follow-up and give advices to truck service operators to perform in accordance with truck transport standards (Q Mark)	←→													DLT	OTP	65.00	
Action Plan 1.3.3.4	Improvement of energy use and reduction of CO₂ in Cold Chain Logistics systems in Thailand	←→												DLT	OTP	286.00	0	
Project 1.3.3.4-1	Study methods for energy use improvement and CO ₂ reduction for Cold Chain Logistics	←→												DLT	OTP	65.00		
Project 1.3.3.4-2	Change of cooling substance used by trucks in Cold Chain Logistics systems to improve the energy use and reduce CO ₂	←→												DLT	OTP	26.00		

Project/ Activity	Action Plan	Timeline											Agency		Budget Million	CO ₂ Reduction (MtCO ₂ e)	
		63	64	65	66	67	68	69	70	71	72	73	Primary	Support			
Project 1.3.3.4-3	Pilot Project for cooling substance change in trucks in Cold Chain Logistics systems to improve the energy use and reduce CO ₂				↔									DLT	OTP	195.00	
Action Plan 1.3.3.5	Logistics System Development	↔													-	0	
Project 1.3.3.5-1	Sustainable logistics operations (Green Logistics) by private sectors	↔															
Total Group 3															44,108.00	-	

Strategy 2 Develop and improve laws promoted GHG reduction

Development and improvement of laws to promote GHG reduction can be divided into 3 measures as follows:

Measure 2.1 Avoid/Reduce

- Development of a law for parking fee collection measure in high-traffic areas (congestion charge)
- Development of a law for Road pricing measure in high-traffic areas

Measure 2.2 Shift/Maintain

- Development of a law for fund establishment to support travel by public transport
- Development of a law for adjusting concession condition of public bus operation
- Development of a law for fuel tax exemption according to service quality of public bus operator

Measure 2.3 Improve

- Development of a law for excise tax rate adjustment according to CO₂ emission amount (reflecting direct fuel consumption rate) for cars
- Development of a law for excise tax rate adjustment according to CO₂ emission amount (reflecting direct fuel consumption rate) for motorcycles
- Development of a law for annual car tax rate adjustment according to CO₂ emission amount (reflecting direct fuel consumption rate)
- Development of a law for promoting disposal of deteriorated vehicles (old vehicles) from the system

Development of laws above were summarized from Transport Sector's NDC Action Plan 2021 – 2030 as shown in **Table 9.1-2** to **Table 9.1-4**. This development will help people, enterprises, and agencies increase motivation in promoting public transport system and support GHG reduction to meet the GHG target of transport sector.

Strategy 3 Develop Measurement, Reporting and Verification, MRV

MRV (Measurement, Reporting and Verification) is a mechanism of measurement, reporting and verification of GHG emission reduction activities to prove operation success of measures, projects, method and policies in GHG reduction. This is called a tool for management and monitoring of GHG emission and reduction to comply with the designated intention.

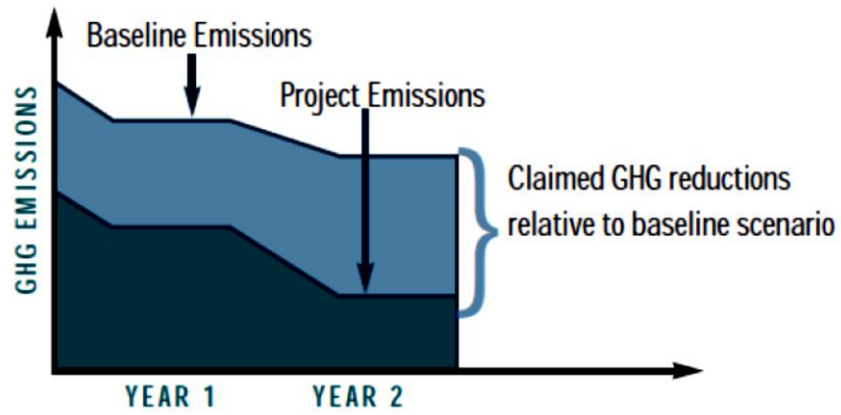
MRV method started from cooperation among various countries in reducing GHG caused by Climate Change in order to maintain the global temperature not exceed 2°C. To certain GHG reduction operation be appropriate mechanism and tracking method, MRV has been used toward the determined target of global and national levels.

Regarding cooperation among the countries, MRV method has been used in various kinds of work as follows:

- 1) MRV of GHG emissions is the system of measurement, reporting and verification of GHG emission:
 - National inventory
 - Company/organization inventories
 - Facility-level inventories
- 2) MRV of mitigation actions and goals (such as Nationally Appropriate Mitigation Actions, NAMAs) is the system of measurement, reporting and verification of GHG emission reduction on measures, policies, plans and projects:
 - GHG reduction goals
 - Policies and actions
 - Projects

For Thailand, Office of Transport and Traffic Policy and Planning (OTP) has been used MRV of mitigation actions and goals under plans and policies on Thailand GHG emission reduction regarding Nationally Appropriate Mitigation Actions (NAMAs) and Nationally Determined Contribution (NDC) on policy base and project base.

Transport Sector's NDC Action Plan 2021 – 2030 has been used MRV of mitigation actions and goals in evaluating GHG on policy base and project base by comparing to base case as shown in Figure 9.1-11.



Source: World Resources Institute, 2014

[https://www.thepmr.org/system/files/documents/Sesion%201B%20-](https://www.thepmr.org/system/files/documents/Sesion%201B%20-%20WRI_MRV%20Panorama%20general.pdf)

[%20WRI_MRV%20Panorama%20general.pdf](https://www.thepmr.org/system/files/documents/Sesion%201B%20-%20WRI_MRV%20Panorama%20general.pdf)

Figure 9.1-11 GHG reduction measurement method comparing to base case

Action Plan 1 Baseline data collection to support Measurement, Reporting and Verification (MRV) according to Avoid-Shift-Improve approach

Baseline data collection is for MRV estimation by Avoid-Shift-Improve approach. The principle is to collect before-after project implementation in every 2 years to compare the changed travel proportion or other baseline data of BAU.

These data will be used to calculate share and shift proportion and CO₂ Emission comparing between before-after project implementation. Data collection is assigned relevant agencies to systematically record and annually report to OTP or use application following by OTP pattern.

OTP is the regulatory agency including collects and analyze data. ONEP/MOT is the verification agency.

Action Plan 2 Template determination and standardization of data collection for MRV evaluation

OTP is the key agency and ONEP is the support agency for template determination and standardization of data collection for baseline preparation and MRV evaluation.

Action Plan 3 Measurement, Reporting and Verification (MRV) facilitation

OTP is the key agency for facilitating Measurement and Reporting. The data collection agencies are the support agency. TGO and ONEP are the verification agency to evaluate GHG reduction results annually. OTP is the center agency to coordinate the action and data collection and report to ONEP.

Action Plan 4 Database formulation to measure GHG emission in transport sector

OTP is the key agency for database formulation and assigns the relevant agencies report the data to OTP to measure GHG emission in transport sector.

Budgeting for Measurement, Reporting and Verification (MRV) was determined according to Avoid-Shift-Improve approach. Baseline data collection to support MRV, template determination and standardization of data collection for MRV evaluation and MRV facilitation are common budgets. The details of budgets are shown in **Table 9.1-5**.

Table 9.1-5 Details of Strategy 3 for development of Measurement, Reporting and Verification (MRV) systems

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
1. To collect basic information (Baseline data) to evaluate MRV measures A-S-I. 2. To define the formulation and the standardization of data collection for MRV evaluation 3. Measurement, Reporting and Verification (MRV)													
Travel Avoidance or Reduction (Avoid/Reduce)	Measure 1.1.1												1. Baseline data collection, including data collection, modification of travel patterns by surveying OD traveling behavior before - after having a project and every 2 years to compare the change of travel proportion with the following important information 1) Travel distance of people according to vehicle type 2) Fuel of various types of vehicles used 3) Changing travel patterns Compared to 2 years ago 2. Formulation and standardization of data collection for MRV evaluation
	Action Plan 1.1.1.1	Development of Travel Demand Management (TDM) Mechanism						50	75				
	Project 1.1.1.1-1	Parking fee collection measure in high-traffic areas	√			OTP	BMA DLT				2.00		
	Project 1.1.1.1-2	Road pricing measure in high-traffic areas	√										
	Action Plan 1.1.1.2	Development of areas surrounding public transport stations (Transit Oriented Development, TOD)									0.9		
Project 1.1.1.2-1	Development of areas surrounding public transport stations (Transit Oriented Development, TOD)	√			OTP	BMA DLT							

Budget according to the Action Plan measures			Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
			1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
														3. Measurement and verification reports (Measurement, Reporting and Verification) 4. Database preparation for measuring the amount of GHG emissions in the transport sector
Shift of Transport Modes (Shift/Maintain)	Measure 1.1.2													1. Baseline data as follows <u>Rail system</u> 1) Number of passengers using the service 2) The volume of passengers traveling 3) Distance and average distance of passengers traveling 3) The amount of energy used in passenger travel 4) Changing travel patterns 5) Consumption rate of various types of vehicles 6) Train information classified by locomotive type Locomotive type and fuel type 7) Energy and efficiency data such as distance or the number of working hours of the car and the
	Action Plan 1.1.2.1	Infrastructure development to support the travel mode shift in railway transport systems						25	50	75				
	Project 1.1.2.1-1	Construction of dual tracks for 32 lines	√			OTP	SRT				1.43	0.03	0.02	
	Project 1.1.2.1-2	Construction of mass transit electric train systems and suburb train systems for 20 lines (including extensions)	√			OTP	รฟฟท.				0.14	0.89	0.03	
	Project 1.1.2.1-3	New railway construction for 14 lines	√			OTP	SRT				0.03	0.03	0.03	
	Project 1.1.2.1-4	High-speed train + EEC for 4 lines	√			OTP	SRT				0.75	0.70	1.34	
	Action Plan 1.1.2.2	Infrastructure development to support the travel mode shift in water transport systems												

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
Project 1.1.2.2-1	Development of Single Rail Transfer Operator (SRTO) at Laem Chabang port, Phase 1 and 2	√			OTP	PORT MD				0.794			amount of fuel separated by locomotive type And type of usage 8) Information that Support in the analysis of energy efficiency of the operation, ie route, distance, average passenger capacity Average volume / weight of product and the lifespan of the current car <u>Land system (bus)</u> 1) Vehicle information Separated by engine size Energy use, distance of the bus 2) Information on energy consumption and efficiency of the current bus service classified by vehicle type and fuel type 3) Information that support in analyzing the energy efficiency of the current operation is the route, distance, average passenger capacity and the lifespan of the current car <u>Water system</u>
Project 1.1.2.2-2	Construction of Chao Praya and Nan river dams for water transport operation	√			OTP	MD				0.081			
Project 1.1.2.2-3	Enhancement of freight transport system via Pasak river	√			OTP	MD				0.048			
Project 1.1.2.2-4	Ferry development linking upper gulf of Thailand	√			OTP	MD				0.0014			
Project 1.1.2.2-5	Laem Chabang Port development, Phase 3	√			OTP	PORT MD					0.412		
Project 1.1.2.2-6	Mab Taphut industrial port development, Phase 3	√			OTP	PORT MD					0.041		
Measure 1.2.2													
Action Plan 1.2.2.1	Infrastructure development to support the travel mode shift in railway transport systems												
Project 1.2.2.1-1	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and vicinity		√		OTP	BMA DOH/DR R					2.83		

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
Project 1.2.2.1-2	Promote walking and bicycle use to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla		√		OTP	DOH./DR R DLA					0.72		1) Total travel distance of passenger and cargo transportation of river routes 2) The volume of passenger travel and water cargo transportation 3) The amount of energy used in passenger travel and water cargo 4) Consumption rate of various types of vessels in the water system 2. Formulation and standardization of data collection for MRV evaluation 3. Measurement and verification reports (Measurement, Reporting and Verification) 4. Database preparation for measuring the amount of GHG emissions in the transport sector
Action Plan 1.2.2.2	Development of travel mode shift promotion mechanism												
Project 1.2.2.2-1	Improvement of urban and outskirt public service via hybrid passenger vehicles		√		OTP	DLT DLA				0.043			
Measure 1.3.2													
Action Plan 1.3.2.1	Development of Travel Mode Shift Promotion Mechanism												
Project 1.3.2.1-1	Establish public transport promotion fund			√	OTP	DLT MOF							
Project 1.3.2.1-2	Improve conditions of public bus service concession			√	OTP	DLT							
Project 1.3.2.1-3	Increase public bus service operating channels and provide priority to public buses in urban areas			√	OTP	DLT BMTA							
Project 1.3.2.1-4	Adjust a number of public bus trips and operation routes to connect to the railway systems (Feeder)			√	OTP	BMTA BUS							

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
Project 1.3.2.1-5	Provide real-time public transport service information via mobile application and improve provision of operating information on intelligent bus stops			√	OTP	DLT BMTA BMA							
Project 1.3.2.1-6	Develop park and ride spots for railway transit customers (phase 2) to support transport demand management system			√	OTP	MRTA							
Project 1.3.2.1-7	Develop an integral common-ticketing system for nationwide transport			√	OTP	MRTA BMTA BUS SRT							
Project 1.3.2.1-8	Publicize information and data to the public to motivate them to use the service			√	OTP	DLT BMA							
Action Plan 1.3.2.2	Infrastructure development to promote travel mode shift in water transport systems												
Project 1.3.2.2-1	Study and manage ship queuing			√	OTP	PORT							
Project 1.3.2.2-2	Establish Bangkok port's one stop service			√	OTP	PORT							
Project 1.3.2.2-3	Develop database and monitor shipping data and information			√	OTP	MD							

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations	
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)		
Improvement and development of energy use efficiency in Transport sector (Improve)	Measure 1.1.3												1. Baseline data as follows <u>Land system (cars and buses)</u> 1) Number of registered vehicles / vehicles Separated by engine size Energy use, distance of cars, motorcycles, buses and all types of cars 2) Information on energy consumption and efficiency and emissions of current vehicles by vehicle type Car life and fuel type 3) Information that support in analyzing the energy efficiency of the current operation is the route, distance, average passenger capacity and the lifespan of the current car 4) Number of users / passengers <u>Rail system</u> 1) Train information classified by locomotive type Locomotive type and fuel type 2) Energy and energy efficiency data such as distance or the number of working hours of the car and the amount of fuel separated by locomotive type And type of usage	
	Action Plan 1.1.3.1	Enhancement of energy use efficiency in private cars					25	50	75					
	Project 1.1.3.1-1	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars	√			OTP	OIE DLT TISI				4.197			
	Project 1.1.3.1-2	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars	√			OTP	OIE DLT TISI				1.338			
	Project 1.1.3.1-3	Annual car tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate)	√			OTP	OIE DLT TISI				1.535			
	Project 1.1.3.1-4	Expansion of Electric vehicles	√			OTP	TISI OIE				1.440			
	Action Plan 1.1.3.2	Enhancement of urban public bus efficiency												
	Project 1.1.3.2-1	Procurement of 35 electric buses including electric charging station construction	√			OTP	BMTA				0.0019			
	Project 1.1.3.2-2	Procurement of 1,453 hybrid buses	√			OTP	BMTA				0.129			
	Project 1.1.3.2-3	Hybrid bus rent (7 years) for 400 buses	√			OTP	BMTA				0.035			
	Action Plan 1.1.3.3	Enhancement of railway system efficiency												

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
Project 1.1.3.3-1	8 power cars modification (61-64)	√			OTP	SRT				0.009			3) Information that support in analyzing the energy efficiency of SRT vehicles to be managed at the current level, ie distance, average passenger capacity Average volume / weight of product and the lifespan of the current car Freight system 1) Number and type of Entrepreneur, Industrial sector and Transport sector 2) Freight volume per day and per year both traveling and returning 3) The average distance in shipping 4) Fuel consumption in transportation 5) Transportation costs 6) Primary system for transporting goods and secondary systems (Feeder) 2. Formulation and standardization of data collection for MRV evaluation
Project 1.1.3.3-2	12 power cars modification (61-64)	√			OTP	SRT				0.0136			
Project 1.1.3.3-3	Provision of diesel electric cars to replace GE diesel electric ones for 50 cars (61-64)	√			OTP	SRT				0.0096			
Action Plan 1.1.3.4	Enhancement of energy use efficiency in aviation												
Project 1.1.3.4-1	Runway constructions, line 3 and 4 of Suvarnabhumi Airport	√			OTP	AOT					0.077		
Action Plan 1.1.3.5	Promotion of logistic management for energy-saving												
Project 1.1.3.5-1	Promotion of Logistics and Transport Management (LTM) for energy-saving	√			OTP	EPPO				0.19			
Project 1.1.3.5-2	Research and development of Logistics and Transport Management Application (LTMA) for energy-saving	√			OTP	EPPO							
Measure 1.2.3													
Action Plan 1.2.3.1	Enhancement of energy use efficiency in private cars												
Project 1.2.3.1-1	Excise tax rate adjustment according to CO ₂ emission amount (reflecting direct fuel consumption rate) for cars based on strict tax measure		√		OTP	OIE DLT TISI					1.866		
Project 1.2.3.1-2	Promote disposal of deteriorated vehicles (old vehicles) from the system (more than 15 years of service or exceeding 200,000 km)		√		OTP	OIE DLT TISI						4.15	

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
Project 1.2.3.1-3	Improvement of air conditioning systems in cars		√		OTP	DEDE					1.00		3. Measurement and verification reports (Measurement, Reporting and Verification) 4. Database preparation for measuring the amount of GHG emissions in the transport sector
Project 1.2.3.1-4	Use of fuel mechanism to carry forward use of effective vehicles		√		OTP	EPPO					2.056		
Action Plan 1.2.3.2	Improvement of urban public passenger vehicle efficiency												
Project 1.2.3.3-1	Replace air-conditioned passenger vans with 4,626 electric minibuses		√		OTP	DLT EPPO						0.028	
Project 1.2.3.3-2	Promote use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla		√		OTP	DLT DOEB						2.50	
Project 1.2.3.3-3	Replace delivery motorcycles with electric motorcycles in Bangkok and vicinity and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla		√		OTP	BMTA Private Bus DLT Delivery company						0.0006	
Action Plan 1.2.3.3	Promotion of Logistic Management for energy-saving												
Project 1.2.3.3-1	Backhaul Management		√		OTP	OTP DEDE					0.06		
Project 1.2.3.3-2	Establish Distribution Center (DC)		√		OTP	OTP DEDE					0.24		
Project 1.2.3.3-3	Establish training center to train for energy-saving driving in 5 regions nationwide		√		OTP	EPPO					0.31		

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
Action Plan 1.2.3.4	Development of Transportation Management System (TMS)												
Project 1.2.3.4-1	Development and promotion of Transportation Management System (TMS)		√		OTP	OTP DEDE					0.12		
Action Plan 1.2.3.5	Change of electric devices such as light bulbs in transport infrastructure												
Project 1.2.3.5-1	Shift to use of LED light bulbs in all ports/airports/highways		√		OTP	PORT MDAOT DOA EXAT					0.82		
Measure 1.3.3													
Action Plan 1.3.3.1	Enhance energy use efficiency in inter-city buses												
Project 1.3.3.1-1	Provide inter-city buses			√	OTP	The Transport							
Project 1.3.3.1-2	Perform in accordance with the Eco-efficiency project according to memorandum of agreement, state enterprise evaluation, accounting year 2018			√	OTP	BMTA The Transport SRT							
Action Plan 1.3.3.2	Development of Training and Monitoring Systems for Eco-driving												
Project 1.3.3.2-1	Establish training center to train truck driving trainers (Training of Trainer) according to Eco-driving course in all regions nationwide			√	OTP	DLT							

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
Project 1.3.3.2-2	Develop On-board Diagnostic (OBD) technology and devices and database system for eco-driving evaluation among trucks			√	OTP	DLT							
Project 1.3.3.2-3	On-board Diagnostic (OBD) technology and devices for eco-driving evaluation among trucks			√	OTP	DLT							
Action Plan 1.3.3.3	Enhancement of truck transport management standards (Q Mark)												
Project 1.3.3.3-1	Enhance truck transport management standards to promote energy efficiency and GHG emission reduction			√	OTP	DLT							
Project 1.3.3.3-2	Recommend and encourage truck service operators to improve their operation quality according to truck transport standards (Q Mark)			√	OTP	DLT							
Project 1.3.3.3-3	Create marketing demands of truck transport standards (Q Mark)			√	OTP	DLT							
Project 1.3.3.3-4	Follow-up and give advices to truck service operators to perform in accordance with truck transport standards (Q Mark)			√	OTP	DLT							
Action Plan 1.3.3.4	Improvement of energy use and reduction of CO₂ in Cold Chain Logistics systems in Thailand												

Budget according to the Action Plan measures		Group			Agency responsible In MRV		Budget for MRV (Million)			Potential to reduce GHG (MtCO ₂ e)			Scope of Operations
		1	2	3	Primary	Support	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	Short Term (63-64)	Medium Term (65-68)	Long Term (69-73)	
Project 1.3.3.4-1	Study methods for energy use improvement and CO ₂ reduction for Cold Chain Logistics			√	OTP	DLT							
Project 1.3.3.4-2	Change of cooling substance used by trucks in Cold Chain Logistics systems to improve the energy use and reduce CO ₂			√	OTP	DLT							
Project 1.3.3.4-3	Pilot Project for cooling substance change in trucks in Cold Chain Logistics systems to improve the energy use and reduce CO ₂			√	OTP	DLT							
Action Plan 1.3.3.5	Logistics System Development												
Project 1.3.3.5-1	Sustainable logistics operations (Green Logistics) by private sectors			√	OTP	PORT MDEXAT DLT DEDE							
Total Budget 1. + 2. + 3.							50	150	225				
		Total					425						
4. Database preparation for measurement of GHG emission reduction in the transport sector							30	10	10				
		Total					50						
Total Budget in the preparation of MRV of all transport sectors							80	160	235	12.17	15.15	8.10	
		Total					475			35.42			

Strategy 4 Rise public participation and enhance capacities to all agencies in GHG reduction

GHG reduction operation needs cooperation from all sectors, government, people and private sector including academic. Public participation on GHG reduction should be risen at the beginning; acknowledgement, understanding and awareness as a part of climate change adaptation and mitigation as details follows:

Plan 1 Public participation in GHG reduction

- 1) Cooperation of all sectors to be a part at the beginning step of planning and studying measure or project related to GHG reduction operation.
- 2) Awareness of importance of GHG reduction operation using financial benefits as a tool to attract people concretely, for example, using an effective car will help reduce pollution including energy and cost saving.
- 3) Market and tax mechanisms support as public participation in GHG reduction, for example, privilege promotion or up-to-date & continuous campaign arrangement to people or enterprise joining the project, etc.
- 4) Using Intelligent Technology (IT) or up-to-date technology to help in data collection systematically and as a planning tool for decision maker in GHG reduction.
- 5) Public relation and dissemination on GHG reduction progress for rising awareness and sharing knowledge on GHG reduction implementation.

Plan 2 Capacity enhancement to officials in MOT

- 1) Enhancement of center agency responsible for data collection, analysis, linkage and evaluation of GHG emission reduction using inventory, mitigation and life cycle analysis to process GHG reduction from cradle to grave. It needs cooperation integration of all sectors; land, rail, water and air agencies.
- 2) Capacity enhancement to officials relative to GHG reduction in data collection activity and GHG reduction calculation.
- 3) Development and improvement of IT and innovation in supporting GHG reduction operation for data management and extension in planning and determining policy on GHG reduction.

Summary of Target and Potential for GHG Emission Reduction in Transport Sector

Transport Sector's NDC Action Plan 2021 – 2030 is devised to promote operations according to Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021 – 2030 (NDC Roadmap 2021 – 2030) and to be in accordance with the GHG reduction target at 20% by 2030. The transport sector has expected potentials for GHG reduction in 2030 of 41 million ton carbon dioxide

equivalent, 31 million ton carbon dioxide equivalent from the energy use efficiency enhancement measures, and 10 million ton carbon dioxide equivalent from biofuel use measure for vehicles.

According to evaluation of GHG reduction amount classified into plans and projects which are able to evaluate the amount and potential of GHG emission reduction through the Measurement, Reporting and Verification (MRV), the target and potential for GHG reduction in transport sector can be summarized in Table 9.1-1 and Figure 9.1-2.

Table 9.1-1 Evaluation of the amount and potential of GHG emission reduction in the transport sector

YEAR	The amount of GHG emissions (CO ₂) in the case of BAU in Thailand (MtCO ₂ e)	The amount of GHG emissions (CO ₂) in the case of BAU in Transport Sector of Thailand * (MtCO ₂ e)	Potential to Reduce GHG (CO ₂) in transport sector (MtCO ₂ e)		
			Group 1	Group 2	Total
2548 (2005)	273.41	57.52	-	-	-
2563 (2020)	407.70	77.98	4.42	4.46	8.89
2573 (2030)	555.00	109.99	18.67	16.74	35.42

(Note: * Thailand's Intended Nationally Determined Contributions (INDC) for transport sector under the BAU case in 2020 and 2030 are at 302 and 426 MtCO₂e, respectively, and according to the biennial progress report, edition 2, 2013, it is found that in the transport sector had an GHG emission of 25.82% from the total GHG emissions from energy sector, the GHG (CO₂) emission from the transport sector under BAU case are 77.98 and 109.99 MtCO₂e in 2020 and 2030, respectively.

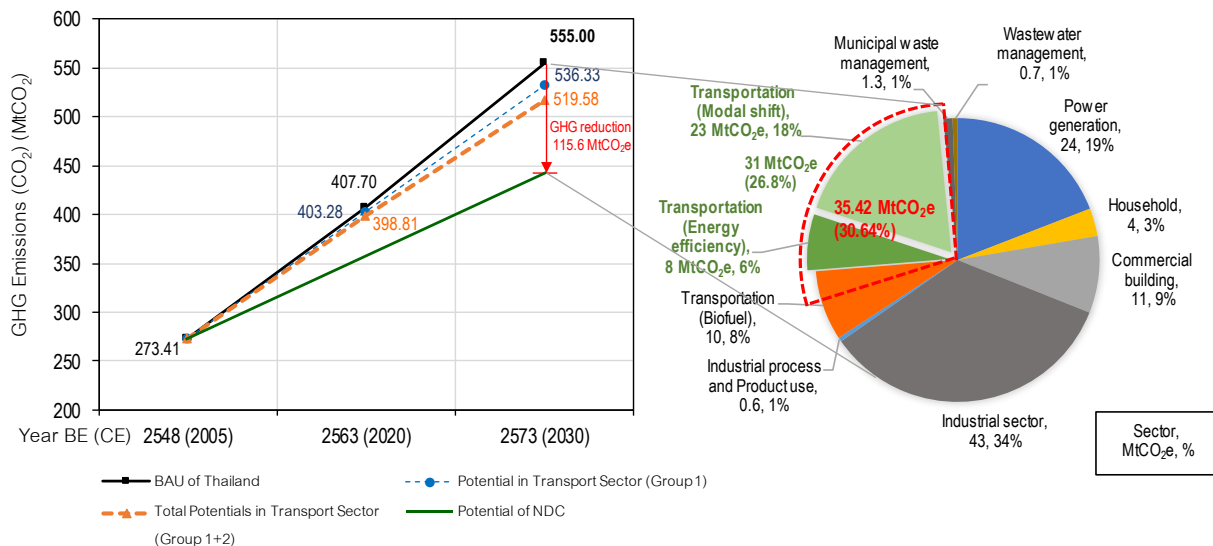


Figure 9.1-2 Evaluation of GHG emission reduction in the transport sector

As in Figure 9.1-2, GHG (CO₂) emission amount in all domestic sectors for the BAU case is 555.00 MtCO₂e. In 2030, according to the evaluation, it is found that GHG emission reduction through the Measurement, Reporting and Verification (MRV) in Group 1 has a potential to reduce the GHG

emission of 18.67 MtCO₂e, i.e. amount of GHG (CO₂) emission in transport sector in Group 1 is 536.33 MtCO₂e, but the projects and actions plans are unable to achieve the reduction target at 31 MtCO₂e. However, if the transport sector implements the projects and plans recommended in the Group 2 - Recommended projects and plans for additional operations in the transport sector has a potential to additionally reduce the GHG emission for more 16.74 MtCO₂e which is in total of 35.42 MtCO₂e, and this can achieve the GHG emission reduction target of 31 MtCO₂e as determined.

Summary of Budgets for GHG Reduction Operation in Transport Sector

According to project and plan evaluation which has potentials to reduce GHG emission in transport sector, Ministry of Transport needs to allocate the budgets in GHG reduction operation in transport sector with compliance to the aim of GHG emission reduction by 20% in 2030 as shown in Table 9.1-7.

Table 9.1-7 Budgets by NDC action plan strategies

Strategy		Budget (Million Baht)			
		Short term (63-64)	Mid term (65-68)	Long term (69-73)	Total
Strategy 1	Support and promote actions regarding relevant agencies in transport sector				
	Group 1	1,149,182.96	1,461,869.30	638,885.00	3,249,937.26
	Group 2	-	1,594.00	30,025.00	31,619.00
	Total	1,149,182.96	1,463,463.30	668,910.00	3,281,556.26
Strategy 2	Develop and improve laws promoted GHG reduction	40.00	150.00	100.00	290.00
Strategy 3	Develop Measurement, Reporting and Verification, MRV	80.00	160.00	235.00	475.00
Strategy 4	Rise public participation and enhance capacities of all agencies in GHG reduction	200.00	500.00	100.00	800.00
Total budget		1,149,502.96	1,464,273.30	669,345.00	3,283,121.26
Added total budget		320.00	2,404.00	30,460.00	33,184.00

Note: Group 1 is Existing projects and plans of Ministry of Transport which already set the budget; group 2 is Recommended projects and plans for additional operations which have to allocate more.

Mechanism for Moving Forward and Implementation of Plan

1) Institutional management which is suitable and in accordance with the operation according to Thailand's Nationally Determined Contribution (NDC) Roadmap on Mitigation 2021 – 2030 as follows:

A. National mechanism i.e. “National Committee on Climate Change (NCCC)” with the Prime Minister acting as the Chairman – it consists of committees from various related permanent secretaries. The determination of policies includes governance and monitoring activities related to climate changes and GHG reduction for main related departments, so that they are in accordance with the action plan and achieve goals of the NDC roadmap 2021 – 2030. Moreover, under the National Committee on Climate Change, two sub-committees, i.e. Climate Change Sub-Committee on Policy and Plan Integral” and “Climate Change Sub-Committee on Academic and Database”, with power covering and supporting the GHG reduction in all respects.

B. Ministerial mechanism i.e. “Implementation and Policy Coordination Committee for Sustainable Climate Change and Transport Operations” in order to present a policy framework and determine measures or operating guidelines to reduce GHG release in all transport systems according to sustainable development guideline to reduce impacts on climate change and coordinate for cooperation so that the related organizations and departments act in accordance towards the same direction, screen performance prior to forwarding it to the Ministry of Natural Resources and Environment. This includes appointing the sub-committees or working groups for suitable operations. The “Implementation and Policy Coordination Committee for Sustainable Climate Change and Transport Management” is established to suggest policies in order to determine measures or guidelines for GHG reduction in transport sector according to the sustainable development guideline, study, analyze and monitor preparedness of the transport sector’s action plan, measure/project to support the policies and sustainable climate change and transport operations. This includes coordinating and preparing the performance report and submitting it to the Committee.

C. The working group mechanism – it can be divided into 2 groups consisting of “Working Group on Climate Change in Road and Rail Transport Sector” and “Working Group on Climate Change in Water and Air Transport Sector” under the Implementation and Policy Coordination Committee for Sustainable Climate Change and Transport Operations, in order to prepare activity data for GHG emission account. This includes activity data for calculation of GHG reduction from road, rail, water and air transport activities, consideration and review as well as suggestions on GHG emission factor which is suitable for emission and accumulation amount in road, rail, water and air transport sectors. This includes consideration on the Measurement, Reporting and Verification (MRV) in road, rail, water and air transport sectors and providing suggestions for the GHG emission reduction measures in such transport sectors.

D. The Office of Transport and Traffic Policy and Planning (OTP) as main responsible agency in the transport sector according to the Thailand's Nationally Determined Contribution (NDC) Roadmap on Mitigation 2021 - 2030, together with representatives from main agencies and supporting agencies has prepared Transport Sector’s NDC Action Plan 2021 – 2030. This includes

developing methods for activity data collection, GHG calculations as well as monitoring and evaluating the performance and reporting the results to agencies in the national mechanism.

2) Operation on budgets to support various measures according to the action plan as follows;

A. To carry forward the operation plan to support operations according to the roadmap within the budget plan through coordination with the Bureau of the Budget for preparing integral budgets on climate change for agencies, so that it can be used for preparation and operation in accordance with individual measure and guideline's operation plans.

B. To coordinate with the ENCON Fund to present the operation plan and measures for the country's energy use and GHG reduction.

C. To coordinate for cooperation with international funds in order to request for financial support under the framework of United Nations Framework Convention on Climate Change (UNFCCC) including requesting for international support in multilateral or bilateral forms.

3) To link the operation plans to agencies and implementation of plan as follows:

A. To create understanding with agencies under the Department of Transport as well as other related agencies through holding a seminar for publicizing the operation plan for understanding, acceptance and awareness on significance of the operation plans including roles and responsibilities of agencies as determined in the operation guideline and goals.

B. To enhance knowledge and potential of related authorities through holding a seminar to create understanding, and organized thinking and plans so that the knowledge can be applied in the agencies.

C. To create understanding for agencies in the Ministry of Transport and other related agencies for participating in the GHG reduction so that they will realize about the potential benefits from the implementation, as well as understanding and realizing its significance and benefits.

D. To determine a flagship project for any important issue that requires promotion at the policy level in order to achieve the national goals for the GHG reduction.

Evaluation Guideline

- 1) Prepare the Transport Sector's NDC Action Plan 2021 – 2030.

Determine key responsible agency for each working plan and GHG reduction project according to Thailand's Nationally Determined Contribution (NDC) Roadmap on Mitigation 2021 - 2030, which specifies details on implementation of the operation plan. The main responsible agencies cooperate with supporting agencies in order to support the operations according to the NDC Roadmap 2021 – 2030 in order to achieve its goals.

- 2) During the preparation process, the agencies will report its progress (during 2019-2020) for every six months to the Office of Transport and Traffic Policy and Planning (OTP), which acts as the core agency for cooperation and data gathering and submits it to the Office of Natural Resources and Environmental Policy and Planning (ONEP).

- 3) During the operation process, the ministerial mechanism will be applied, i.e. Implementation and Policy Coordination Committee for Sustainable Climate Change and Transport Management which will govern and monitor the progress to be in accordance with the national GHG reduction plan, 2021 – 2030 for the transport sector. The agency will report the operating progress (during 2021-2030) every 1 year to the Office of Transport and Traffic Policy and Planning (OTP), which acts as the main agency for cooperation and data gathering and submits it to the Office of Natural Resources and Environmental Policy and Planning (ONEP).

- 4) As for report, monitoring and evaluation of performance in accordance with the Transport Sector's NDC Action Plan 2021 – 2030, the main responsible agencies will use the report, monitoring and evaluation system as determined by the Office of Transport and Traffic Policy and Planning (OTP), i.e. the Measurement, Reporting and Verification (MRV). The evaluation report on GHG emission reduction amount based on the plan/measure/project will be prepared every 1 year in accordance with the Transport Sector's NDC Action Plan 2021 – 2030.

- 5) Actions according to the Transport Sector's NDC Action Plan 2021 – 2030 are long-term operations, so during the process the country's situations might be changes which might give positive and negative impacts on the plan operations. As a result, the operation plan must be reviewed every 5 years in accordance with review of targets of the Thailand's Nationally Determined Contribution (NDC) Roadmap on Mitigation 2021 - 2030.

9.2 Transport Sector's NDC Roadmap 2021 – 2030

Transport Sector's NDC Roadmap 2021 – 2030 is shown situations of Thailand GHG reduction actions since Thailand reaffirm our commitment under the NAMAs from 2014 to 2030 and determined times and periods during 2018 – 2030 in implementing the transport projects and plans. The Transport Sector's NDC Roadmap 2021 – 2030 focuses on significant projects or measures of each year to achieve the country's GHG reduction target and the target of transport sector which has a contribution of 31 MtCO_{2e} of which 23 MtCO_{2e} is for multimodal transport and 8 MtCO_{2e} is for energy efficiency as shown in **Figure 9.2-1**.

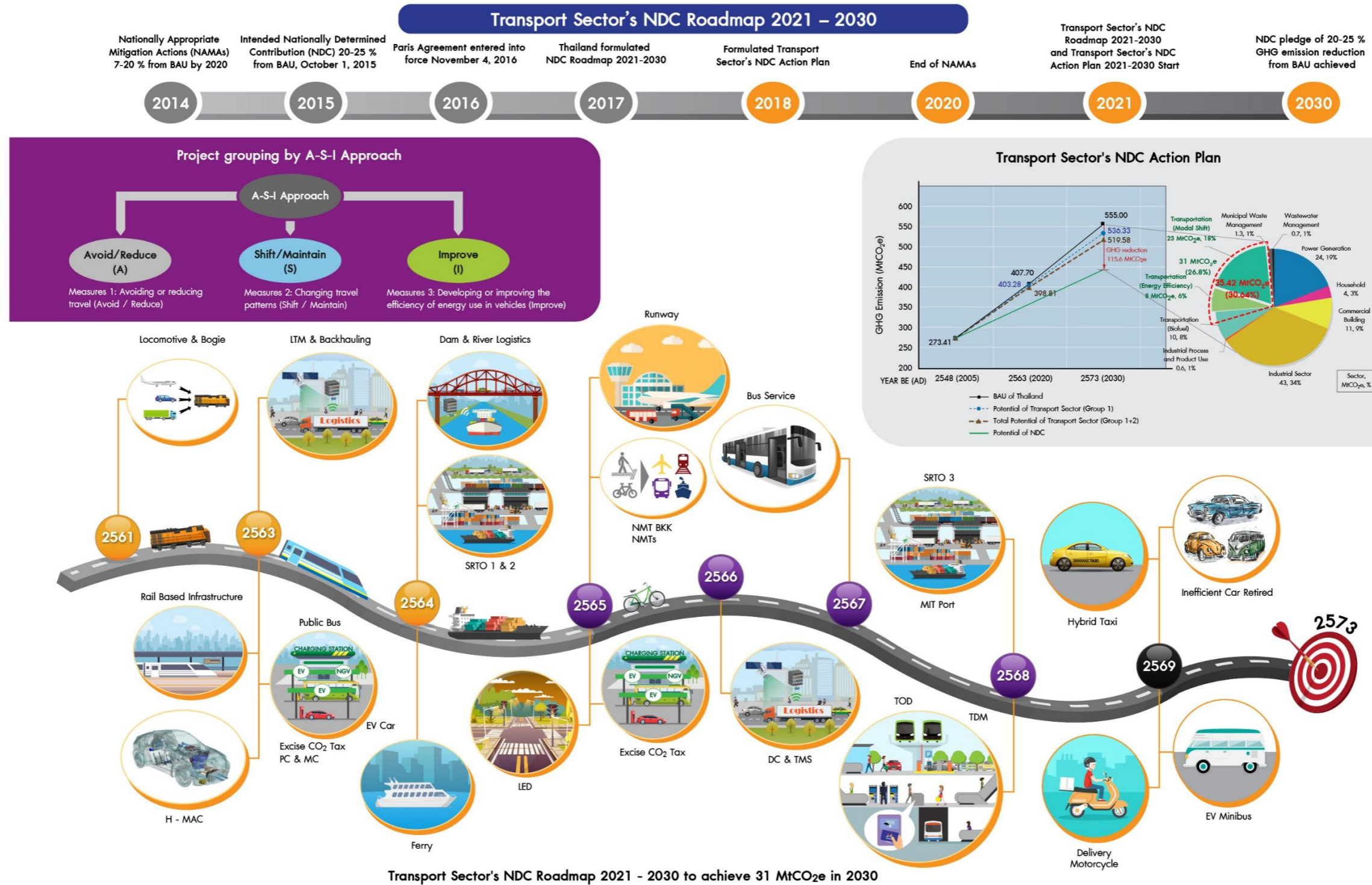


Figure 9.2-1 Transport Sector's NDC Roadmap 2021 – 2030

Chapter 10 Marginal Abatement Cost (MAC) Tool for GHG Emission Reduction under Measures and Policies on Energy Efficient Transport

10.1 Analysis Tool for Marginal Abatement Cost (MAC)

In GHG reduction operation as performed by all related international and domestic agencies, various measures and policies are used and identified with an aim for GHG reduction. A tool used for evaluating the operations is Marginal Abatement Cost Curve (MACC), which can evaluate costs of GHG emission reduction per unit in a form of net cost (cost – benefits) in scenario case compared to base case. The difference is called “marginal abatement cost”.

Study and development of the Marginal Abatement Cost (MAC) tool is necessary for evaluating the unit cost in reducing GHG emission as the net cost (cost-benefit) in cases of the policies or strategies which are used for the GHG reduction compared to the non-policy case. It is called marginal abatement cost. In case of negative result, it means that the certain projects are able to obtain benefits resulting from the operations of GHG reduction projects.

10.2 Tool Development

For development of tools for the Marginal Abatement Cost analysis, excel-based spreadsheet is used for the processing and comparison of investment worth for GHG reduction action plans or projects in a form of graph. The tool is able to rank projects with the most potential and significance. The projects with the lowest investment cost in Million Baht/MtCO₂e unit will be selected, and then MAC Curve (MACC) will be analyzed showing as graph between marginal costs in Y (vertical) and GHG emission reduction in X (horizontal).

Figure 10.2-1 Prioritization of projects and plans in transport sector

No.	Project Short Name	Project Name	CO ₂ emission reduction (MtCO ₂ e)	Accumulative CO ₂ emission reduction (MtCO ₂ e)	Marginal Abatement cost (Baht/ tCO ₂ e)
1	Double Track	dual track railways	14.5	21.2	-64,083
2	Mass Transit	mass transit electric train systems and suburb train systems	6.0	6.6	-138,477
3	New Railway	New railway	0.7	0.7	-302,808
4	EEC	High-speed train + EEC railways	9.4	45.0	-5,570
5	SRTO 1&2	Development of Single Rail Transfer Operator (SRTO) at Laem Chabang port, Phase 1 and 2	9.4	35.6	-5,570
6	River Logistics	Enhancement of freight transport system via Pasak river	0.4	142.3	132,460
7	SRTO 3	Development of Single Rail Transfer Operator (SRTO) at Laem Chabang Port, Phase 3	2.0	141.8	44,845

No.	Project Short Name	Project Name	CO ₂ emission reduction (MtCO ₂ e)	Accumulative CO ₂ emission reduction (MtCO ₂ e)	Marginal Abatement cost (Baht/ tCO ₂ e)
8	MIT Port	Maptaphut Industrail Terminal development, Phase 3	0.1	142.4	171,007
9	NMT BKK	Promoting walking and bicycle uses to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and metropolitan	7.8	100.7	-2,972
10	NMTs	Promoting walking and bicycle uses to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla	1.8	23.0	-45,885
11	Bus Service	Improvement of urban and outskirt public service via hybrid passenger vehicles	0.2	23.2	-13,112
12	Tightened Excise CO ₂ tax PC	Excise tax rate adjustment according to CO ₂ emission (reflecting direct fuel consumption rate) for private cars	22.7	77.1	-3,827
13	Excise CO ₂ tax MC	Excise tax rate adjustment according to CO ₂ emission (reflecting direct fuel consumption rate) for motorcycles	7.4	92.9	-3,718
14	Annual Reg. CO ₂ tax PC	Annual car tax rate adjustment according to CO ₂ emission (reflecting direct fuel consumption rate)	8.4	85.4	-3,798
15	EV car	Expansion of Electric vehicles (EV)	7.8	150.7	358,371
16	Excise CO ₂ tax	Excise tax rate adjustment according to CO ₂ emission (reflecting direct fuel consumption rate) for cars based on strict tax measure	7.6	52.6	-5,069
17	Inefficient car retired	Promoting disposal of deteriorated vehicles (old vehicles) from the system (more than 15 years of service or exceeding 200,000 km)	11.1	139.3	9,606
18	H-MAC	Improvement of air conditioning systems (H-MAC) in cars	3.0	26.2	-6,904
19	Fuel price	Use of fuel mechanism to push forward use of effective vehicles	11.2	25.9	1
20	Hybrid bus	Procurement of 1,453 hybrid public buses	1.5	127.7	6,691
21	Hybrid bus	Hybrid public bus rent (7 years) for 400 buses	0.4	128.1	8,100
22	Hybrid taxi	Promoting use of hybrid systems among public buses, taxi cars and minibuses in Bangkok and metropolitan and 6 regional cities, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla	7.5	108.2	-2,733
23	Bogie	8 and 12 power bogie modification (2018 - 2021)	0.2	126.2	666
24	Locomotive	Provision of diesel electric 10 comotives to replace 50 GE diesel electric 10 locomotives (2018 - 2021)	0.1	141.9	57,687

No.	Project Short Name	Project Name	CO ₂ emission reduction (MtCO ₂ e)	Accumulative CO ₂ emission reduction (MtCO ₂ e)	Marginal Abatement cost (Baht/ tCO ₂ e)
25	Runway	Runway constructions, line 3 and 4 of Suvarnabhumi Airport	0.5	139.8	20,805
26	LED	Change of LED light bulbs in all ports/airports/highways	6.6	114.8	-150
27	LTM	Research and development of Logistics and Transport Management Application (LTMA) for energy-saving	1.7	54.3	-4,425

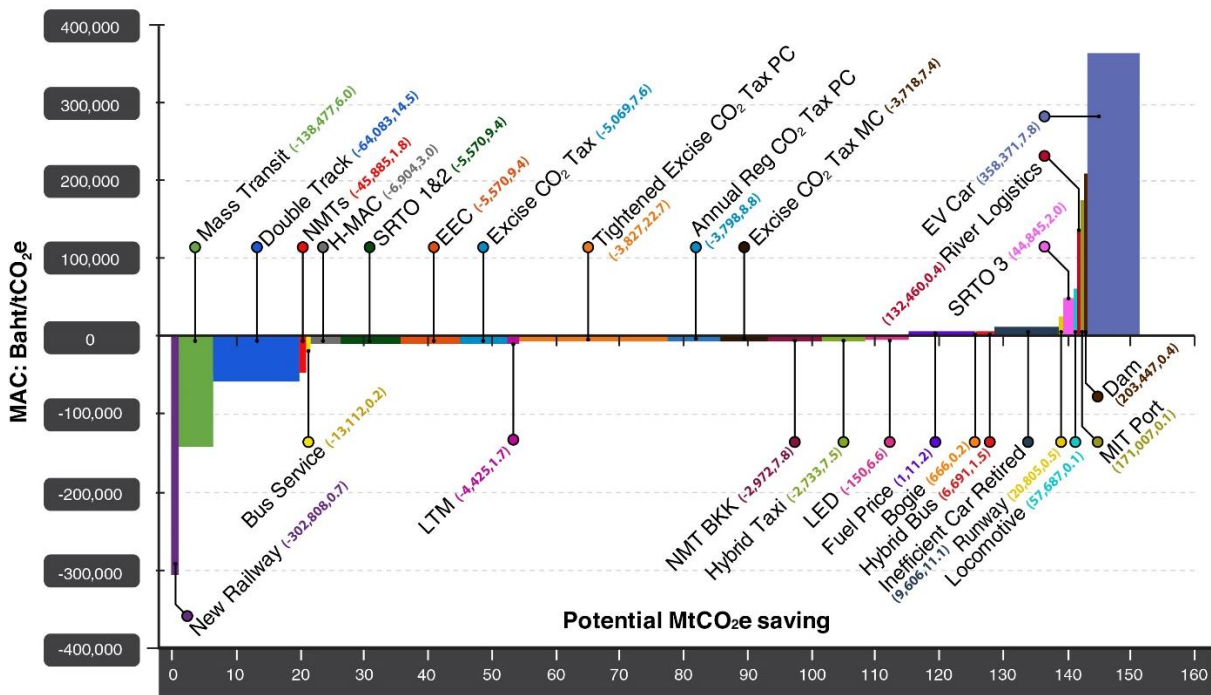


Figure 10.2-1 MAC Curve (MACC) analysis

When the projects and plans regarding Nationally Determined Contribution (NDC), 2021-2030 are applied in the MAC Curve (MACC) analysis, it is found that New Railway projects have the highest potential for GHG reduction, at -302,808 baht per tCO₂e. Moreover, for mass transit electric train and suburban train projects, improvement of public transport system connectivity through Non-Motorized Transport (NMT) and dual-track railways (Shift mode) have potential for GHG reduction as well, from 45,000–138,000 baht per tCO₂e.

The results of this study will provide guideline and manuals to related agencies and officers, and the MACC can be applied for the Marginal Abatement Cost analysis in other projects easily and effectively, in order to decide and determine measures and policies for GHG emission reduction and energy-saving.

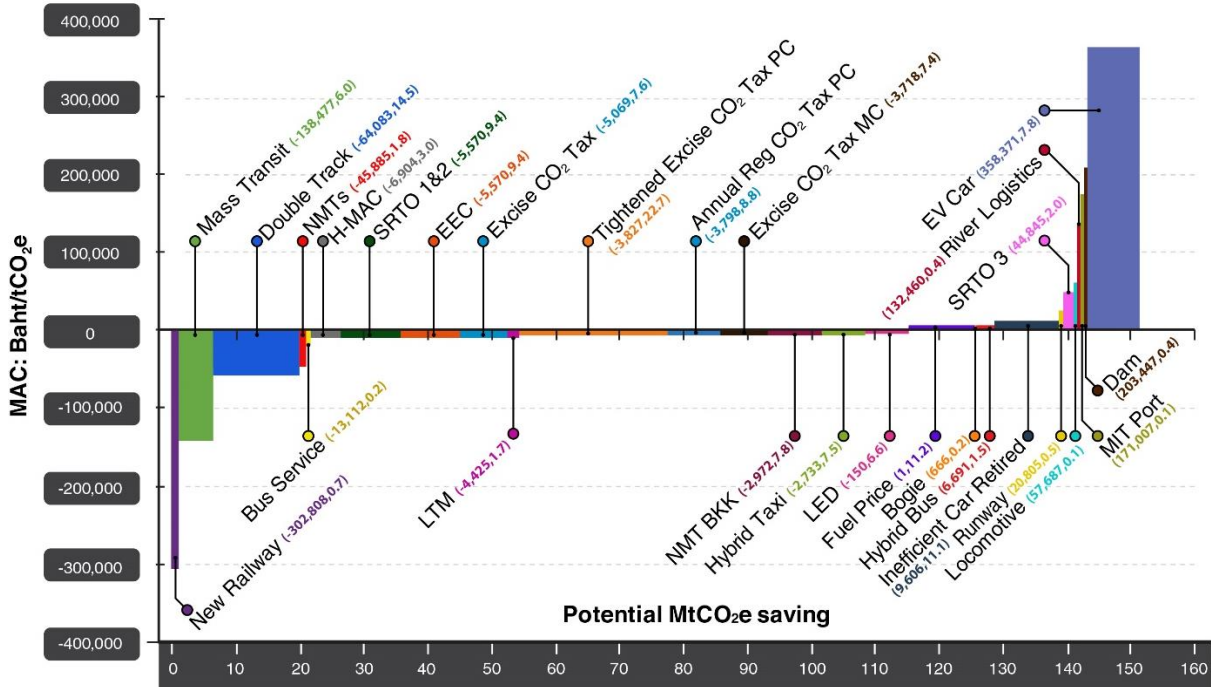
Results and Discussion

1. According to the Nationally Appropriate Mitigation Actions (NAMAs) stating that “Thailand aims to reduce GHG emission by 20% - 25% below the business-as-usual (BAU) or 111 MtCO_{2e} in 2030. Thailand had an estimation of GHG reduction potentials from domestic activities and expected that Thailand had an ability to reduce GHG emissions to 115.6 MtCO_{2e} in 2030. Target for GHG reduction in transport sector is 41 MtCO_{2e}; energy use efficiency enhancement measure at 31 MtCO_{2e} and biofuel use measure for vehicles at 10 MtCO_{2e}. According to evaluation of GHG reduction potentials using Sustainable Transport System of “Avoid-Shift-Improve (A-S-I)” of the projects and plans in transport sector, the transport sector has total potentials to reduce GHG emission of 35.42 MtCO_{2e}. As the transport sector’s projects and plans, it was found that if we complete the implementation of the existing projects and plans in Ministry of Transport including the recommended projects and plans within 2030, the transport sector will reduce GHG emissions in total of 35.42 MtCO_{2e}.

2. The Nationally Determined Contribution Action Plan (2021 – 2030) in transport sector (Transport Sector’s NDC Action Plan 2021 – 2030) is devised to move forward and promote the GHG emission reduction under the Thailand’s Nationally Determined Contribution Roadmap on Mitigation 2021 – 2030 (NDC Roadmap 2021 – 2030), to achieve the reduction target with a mission to support and promote related agencies’ implementation of the operation plans in the NDC roadmap 2021 – 2030, and to develop mechanism for GHG reduction promotion and the Measurement, Reporting and Verification (MRV) through determining the GHG reduction methods to provide related agencies with clear procedures. The meeting of Committee on Policy Coordination and Climate Change and Sustainable Transport Implementation with Permanent Secretary of Ministry of Transport as the Chairman has passed a resolution to approve the draft of Transport Sector’s NDC Action Plan 2021 – 2030 on October 31, 2018. Then, the National Climate Change Policy Committee with Deputy Prime Minister (Gen. Prawit Wongsuwan) as the Chairman has passed a resolution to approve the draft of Transport Sector’s NDC Action Plan 2021 – 2030 on November 19, 2018, and Gen. Surasak Karnjanarat as the Deputy Minister of the Ministry of Natural Resources and Environment has stated on behalf of Thailand to show vision on global climate change operation and reported the progress of the draft of NDC Action Plans 2021 – 2030 in energy, transport, municipal waste, industrial process and product use, and industrial waste sectors in the 24th United Nations Framework Convention on Climate Change (COP24) which held from December 3-14, 2018 in Poland.

3. Marginal Abatement Cost per unit (baht per ton of carbon dioxide equivalent) is one of the indicators for GHG reduction efficiency evaluation under the 12th National Economic and Social Development Plan, B.E. 2560 – 2564 (2017 – 2021), the fourth strategy, environmental friendly development for sustainable development. Consequently, it is an important variable for GHG reduction operations. According to the marginal abatement cost evaluation, it is found that New Railway projects have the highest potential for GHG reduction, at -302,808 baht per tCO_{2e}, followed by mass transit electric train and suburban train projects, dual-track railways and improvement of public transport system connectivity through Non-Motorized Transport (NMT) which are the shift

mode project and are in the Strategic Operation Plan of Ministry of Transport 2017 – 2020. These projects have potentials for GHG reduction between -45,000 to -138,000 Baht/tCO₂e. A negative value of the project means that a benefit of project implementation is higher than a cost; on the other hand, a positive value means that the project has low benefit.



Summary of priority projects

1) New Railways 14 routes, MAC of -302,808 Baht/tCO₂e and GHG emission potential in total of 0.7 MtCO₂e in 2030.

2) Mass transit electric train and suburban train projects, consist of mass transit electric trains with extension 9 routes, suburban trains 5 routes and ARL with extension 2 routes, MAC of -138,477 Baht/tCO₂e and GHG emission potential in total of 6.0 MtCO₂e in 2030.

3) Double Tracks 32 routes, MAC of -64,083 Baht/tCO₂e and GHG emission potential in total of 14.5 MtCO₂e in 2030.

4) Promoting walking and bicycle uses to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 140 lines in Bangkok and metropolitan and promoting walking and bicycle uses to connect to public transport systems (Non-Motorized Transport, NMT) through improvement of pavement, footpath, and bicycle lanes for 6 regional cities having public transport systems, i.e. Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima and Songkla, MAC of -45,885 Baht/tCO₂e and GHG emission potential in total of 1.8 MtCO₂e in 2030.

4. The Marginal Abatement Cost Curve (MACC) is developed based on Excel-based spreadsheet to process and rank projects with potential and significance of the operations, and compare profits from investment in the GHG reduction related to plans or projects in a graph form.

Summary

Marginal Abatement Cost Curve (MACC) is an effective tool in prioritizing the potential and significant projects mainly regarding costs and comparing the value for investment in plans and projects related to GHG reduction as a curve. However, in the decision of appropriate projects for investment depends on the Government in considering preferable the value of investments, enhancing of national economic developments or the NDC target of GHG reduction. There are many factors that need to be used for decision making, such as economic conditions, urgent policies, or investment readiness, etc.

In decision of the project, it is unnecessary to always select the negative marginal abatement cost (-). It should consider the high potential project on GHG emission reduction. For example, if considering MACC, the marginal abatement cost (MAC) of the electric vehicle car project (EV car) has positive (+). This means that this project is not worth for investment. But if considering CO₂ reduction, this project will have more contribution to achieve the NDC target.

Expected Benefits

1. The government sector obtains information and data on projects and action plans with the highest potential for GHG reduction to be used as a guideline for decision-making process and determination of policies on the GHG reduction according to the target appropriately.
2. Preparation of GHG reduction cost per unit for transport sector's action plans and projects will make the government sector realize which action plans or projects are worth the investment and able to maximize the reduction. The economic analysis is an important tool for investment worth evaluation through comparison between costs of base case and measure case.
3. The government acquires an overall insight on GHG reduction in the transport sector, and decision-making or policy determination to increase the reduction can be properly performed.
4. The government sector obtains proper methods for transport sector's project operations complied with the roadmap as an appropriate guideline.

Suggestions

1. The Measurement, Reporting and Verification (MRV) is used for measuring CO₂. This project uses Bottom-up MRV method that is able to concretely analyze transport or energy measures for each activity. As a result, it is able to determine methods for GHG emission reduction and set an appropriate goal of the reduction. However, the MRV analysis is project-specific method, so hypothesis and guideline must be determined, and suitable information and data must be selected for the analysis and measurement.

2. Amount of GHG emission reduction will be accurately analyzed and measured, if there is sufficient baseline data such as the number of passengers and freights in railways, travel time, etc. Since the Shift mode project has high potential for GHG emission reduction, a responsible agency that distributes such data should have proper approaches for data collection, storage and distribution systematically. Information Technologies (IT) may be applied for the system development.

3. Amount of GHG emission reduction in transport sector is evaluated through the Measurement, Reporting and Verification (MRV) methods as of 2030. Consequently, it is highly necessary that the evaluation of GHG emission reduction should be done every 5 year for tracking in individual project in order to further monitor each project's performance.

4. Marginal Abatement Cost (baht per ton of carbon dioxide equivalent) is one of the indicators for GHG reduction efficiency evaluation under the 12th National Economic and Social Development Plan, B.E. 2560 – 2564 (2017 – 2021), stating that the marginal cost of GHG emission reduction (baht/tCO₂e) trends to decrease. According to the project study result, it is found that the marginal cost of GHG emission reduction does not trend to decrease for every project. Some projects have higher cost per unit, especially operation and maintenance costs; for example, NGV bus procurement project which has higher maintenance cost than diesel bus ones, so it is not worth the investment.

5. The electric vehicle car (EV car) is the positive value (+) project with the MAC of 358,371 Baht/tCO₂e. Even though it has high potential on GHG reduction of 7.8 MtCO₂e but the benefit is lowest. Due to current electric vehicle value of 2018 (upfront price and operation and maintenance costs) is higher than diesel vehicle. On the other hand, the MAC of the new railway project is negative value (-) which evaluated from infrastructure investment cost, travel and operation and maintenance costs of rail-based system of which the value is lower than road-based system. However, if compared the MAC of the electric vehicle car (EV car) in other countries, the MAC have positive (+) values or low benefits. The results of MAC evaluation of the EV car in Thailand has higher cost due to Thailand does not have production base for EV car. If Thailand has own base, it will decrease EV car technology cost lower and economy to scale. Therefore, EV car is an effective project to push forward in contribution with the GHG emission reduction in lifetime or for reducing environmental impact in long term.

6. The Marginal Abatement Cost Curve (MACC) is an effective tool for ranking the potentials, and it is important for operations mainly based on cost and expenses. It can be used to compare project investment in reducing GHG emission in a graph form. However, in decision-making on project selection that is suitable for the government investment requires many factors into consideration such as economic conditions, urgent policies or preparedness for investment, etc.

7. Resulting from dynamic global changes, new technologies of projects may be added, so the Marginal Abatement Cost Curve (MACC) should be modified, in order to continuously prioritize and update new projects that are worth the investment.

8. In order to perform the Thailand GHG emission reduction target by 20% - 25% from the business-as-usual (BAU) in 2030, it is highly necessary to define GHG emission reduction issue as a key mission of the agencies, so that the officers are well-prepared for the operations and planning, and duties and responsibilities are clearly assigned in order to achieve the national GHG emission reduction target.