



Development of the Thailand Clean Mobility Programme (TCMP)

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Project Background

Transport is the highest energy-consuming sector in 40% of all countries worldwide and causes about a quarter of energy-related CO₂ emissions. To limit global warming to two degrees, an extensive transformation and decarbonisation of transport is necessary. The TRANSfer project's objective is to increase the efforts of developing countries and emerging economies for climate-friendly transport. The project acts as a mitigation action preparation facility and thus, specifically supports the implementation of the Nationally Determined Contributions (NDC) of the Paris Agreement. The project supports several countries (including Peru, Colombia, the Philippines, Thailand, Indonesia) in developing greenhouse gas mitigation measures in transport.

The TRANSfer project is implemented by GIZ and funded by the International Climate Initiative (IKI) of the German Government and operates on three levels.

Mobilise

Facilitating the MobiliseYourCity Partnership

The goal of the multi-stakeholder partnership MobiliseYourCity, which is currently being supported by France, Germany, and the European Commission, is that 100 cities and 20 national governments commit to ambitious climate action targets for urban transport and take appropriate measures.

Prepare

Preparation of Mitigation Measures

Standardised support packages (toolkits) are developed and used for the preparation of selected mitigation measures. As a result, measures can be prepared more efficiently, until they are ready for implementation and eligible for (climate) financing. Accumulated over 10 years, the targeted measures aim for a total reduction potential of 60 MtCO₂.

Stimulate

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Based on these experiences, TRANSfer is sharing and disseminating best practises. This is achieved through the development of knowledge products, the organisation of events and trainings, and the contribution to an increasing level of ambition. Personal exchange of experience and dialogue is promoted at events, including the annual Transport and Climate Change Week in Berlin, the United Nations Climate Change Conference (COP), or the International Transport Forum.

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Exchange rates

Local Currency	EUR	USD	Date
THB 1	EUR 0.02984	USD 0.03269	03.10.2019

List of acronyms and abbreviations

ADB	Asian Development Bank
AFD	Agence Française de Développement
AIT	Asian Institute of Technology
A-S-I	Avoid-Shift-Improve
AQI	Air Quality Index
BAU	Business as Usual
BB	Bureau of Budget
BEV	Battery Electric Vehicles
BMA	Bangkok Metropolitan Administration
BMR	Bangkok Metropolitan Region
BMTA	Bangkok Mass Transit Authority
BTS	Bangkok Mass Transit System
CBU	Completely Built-Up
CC	Congestion Charge
CGD	The Comptroller General's Department
CO ₂	Carbon Dioxide
COP	Conference of the Parties
CMF	Clean Mobility Fund
DEDE	Department of Alternative Energy Development and Efficiency
DIW	Department of Industrial Works
DLA	Department of Local Administration
DLT	Department of Land Transport
DOPA	Department of Provincial Administration
DRR	Department of Rural Road
DRT	Department of Rail Transport
EBF	Extra-Budgetary Fund
EPPO	Energy Policy and Planning Office
EUR	Euro
EV	Electric Vehicle
FPC	Fiscal Policy Office
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GHG	Greenhouse Gas
ICE	Internal Combustion Engine
INDC	Intended Nationally Determined Contribution

IPPU	Industrial Processes and Product Use
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
LRT	Light Rapid Transit
LTC	Land Transport Committee
LT-LEDS	Long-term Low Emissions and Development Strategy
M&E	Monitoring & Evaluation
M-Map	Mass Rapid Transit Masterplan for Bangkok Metropolitan Area
MNRE	Ministry of Natural Resources and Environment
MOE	Ministry of Energy
MOF	Ministry of Finance
MOI	Ministry of Interior
MONRE	Ministry of Natural Resources and the Environment
MOT	Ministry of Transport
MRT	Mass Rapid Transit
MRTA	Mass Rapid Transit Authority
MRV	Measurement, Reporting and Verification
MTCO _{2e}	Metric Tons of Carbon dioxide equivalent
NCCC	National Committee on Climate Change
NDC	Nationally determined contributions
NEP	National Energy Plan
NEPC	National Energy Policy Council
NESDC	Office of the National Economic and Social Development Council
NESDP	National Economic and Social Development Plan
NMT	Non-Motorised Transport
NO ₂	Nitrogen Dioxide
ONEP	Office of Natural Resources and Environmental Policy and Planning
OTP	Office of Transport and Traffic Policy and Planning
PCD	Pollution Control Department
PDPA	Personal Data Protection Act
PM _{2.5}	Small Particulate Matter
PPP	Public Private Partnerships
SRT	State Railway of Thailand
SWOT	Strengths, Weaknesses, Opportunities and Threats
TC	Transport Company
TCMF	Thailand Clean Mobility Fund

TCMP	Thailand Clean Mobility Programme
TDM	Travel Demand Management
TFFIF	Thailand Future Fund
THB	Thai Baht
TMS	Transportation Management System
TOD	Transit Oriented Development
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax
VKM	Vehicle Kilometres Travelled
WHO	World Health Organisation

Executive Summary

Background and motivation

Transport accounts for 27% of energy-related CO₂ emissions globally and continues to remain a rapidly growing sector. According to the latest ITF Transport Outlook CO₂ emissions could increase by 16% by 2050 (ITF, 2021) even if current commitments to decarbonise transport are fully implemented. The reduction in GHG emissions expected from these policies could be more than offset by growing transport demand. According to the Department of Alternative Energy Development and Efficiency (DEDE), the transport sector in Thailand ranks as the most energy-consuming sector in the Kingdom, accounting for 39% of all energy consumed in 2019. The transport CO₂ increased 23% between 2000 and 2015 on a per capita basis.

Thailand submitted the Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2015, which aims to reduce its greenhouse gas (GHG) emissions by 20%-25% compared to the projected Business-as-Usual (BAU) level by 2030. After the INDC submission, the NDC Roadmap on mitigation (2021-2030) was developed to provide a policy direction in achieving the GHG emission reduction targets, with the transport sector being one of the four main sectors that have been tasked to fulfil the country's climate pledge. According to the Roadmap, transport sector is responsible for a GHG emission reduction of 41 MtCO₂ in 2030, which comprises of 31 MtCO₂ from energy efficiency improvements led by the Ministry of Transport and 10 MtCO₂ from biofuel consumption under the responsibility of the Ministry of Energy (MOE).

According to the Thailand NDC Roadmap, the transport sector is responsible for a GHG emission reduction of 41 MtCO₂ in 2030, comprising 31 MtCO₂ from energy efficiency improvements led by the Ministry of Transport and 10 MtCO₂ from the biofuel consumption under the responsibility of the Ministry of Energy. Following the NDC Roadmap, the OTP developed the NDC Action Plan for the Transport Sector, identifying measures for achieving the NDC GHG emission reduction target based on the Avoid-Shift-Improve (A-S-I) approach. The target of overall GHG reduction potential from this action plan is approximately 35.4 MtCO₂, exceeding the 31 MtCO₂ reduction target.

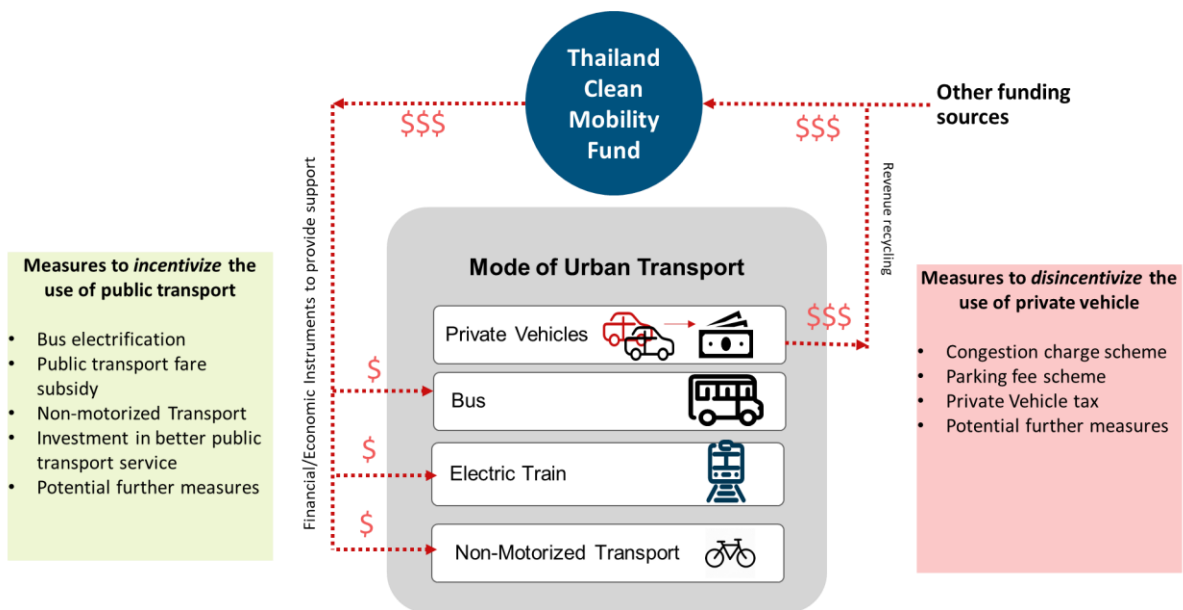
At COP 26, the Prime Minister announced a new target to reach carbon neutrality by 2050 and zero greenhouse gas emissions by 2065. Moreover, Thailand also set out the ambitious NDC target of 40% GHG emissions reduction by 2030 with international support. In 2021, Thailand also announced the EV 30@30 policy with the target of 30% of EVs in the overall domestic vehicle sales by 2030. To reach the EV 30@30 target, the Thai government has assigned the National EV Policy Committee to develop and implement an EV Roadmap, clearly committing to e-mobility as a key measure for NDC and LT-LEDS realization. In tandem with the EV Roadmap, the National Energy Policy Council (NEPC) approved the National Energy Plan (NEP) to support Thailand in pursuing clean energy and becoming carbon neutral. The approved EV Roadmap and NEP show a positive sign that lays out a solid foundation for decarbonizing the transport sector.

Congestion charge is being recognized as one of the most sophisticated and effective instruments of travel demand and traffic management and it is anchored in the Thai NDC Action Plan for the transport sector as medium-term measure with a planned implementation between 2022 and 2025 together with the electrification of minivans as planned for 2026-2030. The introduction of congestion charge would internalize the external costs of road transport and generate revenue to support public transport improvement. A sound and designated communication strategy implemented prior to the introduction of a congestion charging scheme would increase public acceptance of the programme.

Main idea behind the measure

The measure to be introduced is congestion charge, accompanied by the establishment of a clean mobility fund. Both measures are part of the overarching Thailand Clean Mobility Programme (TCMP). The main objective of the TCMP is to mitigate GHG emission and air pollution from urban transport by internalizing (some of the) actual costs of private vehicle use and at the same time improving public transport modes. Hence, the revenue from the congestion charge will feed into the clean mobility fund to establish a continuous funding source for sustainable urban transport projects in Thai cities (Transport-Finances-Transport). As an overall result, GHG mitigation will be targeted through reduced car travel and increase mass transit ridership (Push and Pull Approach).¹

Figure 1: Thailand Clean Mobility Programme concept



Source: GIZ, 2020

Congestion charging shall be introduced in an initial pilot area in Bangkok, as the capital city with major importance in terms of percentage of total inhabitants and economy in the country. The scheme can be then replicated to other major and medium-sized cities in Thailand.

The objectives of the introduction of congestion charging in a pilot area in Bangkok together with the establishment of a clean mobility fund are:

1. Reduction of individual car use by shifting travel demand towards public transport.
2. Mitigation of CO₂ / GHG emissions.
3. Reduction of PM_{2.5} levels and overall air pollution in urban areas.
4. Establishment of a long-term funding source for transport service and infrastructure improvement.

The main objective behind the introduction of congestion charge in Bangkok is to discourage private car use by at the same time encouraging modal shift to low-carbon modes by public transport system improvement, including the technical study of below approaches:

¹ Experience from other cities shows a reduction of car trips by 20 to 70% and increase public transportation ridership by 20 to 40%.

1. Development of congestion charging scheme.
2. Set up of clean mobility fund as an innovative mechanism to support the financing of sustainable transport measures nationwide through the use of the CC revenue.
3. Enhancement of sustainable transport through increased low-carbon transport investment.

Table 1: The Mitigation Action at a glance

Contribution to NDC implementation	<ul style="list-style-type: none"> - Reduction of individual car use by shifting travel demand towards public transport - Mitigation of CO₂ / GHG emissions - Reduction of PM_{2.5} levels and overall air pollution in urban areas - Establishment of a long-term funding source for transport service and infrastructure improvement 		
Type of action	National Programme	Subsector	Urban transport - Transport Demand Management (TDM) - Public Transport
Geographical scope	Bangkok Metropolitan Region (BMR)	Type of policy instruments	<u>Regulations:</u> yes <u>Economic instruments:</u> yes <u>Public spending/ investments:</u> yes <u>Communication and information:</u> yes
Organisation	<u>Responsible organization:</u> Office of Transport and Traffic Policy and Planning (OTP) <u>Involved national partners:</u> Bangkok Metropolitan Administration (BMA), Department of Land Transport (DLT), Local governments, Ministry of Finance (MOF)		
Main mitigation measures	(1) Congestion charge (2) Clean mobility fund		
Schedule	<u>Phase 1:</u> Preparation <u>Phase 2:</u> Establishment of framework conditions, pilot-testing, evaluation and communication <u>Phase 3:</u> Full scale implementation		
GHG mitigation effect and other benefits	<u>GHG mitigation:</u> 3.4 MtCO _{2e} between 2027 and 2037; average annual mitigation 0.34 MtCO _{2e} Other benefits: Shift of private car use to public transportation, reduction in overall congestion and related externalities, reduction in local air pollutants and noise emissions, positive economic impact on individual and social welfare, establishment of a constant financing source for sustainable mobility investment		

Type of required support	<u>Technical support:</u> <ol style="list-style-type: none"> 1. Technical study on the development and implementation of congestion charge in Bangkok 2. Recommendations on the legal, institutional, administrative and financial set-up of a clean mobility fund <u>Financial support:</u> <ol style="list-style-type: none"> 1. Introduction, deployment and maintenance of a congestion charge system in Bangkok (selected areas)
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Source: Author

■ PM Emission Reduction

The congestion charge is estimated to reduce PM emissions from reduction of cars usage ranging from 1-17% per year or equivalent to 554 to 4,897 tonnes per year.

■ Mitigation of Congestion

Congestion mitigation shows a substantial socioeconomic benefit. The benefit is calculated based on value of time. The in-vehicle travel time reduction is assumed based on average congestion charge modelling results of each charging level of given scenarios for all years. This analysis yields a socioeconomic benefit of up to THB 41.6 Billion (EUR 1.24 Billion) for the first year of operation of the congestion charge (GIZ, 2020).

■ Accident Reduction

Road accidents have been a chronic problem for Thailand's transportation sector for a long time. The congestion charge could help to reduce the number of road accidents by shifting commuters from private car to public transportation, with an estimated positive economic impact ranging from THB 0.2 to 100 Billion (EUR 5.96 Million to 2.98 Billion) per year (GIZ, 2020). The results are calculated based on mode shift assumptions from private vehicle to public transportation leading to an equivalent reduction in car insurance spending. Annual expenditures on car insurance are assumed to be THB 6,570 /year/vehicle (EUR 196).

The clean mobility fund that is fed from the congestion charge aims to support various types of sustainable transport measures, all leading to additional direct and indirect GHG emission reductions and encompassing the following modes:

- Public Transport
 - City bus / Van / Song-Teaw modernization through replacement of old vehicles with low-carbon or zero-emission vehicles (e. g. EVs)
 - Operational subsidies to bus companies to improve service levels
 - Low carbon last and first mile public transport schemes (e. g. electric Tuk-Tuk and motorcycle shuttles)
 - Implementing designated public transport lanes
- Mass Rapid Transit
 - Subsidies to reduce fares for selected traveller groups
- Non-motorised transport
 - Widening of sidewalks
 - Creation of designated cycling lanes and bicycle parking facilities

- Introduction of city bike sharing services
- Motorized individual transport
 - Subsidies for fleet electrification (delivery fleets, taxi fleets, company fleets) and public charging infrastructure build-up
 - Enhancement of car sharing services

Table 2: Estimated benefits from congestion charge in Bangkok

Scenario	Charge level (Bath/time)	Vehicle kilometres travelled reduction (Million kilometers/year)	Gross revenue (Million Baht/year)	CO ₂ emissions reduction (Tonnes/year)	Charge in consumer surplus (Million Baht /year)
1	50	0.21	5,906	209,750	-116
	80	-0.07	7,639	193,453	-418
	120	-0.27	8,547	184,007	-832
2	50	3.33	8,273	108,643	647
	80	3.35	11,542	110,603	-24
	120	3.22	14,807	101,815	-1,006
3	50	3.74	8,273	146,560	647
	80	3.89	11,542	149,520	-24
	120	3.87	14,807	141,696	-1,006
4	50	16.46	20,027	109,159	863
	80	23.80	29,922	312,405	617
	120	31.69	41,611	658,293	-128
5	80	3.43	21,688	166,558	-973
6	80	4.09	24,115	193,775	-1,066
	120	4.42	32,836	214,439	-2,681
7	80	16.62	29,199	344,251	-243
	120	20.62	39,388	615,098	-1,533

Source: GIZ, 2019

Financing concept

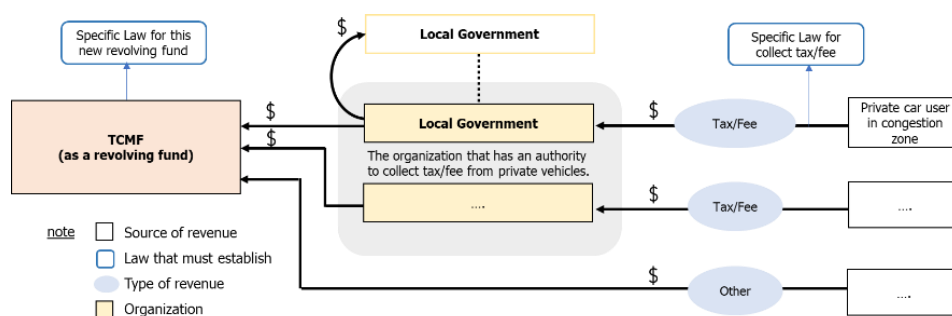
The main logic behind the congestion charge scheme and clean mobility fund implementation as measures of the overarching TCMP is to generate revenue from disincentivizing measures to discourage private vehicles, while reallocation the revenue to incentivize and promote measures to support urban public transport systems.

Regarding the disincentivizing measure, the financial analysis shows that revenues from the congestion charge scheme (e.g., if implemented in Bangkok alone) is estimated to be in a range from THB 5.6-39.0 Billion per year (EUR 0.16-1.16 Billion), therefore, it is financially feasible. From the economic analysis, the result shows that in most scenarios of the congestion charge can generate positive socioeconomic benefits NPV and therefore are economically feasible, except Scenario 1.

Regarding the incentivizing measures, the financial analysis shows that both the bus modernization and MRT/BTS fare subsidy are not a financially feasible investment and therefore need financial support to be implemented. The model shows that for the bus modernization there is roughly a THB 4 Billion funding gap to convert Bangkok's 2,834 private bus fleet to EV. The annual financial cost of the subsidy to public transport fares (BTS/MRT) ranges from THB 5 - 9 Billion per year (EUR 0.14-0.26 Million per year). Therefore, for TCMP's incentivizing measures, financial support around THB 9.0-13.0 Billion per year (EUR 0.26-0.38 Billion per year) are needed. For the economic analysis, the result shows that both measures are economically feasible since they can create extensive positive Socioeconomic Benefit NPV to the country that outweigh their financial cost.

The Clean Mobility Fund (CMF) can be established by the Thai Government as a revolving fund fed by the revenues of a congestion charge scheme (or other tax revenue from car use) and specifically designed for supporting sustainable urban transport measures. The figure below shows the general concept of the CMF. The revenues of a congestion charge in Bangkok (or another travel demand management measures) are fed into the revolving fund, which will be established at national level. Municipalities can access this fund to finance sustainable transport measures within their jurisdiction and according to set criteria and the pre-established whitelist of sustainable urban transport measures eligible for funding.

Figure 2: Operational Framework of the TCMF



Source: GIZ 2019

In summary, the analysis shows that the congestion charge is both financially and economically feasible. While the bus modernization and the BTS/MRT fare subsidy are not financially feasible, they can create positive socioeconomic benefits to the country. If all of the above TCMP's measures are implemented as a package (i.e., congestion charge, bus modernization and BTS/MRT subsidy), they will be both financially and economically attractive, because the revenue from the congestion charge scheme can sufficiently support the expenses of the bus modernization and

BTS/MRT subsidy. It is estimated that these measures will generate revenue at EUR 0.16-1.16 Billion per year, while the expense is estimated at EUR 0.26-0.38 Billion per year. Thus, it is highly likely that the TCMP's measures could self-fund itself without the need to rely on the budget from the national government.

1. Introduction

Thailand had round 70 Million inhabitants in 2020². 9 Million or 13% of the country's population live in Bangkok, and more than 15 Million³ (or 24% of the total population) live in the Bangkok Metropolitan Region (BMR)⁴. Being the largest urban area in the country, Bangkok has been ranked as the **11th most congested city** at the TomTom Traffic Index 2019⁵. While Bengaluru, India and Manila, the Philippines accounted for the highest congestion level with 71%, Bangkok reaches 53%. This means that a 30-minute trip will take 53% more time than it would during Bangkok's baseline uncongested conditions, resulting in significant social and economic loss. According to a study by UBER in 2017, people in Bangkok spent 24 days/year in traffic congestion, which equals to the annual loss of THB 157,000 (EUR 4,685) per person.

Table 3: General Information - Thailand

Country's Population (2020)	69,799,978
Population in Bangkok Metropolitan Region (BMR) (2017)	15,931,300
Country's Population Growth (annual average 2007-2017)	0.35%
Population Growth in BMR (annual average 2007-2017)	0.76%
GDP per Capita (2017)	THB 215,010 (EUR 6,147)
Number of vehicles (all type of vehicles) (2018)	39,551,789
Country's Car Ownership Rate (Vehicle/1,000people)	275
Car Ownership Rate in Bangkok (Vehicle/1,000people)	646

Source: Office of the National Economic and Social Development Council (NESDC) of Thailand, and DLT

Transport is also the main cause of environmental problems in Thailand, in that the transport sector accounted for 26% or 61.2 out of 318.6 Million tonnes (Mt) of Thailand's CO₂ emissions (OTP, 2018). Considering air pollution, research from the Asian Institute of Technology (AIT) in 2019 reveals that land transport contributed to 72.5% of small Particulate Matter (PM_{2.5}) emissions in the BMR, which has increasingly threatened Thais' health over the past years. Data from 9 hospitals in Bangkok shows that there were 9,980 respiratory-related cases in January 2019 (November – February is the peak period of PM_{2.5}) comparing to 6,445 cases in 2018⁶.

Transportation in Bangkok is still highly dependent on road-based (private) modes, and in many places, it is the only option for traveling. At the same time, Bangkok has only a road-to-area ratio of 8% (comparing to 32% in New York, and 23% in Tokyo). Despite the fact that there is limited road space, car ownership of Bangkok with 646 vehicles per 1,000 inhabitants is higher than Singapore (170/ 1000), Hong Kong (92/ 1000) and London (320/ 1000), implying that there is a higher dependency on private cars. In addition, the vehicle ownership continues to grow by almost 2% per year across Thailand, and by 3% in Bangkok, translating into high levels of congestion. The Thai Government has recognized this problem and is rapidly building up its rail-based mass

² <https://www.worldometers.info/world-population/thailand-population/>

³ <http://citypopulation.de/php/thailand-prov-admin.php>

⁴ Bangkok Metropolitan Region (BMR) refers to a "political definition" of the urban region surrounding the metropolis of Bangkok, which gets filled in as development expands. The political definition is defined as the metropolis and the five adjacent provinces of Nakhon Pathom, Pathum Thani, Nonthaburi, Samut Prakan, and Samut Sakhon.

⁵ https://www.tomtom.com/en_gb/traffic-index/ranking/

⁶ https://www.dailynews.co.th/bangkok/689752?fbclid=IwAR1Xd7jw33Mx6podXP8I2TPpWqvqGuTJj-EPWcPmljo_5Q8Tta15etR_tNw

transit system in the capital (currently 212 km rail, 565 km to be completed in 2027). However, rail transit only accommodates 6% of all trips and congestion is ever so present on Bangkok's streets. Moreover, despite the efforts to continuously extend rail-based transport network, modeling-based projections show that the rail system will not be able to accommodate rising mobility needs even if the network is completed.

The existing bus system is adding to the problem with insufficient service levels, a lack of integration with rail-based modes and very old and hence polluting fleets (modal share 20% of all trips).

Congestion Charging as part of the Thailand Clean Mobility Programme

Realizing the urgent need to shift trips from private vehicles to sustainable transport modes, OTP, supported by GIZ project TRANSfer III, has designed the "Thailand Clean Mobility Programme (TCMP)". The programme addresses the two major challenges for a shift towards sustainable transport in Thai cities: a low-quality public transport service based on old vehicles with high specific emissions (25 years on average) and a rapid increase in private motorization (300,000 new vehicles/ year). To do so, the TCMP employs a Push and Pull Approach, that makes public transport more attractive by improving connectivity, reducing fares and improving technology (Pull), and disincentivizes car travel by internalizing road usage costs and environmental externalities by means of a congestion charge (CC) (Push), inducing a shift from private to public modes in a sustained manner. Experience from other cities that have introduced Congestion Charging shows a reduction of car trips by 20 to 70% and increase public transportation ridership by 20 to 40%. The revenues of the CC will feed into the clean mobility fund (CMF), which creates a continuous funding source for sustainable urban transport projects in Thai cities (Transport-Finances-Transport). A estimation results suggest that the introduction of CC in Bangkok will reduce 0.34 MtCO_{2e} emissions per year.

Moreover, as Congestion charge is being recognised as one of the most sophisticated and effective instruments of travel demand and traffic management and it has been anchored in the Thai NDC Action Plan for the Transport Sector as medium-term measure with a planned implementation between 2027 and 2037 together with the electrification of minivans envisaged for 2026-2030. The introduction of Congestion charge would internalize the external costs of road transport and generate revenue to support public transport improvement. A sound and designated communication strategy implemented prior to the introduction of a Congestion Charging scheme would increase public acceptance of the programme.

2. Sector overview

2.1 Mobility in the Bangkok Metropolitan Region (BMR)

Thailand's urbanization rate is still comparatively low. However, urbanization has increased sharply in the last decade, from only 36% in 2008 to 50% in 2018. Of all urban dwellers, 48% live in the Bangkok Metropolitan Region (BMR) (GIZ, 2019). In 2020, the urban population growth rate for Bangkok reached 2.3, compared to other comparable cities with rates ranging between 1.2 and 1.4⁷.

Table 4: Population and density of urban areas in Thailand (2014)

City or Municipality (Urban Area)	Province	Population*	Area (km ²)	Density (people/km ²)
Bangkok Metropolitan Administration (BMA)	Bangkok	10,350,204	1,568	6,600
BMR in urban areas	BMR	12,586,200	2,871	4,384
Nakhon Ratchasima	Nakhon Ratchasima	174,332	39	4,470
Chiang Mai	Chiang Mai	174,235	47	3,707
Hat Yai	Songkhla	159,233	21	7,583
KhonKaen	KhonKaen	129,581	52	2,492
Phitsanulok	Phitsanulok	89,480	19	4,709
Phuket	Phuket	75,536	12	6,295

Source: Department of Provincial Administration (DOPA), NESDC

Bangkok, the country's capital city has an estimated population of round 10.1 Million inhabitants as of 2020⁸. Together with 5 adjacent provinces including Nakhon Pathom, Pathum Thani, Nonthaburi, Samut Prakan, and Samut Sakhon, it forms the BMR covering an area of 7,762 km with approximately 15 Million inhabitants⁹. Hosting more than a fifth of the country's population, the BMR plays an important role in driving the country's economy, as industrial and residential zones have been developed in these surrounding provinces to accommodate the growth of Bangkok (Robinson, 2011).

⁷ <https://worldpopulationreview.com/world-cities/bangkok-population/>

⁸ <https://en.wikipedia.org/wiki/Bangkok>

⁹ Bangkok Metropolitan Population report 2018

Figure 3: Map of Bangkok Metropolitan Region (BMR)



Source: https://www.thaiappraisal.org/english/thairealestate/tre_preview.php?strquery=thair5.htm

The city of Bangkok has a variety of different public transport modes, including overground and underground rail, bus, canal-boats, smaller public transport vehicles such as vans and traditional Song-Teaw, as well as last mile services such as motorcycle-taxis or Tuk-Tuk. Even though rail-based mass transit has been rapidly developed over the last decade, the predominant mode of transport is still the individual private vehicle with a share of round 79%. Especially city dwellers living outside of the BMR core of Bangkok, often rely on private vehicles, as public transport coverage is not sufficient in those areas.

Private motorized modes are followed by the bus, which is chosen primarily by low-income groups and often runs in parallel to rail-based services on the main roads. BMR is served by a total of round 7,300 buses¹⁰ with an average age of 26-30 years¹¹. With rising coverage by rail-services and deteriorating service quality (unreliable schedules due to traffic jams and lack of priority lanes, lack of air conditioning on half of the bus fleet leading to breathing in polluted air and rain entering the bus during rainy season, over-crowding due to bad network design), the bus has recently been losing ridership, in particular among people who can afford other modes of transport such as private vehicles or taxis instead of buses (Nichamon Thongphat, 2017).

¹⁰ Data from Bangkok Mass Transit Authority (BMTA), 2019

¹¹ Board of Directors of BMTA 2018

Table 5: Number of commutes in Bangkok Metropolitan Region (BMR) by type of transport

Type of Transport	Number of Commuters (Million people-trip/year)	
	2017	2018
Mass transit system ¹²	402.26	413.94
BRT bus	5.82	4.56
Bus	2,233.76	2,227.50
Van	211.20	204.60
Boat	71.90	69.28
Total public transport	2,924.74	2,919.88
Total private transport trip	8,568.06	8,989.75
Total trip	10,783.77	10,949.40

Source: Transport Infrastructure Report 2018, (OTP)

The Government has ambitious plans for the rail-based urban mass transit network, which is planned to be extended from currently 212 km to 565 km within the next decade. Currently there are 8 lines in operation, including Light & Dark Green, Blue, Purple, Airport Rail-Link, and Gold line. Light & Dark Red line started operating in November 2021, Pink and Yellow in 2023, and all planned- 12-metro lines are expected to fully operate in 2029 (DRT, 2022).

Rail and bus services are complemented by round 2,050 so-called “Song-Teaw”, a passenger vehicle adapted from a pick-up truck or a larger truck, that is used as a shared taxi or bus mainly in the outskirts of the city where bus coverage is not sufficient. Some Song-Teaw run on fixed routes, while others act as a taxi service. Due to relatively inconvenient and unreliable services of the Song-Teaw, households who are able to afford motorbikes or cars tend to choose private vehicles instead.

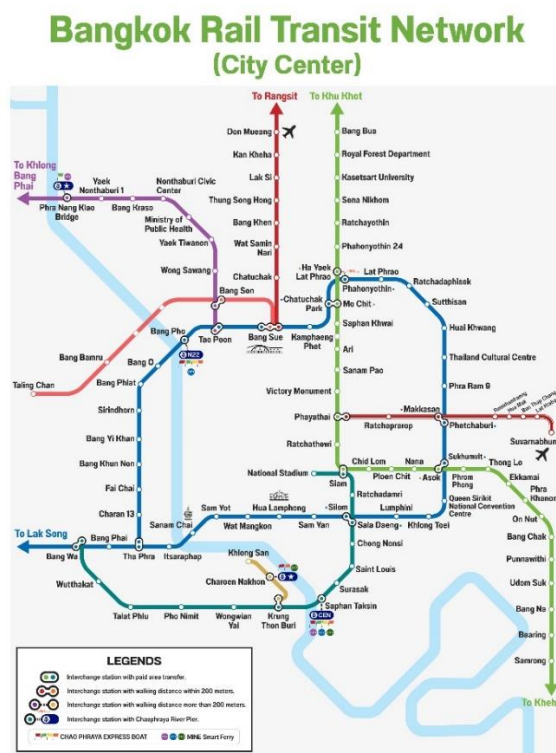
Bangkok’s unique urban structure with few major roads and large “Super-Block”-like structures with up to 1,500 m radii¹³ characterized by narrow roads with round 6,240 km of dead-end streets, equals to 37% of total road distance in Bangkok.¹⁴ Prevalent one-way roads lead to difficulties in access to rail and bus transport. Public transport in Bangkok hence relies on last-mile services such as motorcycle taxis and Tuk-Tuk that bring commuters from the station to their final destinations and vice versa.

¹² Mass transit system in BMR consists of: BTS Skytrain, MRT Bangkok Metro, Airport Rail Link (ARL), and inner city train

¹³ BMA, 2014

¹⁴ <http://www.urbanwhy.com/2016/12/21/bkk-traffic-inadequate-streets/>

Figure 4: A map of Mass Rail Transit network in BMR in 2022



Source: LivingPop

Motorisation rates

In 2018, there were 39 Million registered vehicles (all vehicle types) in Thailand. 25% or 10 Million of these vehicles were registered in Bangkok. Given that less than a quarter of the Kingdom's population resides in Bangkok, the region accounts for disproportionately more vehicles than the rest of the country. This is perhaps unsurprising given that Bangkok is also the most affluent region of Thailand. Between 2014 and 2018, the number of registered vehicles (all vehicle types) across Thailand increased by an average of almost 2% per year, while this increase was 3% in the capital city.

Table 6: Accumulated registered vehicles and Motorisation Rate

Province	Accumulated registered vehicles (All types of vehicles, 2018)	Motorisation Rate (Vehicles/1,000 People)	
		Including Motorcycles	Excluding Motorcycles
Whole Kingdom	39,551,789	585	275
Bangkok	10,244,144	1,034	646
BMR	11,478,006	637	387
Nakhon Ratchasima	1,368,421	486	201
Chiang Mai	1,457,217	795	330
Songkhla	829,239	517	232
KhonKaen	866,898	465	216
Phitsanulok	509,673	522	220
Phuket	488,366	821	291

Source: DLT, 2018

Table 6 exhibits the motorisation rates for Bangkok and six secondary cities of Thailand (Nakhon Ratchasima, Chiang Mai, Songkhla, KhonKaen, Phitsanulok and Phuket). Including motorcycles, for every 1,000 people in the Bangkok Metropolitan Administration area, there are close to 1,030 vehicles. In BMR as a whole region, the motorisation rate is 640 vehicles per 1,000 people. Notably, Phuket (821/1,000) and Chiang Mai (795/1,000) have higher motorisation rates than BMR. Excluding motorcycles, the car ownership rate in Bangkok (646/1,000) is considerable higher than overall BMR areas as well as in Thailand's six major cities.

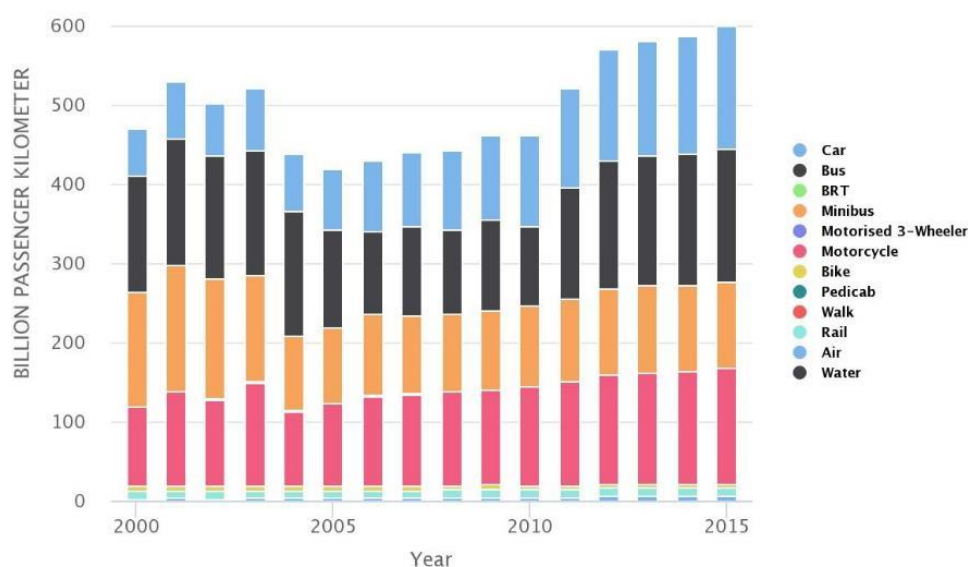
Car registration data in Bangkok shows that there are 6.1 Million registered private cars, or one car for every 2.6 residents. This compares to one car for every 10 residents in Singapore, one for every 7.5 residents in Hong Kong and one for every 3 people in London.

The number and proportion of private cars in Bangkok makes it very difficult to provide adequate road space to meet car use demand. In addition, Bangkok has rather little road space given its proportion of 8% while the standard percentage of road within a city ranges between 20-25% (Poonyakanok, 2016). In addition, the lack of proper city planning, and regulations causes dead-end and long small streets in many cities in Thailand, especially super-block in Bangkok, which undoubtedly lead to congestion (Poonyakanok, 2016). Given this starting situation, it becomes clear that demand management measures are required to contain or restrict personal vehicle use alongside supply side improvements to the sustainable transport network. Without policies to discourage greater levels of motorisation, the negative impacts of motorisation, congestion and its associated economic costs, road safety, air quality and CO₂ emissions could further deteriorate.

Passenger Transport Demand

Across Thailand, in 2015, cars (26%) and motorcycles (24%) accounted for around half of all passenger-km travelled across all modes, as presented in Figure 5. Buses accounted for the highest share of passenger-km travelled (28%). This emphasises buses as being an important transportation mode for a significant proportion of the population that should continue to be at the forefront of tackling congestion, poor air quality and reducing CO₂ emissions.

Figure 5: Passenger km travelled by mode



Source: ADB Transport Databank, 2018

There has been a steady increase in car-km travelled from 61 Billion passenger-km (2000) to 156 Billion passenger-km (2015). During the same period, motorcycle-km travelled have increased by 45% to 145 Billion passenger-km. The growing numbers of passenger-km travelled imply that the population is becoming more mobile by either making more journeys or making longer distance journeys. At the same time, bus-passenger-km travelled has remained broadly stable. However, it can be seen from the graph that as people become more mobile, they tend to rely on private vehicles more than public transport.

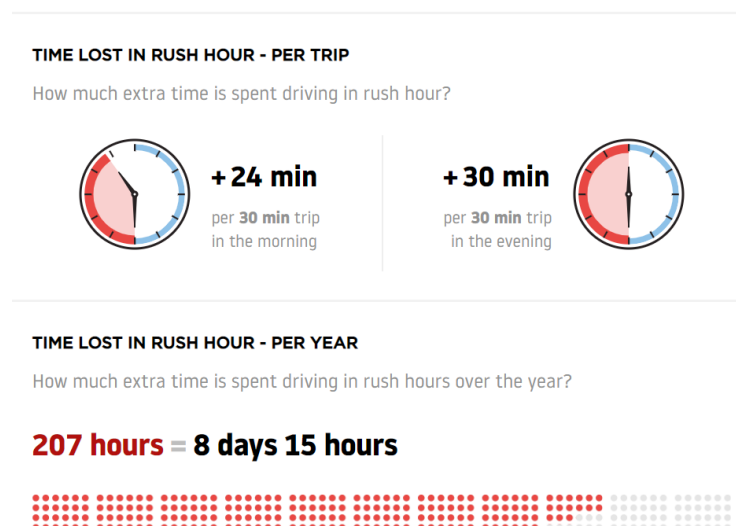
Congestion in Bangkok – negative environmental and social impacts

Congestion Charging is often considered in cities that have significant traffic related problems, such as congestion, traffic safety issues, poor air quality, equity issues or insufficient public transportation quality of service. All these issues are harmful for the residents and threaten the liveability and economic attractiveness of cities.

If Bangkok is compared to other cities around the world using global comparable metrics from TomTom and Inrix, Bangkok ranks high in congestion index reports, reaching place 11th among all cities on TomTom ranking and place 8th for a selection of large cities. On the Inrix ranking Bangkok has reached place 33rd in 2019. The exact ranking might not even be that important, but Bangkok being ranked high independently the source validates the consistently high level of congestion compared to other cities. These congestion levels have negative impacts among others on productivity and people's quality of life.

People in Bangkok lose a significant amount of time by being stuck in traffic. On average, vehicle users in Bangkok spend a total of 8 days and 15 hours per year in congestion. Kasikorn Ressarch (2016) found that the time lost in congestion amounts to about THB 11 Billion (EUR 0.33 Billion) per year, and that when the opportunity costs of these time losses are equivalent to about THB 60 Million (EUR 1.79 Million) per day¹⁵. Congestion has a large negative economic and social impact on Bangkok. It limits growth opportunities and negatively impacts productivity of the work force.

Figure 6: TomTom congestion information Bangkok



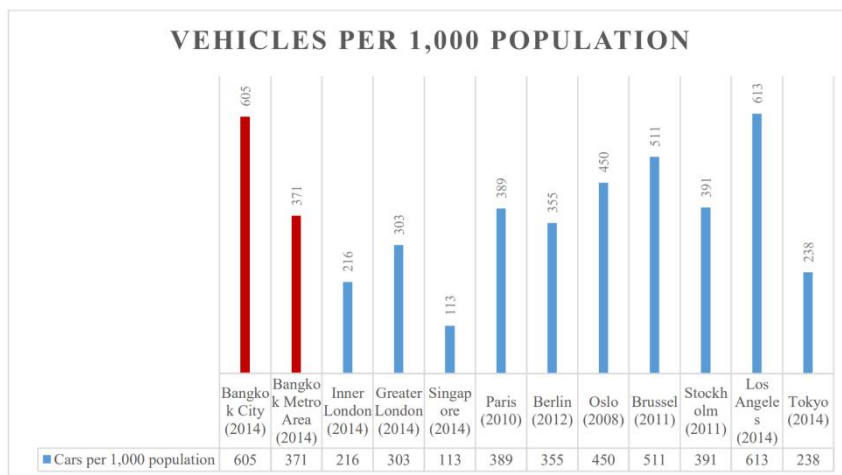
Source: https://www.tomtom.com/en_gb/traffic-index/bangkok-traffic/

¹⁵ The opportunity cost is the "cost" incurred by *not* enjoying the benefit associated with the best alternative.

The 10 Million cars in Bangkok not only create traffic congestion which cause the waste of time, energy, and money, but they also take up space that could be used for other purposes. For example, footpaths in Bangkok tend to be narrow as the space is dedicated to roads. The average width of pedestrian walks in Bangkok is around 1 meter, while the standard walkway should be at least 1.5 meter (GoodwalkThailand, 2016). Lack of walking infrastructure poses a problem in the entire city of Bangkok as well as other compacted cities in Thailand. Moreover, pedestrians have to take risks from being exposed to noise and air pollution from massive number of vehicles in the city.

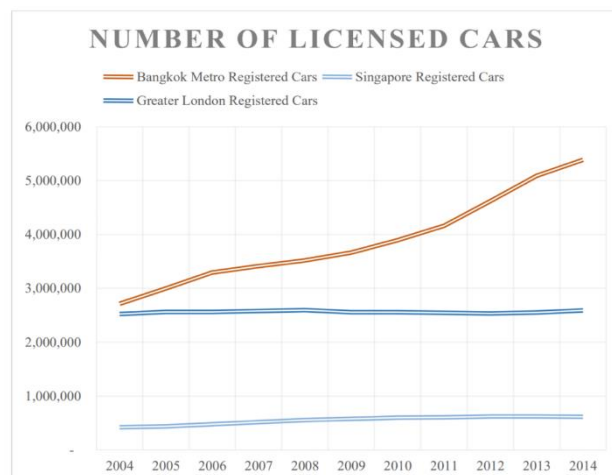
Nirattiwongsakorn (2015) found that one of the underlying reasons why congestion is so bad in Bangkok is because vehicle ownership is high (Figure 7) and increasing (Figure 8). This is most likely linked to economic growth, creating a larger middle class that can afford to own a car. But also, other factors contribute to congestion, including urban planning decisions that support urban sprawl as well as historically insufficient investment in public transportation, walking and cycling infrastructure.

Figure 7: Vehicle ownership in Bangkok compared to other cities



Source: GIZ, 2021

Figure 8: Trends in car registrations for Bangkok, London, and Singapore



Source: GIZ, 2021

Bangkok is extending public transportation with a number of new rail connections. As shown in Table 7, public transportation demand is expected to increase from about 10 Million in 2017 to about 12 Million trips per day in 2042, with mode shares only marginally increasing (from 32% to 34%). The projected growth for Bangkok is so high that the total number of trips is expected to increase from about 32 Million in 2017 to 40 in 2042. Of the 8 Million projected additional trips, 2 Million trips are expected to be effectuated using public transportation. Thus, the investment in public transportation infrastructure supports Bangkok's development of the transport network, however will not be sufficient to imply a systemic change in public transportation use shares, nor reduce car travel and congestion.

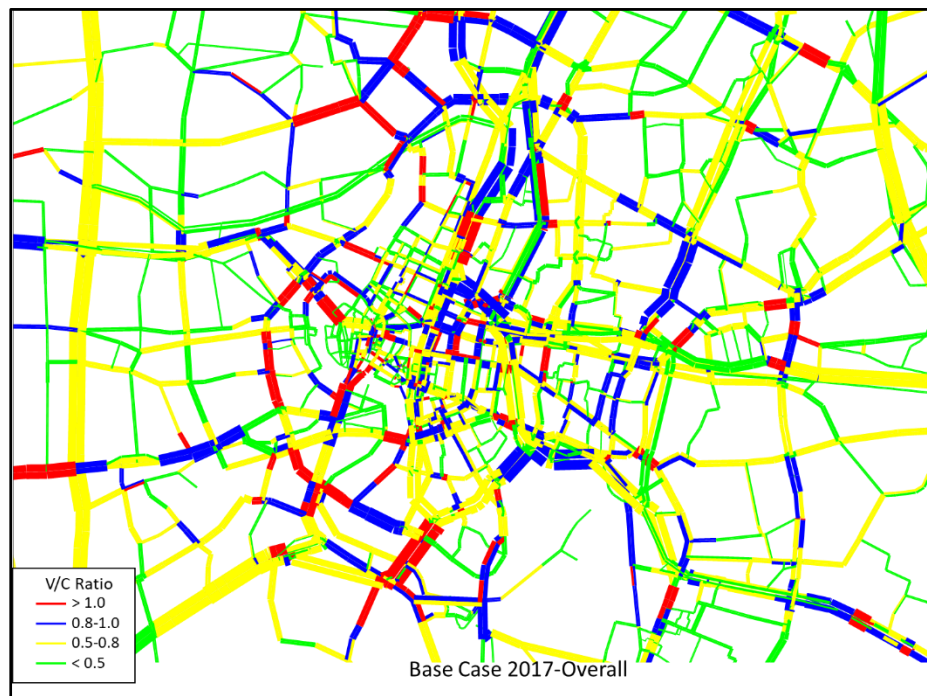
Table 7: Forecasts of travel demand and mode shares for Bangkok (eBUM model)

Mode	Volume of travelling (Million trips/day)					
	2017	2022	2027	2032	2037	2042
Private vehicle	22.44 (68.7%)	23.30 (66%)	24.43 (64.8%)	24.99 (64.5%)	25.00 (63.6%)	24.29 (60.8%)
Car	14.12 (43.2%)	15.60 (44.2%)	17.22 (45.7%)	18.31 (47.3%)	18.98 (48.3%)	19.11 (47.8%)
Motorcycle	8.32 (25.5%)	7.70 (21.8%)	7.21 (19.1%)	6.68 (17.2%)	6.02 (15.3%)	5.18 (13.0%)
Public transportation	10.21 (31.3%)	11.99 (34.0%)	13.25 (35.2%)	13.76 (35.5%)	14.31 (36.4%)	15.64 (39.2%)
Taxi	1.36 (4.2%)	1.59 (4.5%)	1.87 (5.0%)	2.01 (5.2%)	2.19 (5.6%)	2.44 (6.1%)
Public bus	6.60 (20.2%)	7.83 (22.2%)	8.62 (22.9%)	8.85 (22.8%)	9.09 (23.1%)	9.94 (24.9%)
Shuttle bus	0.62 (1.9%)	0.81 (2.3%)	0.88 (2.3%)	0.96 (2.5%)	1.06 (2.7%)	1.26 (3.2%)
Walking	1.63 (5.0%)	1.76 (5.0%)	1.88 (5.0%)	1.94 (5.0%)	1.97 (5.0%)	2.00 (5.0%)
Total	32.65	35.29	37.68	38.75	39.31	39.93

Source: OTP, 2015

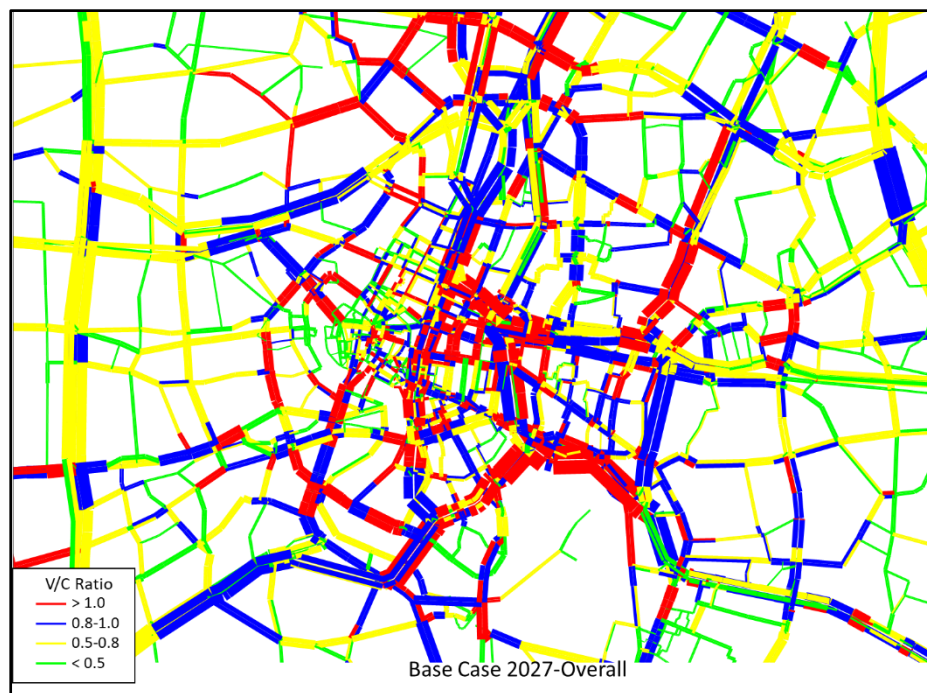
Besides the globally available data sources, transportation model results to see how congestion levels change in future years. Figure 9 and Figure 10 show the increase in congestion between 2017 and 2027 (more red lines and blue lines) on each road segment in Bangkok. The colouring of the roads is done based on V/C-ratios. This ratio stands for road demand on a specific road segment divided by the capacity of that road segment. If the ratio is above 1, congestion is classified as serious. Comparison between Figure 9 and Figure 10 shows that in 2027 the road segments that are coloured red and blue increase dramatically, indicating that congestion is already bad, but will still intensify over time.

Figure 9: Modelled congestion for 2017



Source: GIZ, 2021

Figure 10: Modelled congestion for 2027



Source: GIZ, 2021

If Bangkok is going to reduce congestion, or at least maintain its level, it needs to reduce the demand and dependency on private vehicles. This will require significant policy changes and investments. The policy changes should ideally focus on, e.g. air pollution control and mitigation policies together with car purchase, car ownership and car use regulations. Also, urban space

reallocation from road towards bike lanes or walkways as well as public and community space planning should be included in the systemic approach to develop a sustainable transport network in Bangkok. Increased investment is needed to improve cycling and walking infrastructure, public transportation service level and quality as well as enhance system integration with other energy and emission efficient modes, including shared services. Congestion Charging can play an important role in making the use of the private car less attractive.

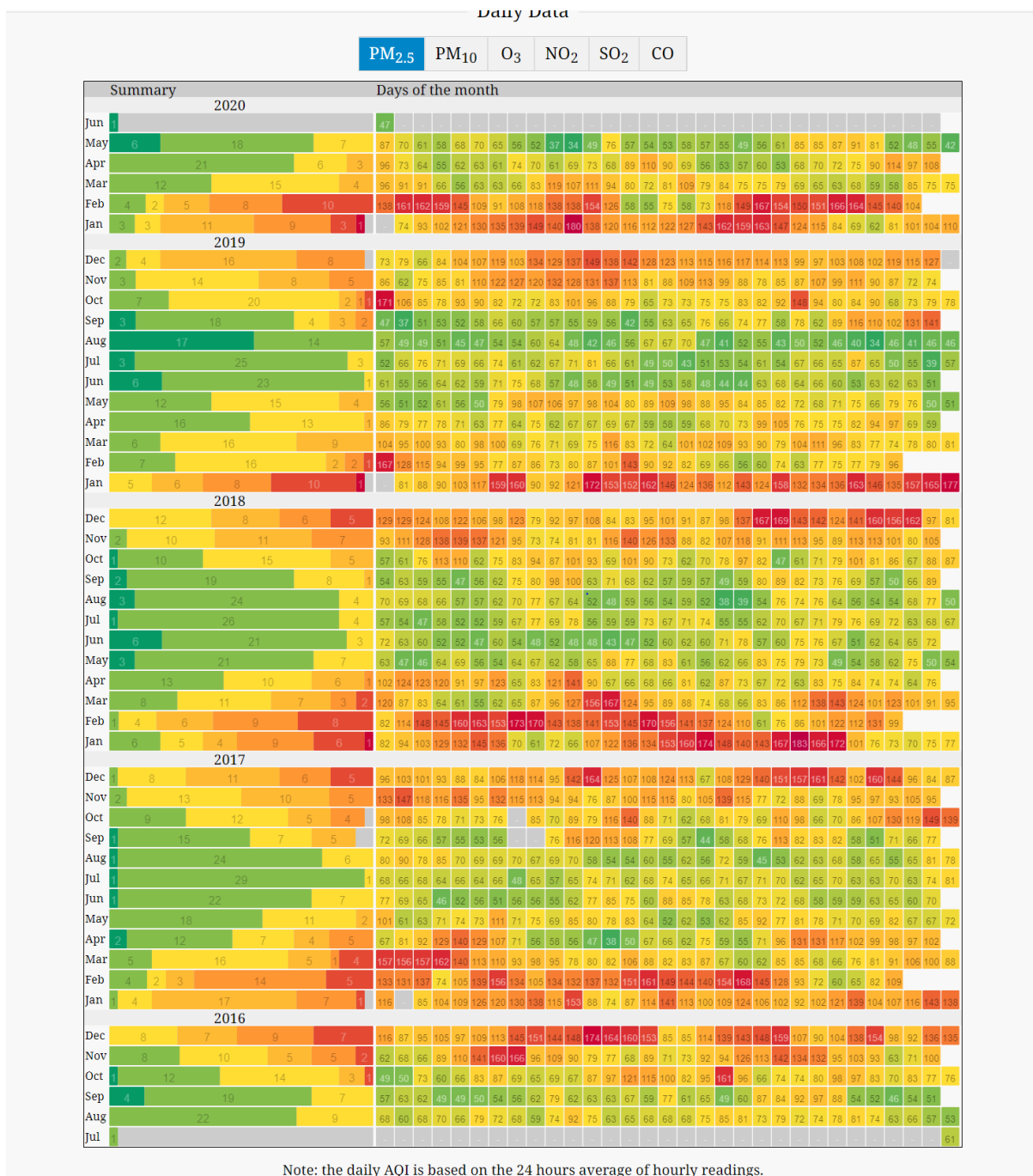
Air Quality

In 2014, Thailand contributed 316 MtCO₂ to the global GHG emissions with transportation accounting for 25% or 79 MtCO₂ (OTP, 2018). Transport CO₂ per capita has increased steadily since 2000. CO₂ emissions from the transport sector equated to 0.95 tonnes per capita in 2000, and 1.17 tonnes per capita in 2015, an increase of 23% in just 5 years.

Cars and motorcycles account for round 40% of the CO₂ emissions while freight vehicles, ranging from light commercial vans to heavy freight trucks, account for 31% of all transport related CO₂ emissions. Busses account for 7%, air transport accounts for 17%. The remaining percentages are shared between rail and water based transport. Road-based transport therefore accounts for the major share of emissions, and the trend will continue to grow with the growing number of vehicles on the road without any intervention.

Considering air pollution, a study by Greenpeace found that transportation generated 50,240 tonnes of PM_{2.5} and 246,000 tonnes of NO₂ in 2015 (Greenpeace, 2019) in Thailand. Small Particulate Matter, PM_{2.5} and PM₁₀ in particular, are the main pollutants contributing to the poor air quality. Figure 11 shows the average daily PM_{2.5} levels in Bangkok in the past three years. The colours and numbers refer to the Air Quality Index (AQI), where values over 100 (orange, red, purple and brown) represent unhealthy conditions. Air quality is initially harmful to sensitive groups only (orange) until it reaches the hazardous levels for everybody (brown). In Bangkok, many days and months have substantial orange and red periods, and there is a seasonality to PM_{2.5} concentrations where October through March¹⁶ are the months with the highest concentration levels of PM emissions. According to the Thai Pollution Control Department (PCD) average PM_{2.5} levels measured in Bangkok exceeded the Thai air quality limit of 50 µg/m³ on 49 days in 2019 while the World Health Organisation (WHO) guidelines a limit at 25 µg/m³.

¹⁶ During the winter, from time to time, a ridge from the high-pressure system dominating over China extends to central Thailand. Accompanied by relatively strong winds, the ridge brings in cooler air and carries some pollutants along with it. After a few days, the ridge stabilizes, creating stagnant air conditions, with limited vertical motion and calm winds. This induces a phenomenon called 'radiative inversion,' which is witnessed at nighttime when temperatures rise with height in the lower layers of the atmosphere. These conditions cause pollutants, once emitted, to remain close to the source locations and build up to high levels. This implies that the particulate matter, for example after it is released from vehicle exhausts, does not rise high enough or is not transported horizontally for long enough periods to become diluted. With no rain, the dry season worsens the problem because pollutants remain suspended in the air for extended periods. Add to this vehicular and open-burning pollutants, and the situation is exacerbated. The combination of dry weather, traffic emissions, biomass burning, and meteorological factors such as stable high-pressure ridges create the toxic environment noticeable in the winter months.

Figure 11: Daily average PM_{2.5} emissions in BangkokSource: <https://aqicn.org/city/bangkok/>

(Chuersuwan et al., 2008) show that road transport is an important contributor of PM₁₀ and PM_{2.5} emissions in Bangkok and estimate that 22% to 39% of the PM emissions go back to car travel. According to the Asian Institute of Technology (AIT) (2019) land transport is contributing round 73% to the PM_{2.5} emissions in the BMR region. These high concentrations of PM₁₀ and PM_{2.5} lead to a number of health issues as they affect the cardiovascular system. Tamura et al., (2003) concluded that the increased prevalence of respiratory symptoms among traffic policemen was associated with urban traffic air pollution. Ostro et al., (1999) looked at the mortality rate and found that a 10-µg/m³ change in daily PM₁₀ is associated with a 1–2% increase in natural mortality,

a 1–2% increase in cardiovascular mortality and a 3–6% increase in respiratory mortality. These relative risks are generally consistent with or greater than those reported in most studies undertaken in the United States. Preuthippan et al., (2004) looked at how school children with and without asthma are affected by air pollution and conclude that elevated levels of PM₁₀ concentrations in Bangkok affect the respiratory symptoms of schoolchildren with and without asthma. Air pollution in Thailand is responsible for cutting short 50,000 lives every year.

In summary, it can be concluded that Bangkok has severe air quality problems that are to a great extent caused by road transport and results in negative effects on health and quality of life. Resolving these air quality problems will require a shift from car use towards an increased use of public transportation, more walking and cycling and the use of cleaner, more emission efficient or entirely zero-emission vehicles. Again, Congestion Charging can provide a push in that direction. The primary effect of Congestion Charging on air quality is a decrease in car demand and vehicle-kilometers. Charges can, however, also be differentiated towards the environmental characteristics of vehicles, steering towards both a reduced use of cars and towards the use of less polluting vehicles.

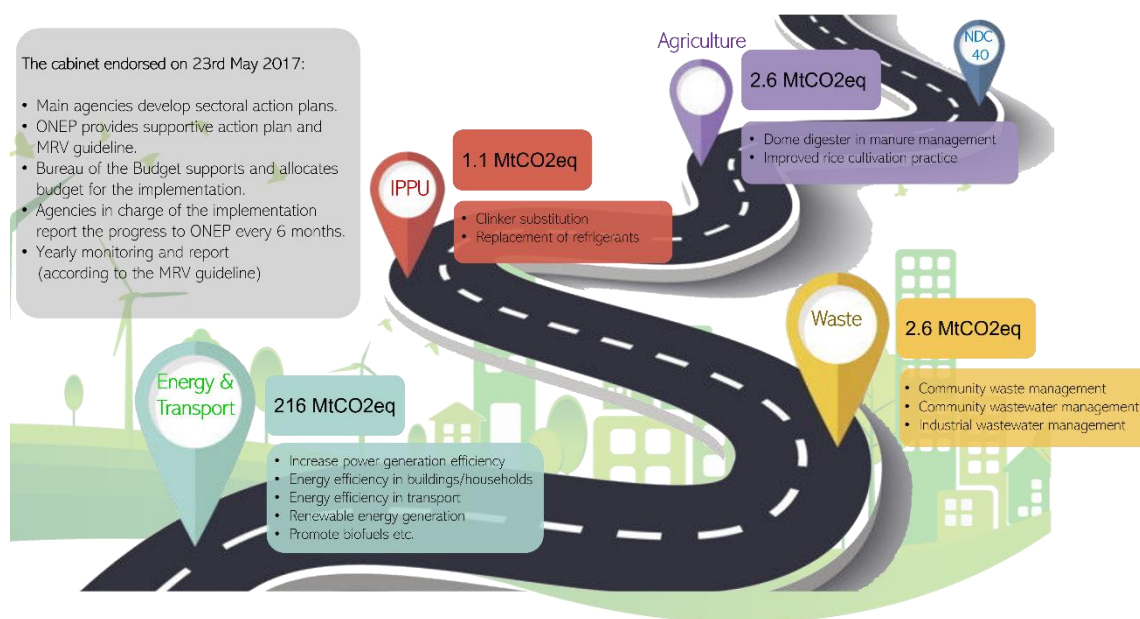
In addition to poor air quality road transport is a major threat to safety. According to the World Health Organization (WHO), Thailand has the second highest road traffic fatality rate in the world. The WHO reports the fatality rate at round 36 death per 100,000 with over 24,000 fatalities per year. This differs slightly from the Ministry of Public Health's record of 24 death per 100,000. It is estimated that the cost of road traffic crashes to the Thai economy ranges between 3% and 5% of the GDP, which suggests that road accidents and particularly fatalities, are a significant issue for Thailand. Motorcycles account for far the biggest share of the fatalities.

2.2 Transport and climate policy context

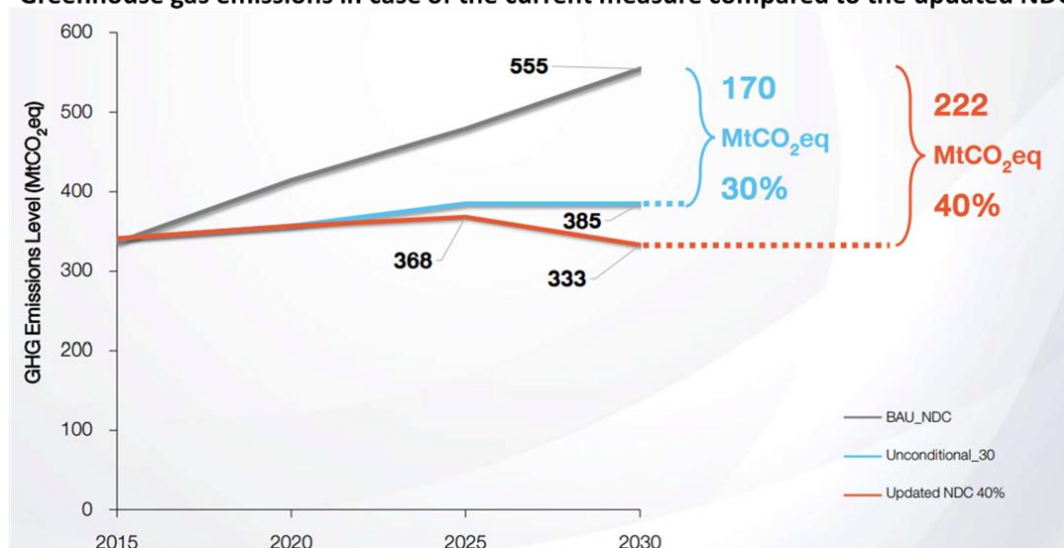
According to the Department of Alternative Energy Development and Efficiency (DEDE), the transport sector in Thailand ranks as the most energy-consuming sector in the Kingdom, accounting for 39% of all energy consumed in 2019. The transport CO₂ increased 23% between 2000 and 2015 on a per capita basis.

The GHG emission level of 555 MtCO₂ was used as a reference of Business as Usual (BAU) in 2030 to calculate the NDC target. Thailand committed to the United Nations Framework Convention on Climate Change in 2015 to reduce 20-25% of its GHG emissions compared to Business as Usual (BAU) in 2030, translating into 115.6 MtCO₂ (Laopongpith, 2019). This resulted in the so-called NDC25. With the cabinet endorsement in May 2017, the Office of Natural Resources and Environmental Policy and Planning (ONEP) of the Ministry of Natural Resources and Environment (MNRE) was assigned the task of developing Thailand's Nationally Determined Contribution (NDC) Roadmap on Mitigation 2021-2030. However, the Prime Minister announced a new target to reach carbon neutrality by 2050 and zero greenhouse gas emissions by 2065 at COP 26. Therefore, Thailand is preparing the updated Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS) and NDC. Thailand's updated NDC aims to set greenhouse gas emission reduction target at 40% with additional governmental and international supports by 2030. The 40% reduction of Thailand's GHG emissions equals to 222 MtCO₂ in which 170 MtCO₂ can be achieved by the current national measures and the remaining 52 to 53 MtCO₂ will require additional governmental and international supports, as shown in Figure 12.

Figure 12: Thailand's updated NDC Roadmap on Mitigation 2021 - 2030



Greenhouse gas emissions in case of the current measure compared to the updated NDC

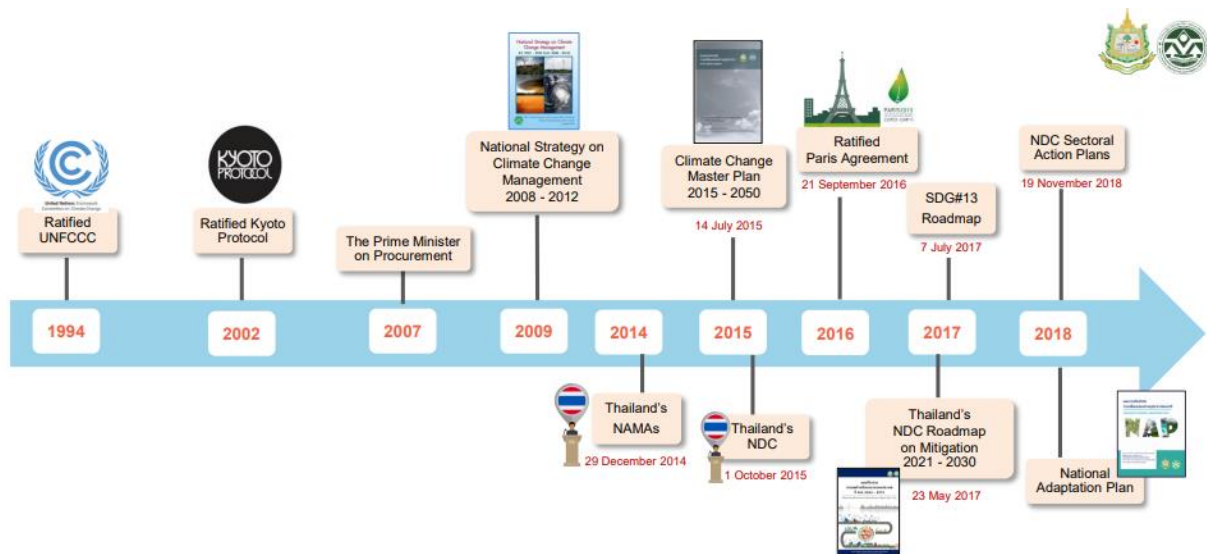


Source: ONEP, 2022

In general, the development of the NDC roadmap has involved line ministries and agencies contributing to a working group on mitigation planning. Following public consultations, the NDC roadmap is prepared. This will be then considered by the Sub-National Board on Policy Integration and the National Board of Climate Change Policy before, finally, the Cabinet is responsible for finalizing and formally ratifying the NDC Roadmap on Mitigation. See Figure 13.

Currently, the updated NDC is in the phase of public consultation. The main objective of this phase is to share the result of the revised LT-LEDS and NDC and receive feedback and recommendations from the public for further Thailand's climate policy enhancement and development. The revised LT-LEDS and NDC are planned to be submitted to UNFCCC before COP27 takes place in November 2022.

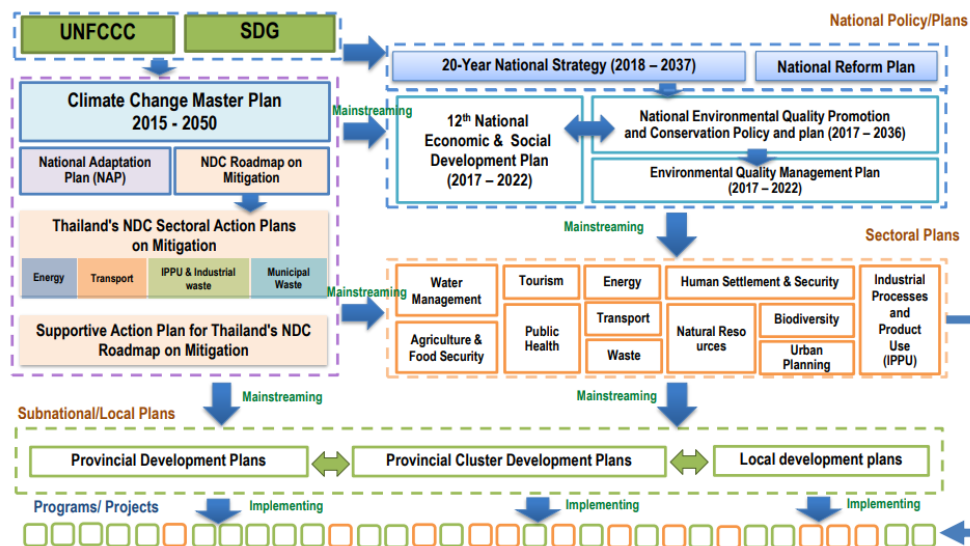
Figure 13: The Development of Thailand's Climate Change Policy and Action



Source: ONEP, 2019

Based on the old NDC or the NDC25, four sectoral NDC's Action Plans were developed in accordance with the NDC Roadmap on Mitigation, as demonstrated in Figure 14. The Energy Policy and Planning Office (EPPO) was responsible for the energy sector, the Pollution Control Department (PCD) for the waste sector, the Department of Industrial Works (DIW) was in charge of the Industrial Processes and Product Use (IPPU), and the Office of Transport and Traffic Policy and Planning (OTP) for the transport sector. Even though the four sectoral NDC Action Plans have been completed, the translation into local plans and implementation are still open or ongoing.

Figure 14: Development of Thailand's NDC Policies and Actions

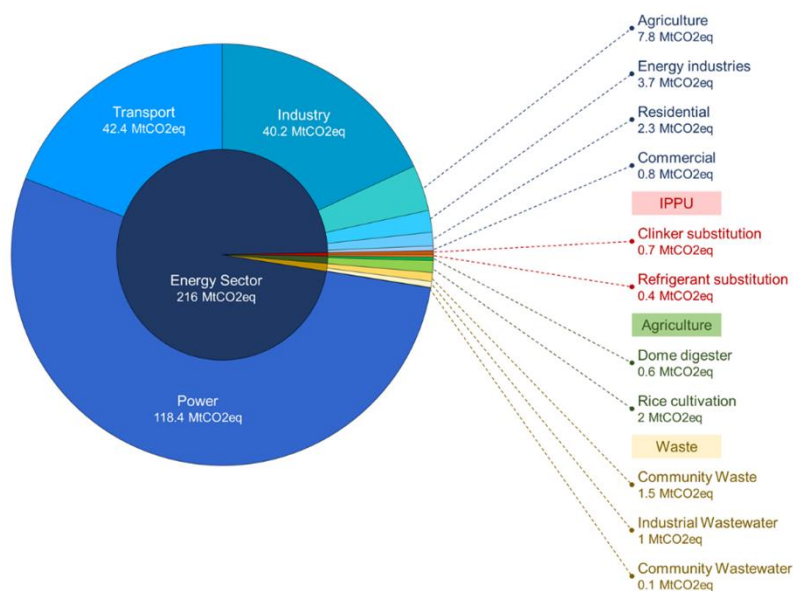


Source: ONEP, 2019

The total reduction target of 222 MtCO₂ equivalent can be divided into four sectors, of which 216 MtCO₂ are attributed to the energy and transport sector. See Figure 15. According to ONEP and Sirindhorn International Institute of Technology (SIIT)'s recent study, the remaining 53 MtCO₂,

which requires further measures, will result from energy sector. In the study, energy sector refers to the totality of industries involved in producing, supplying energy, energy products and energy services. Transport is considered as an end consumer of this sector that uses fossil fuels as the main energy source. The major emitters of energy sector are therefore energy industry and transport respectively.

Figure 15: Thailand's updated NDC Target



Source: ONEP, 2022

After the revised NDC is finalized, MNRE will respectively ask the line ministries to develop Action Plans on how to achieve the reduction of 222 MtCO₂. Based on the NDC25, the NDC Action Plan in the transport sector was developed by OTP and approved by the National Committee on Climate Change (NCCC) on November 19, 2018. Some additional measures will be included in accordance with the final updated NDC; however, the core of the Action Plan remains unchanged. The identified potential on CO₂ reduction in the transport sector is reported to be 42.4 MtCO₂ in 2030, of which 12.6 MtCO₂ are to be reduced by the use of biofuels and EV.

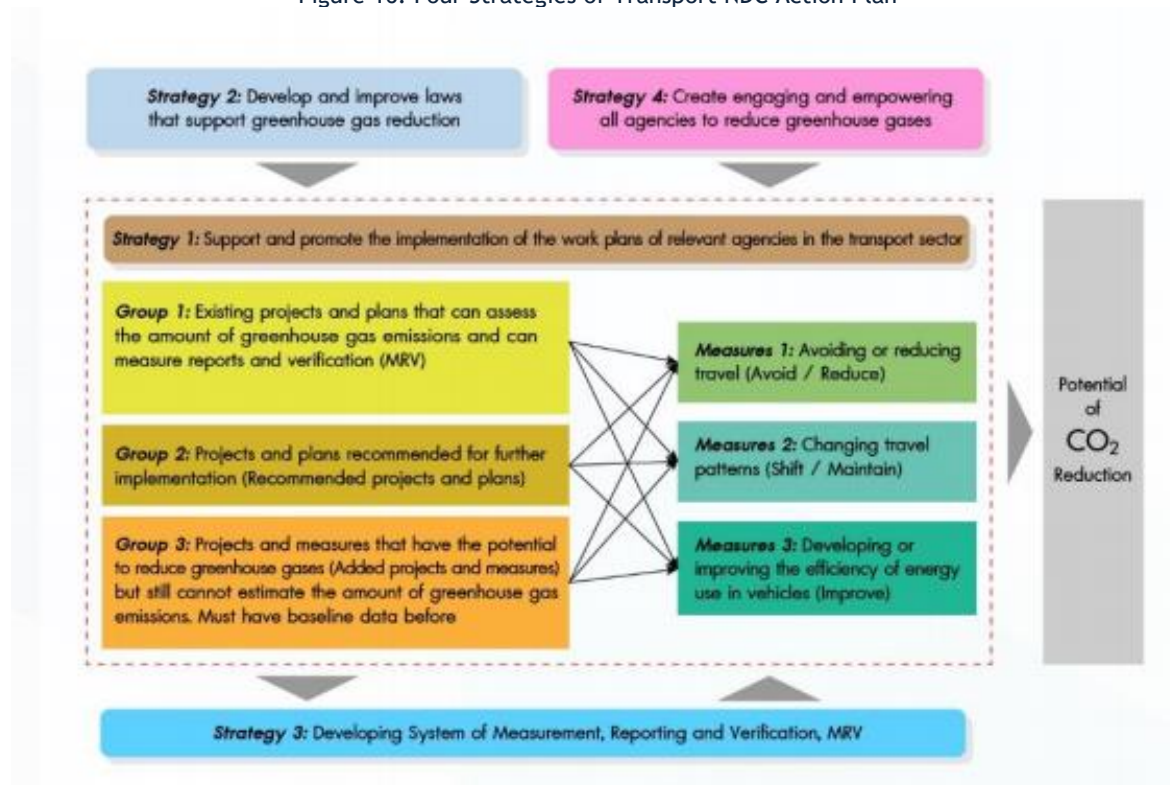
NDC Action Plan for the transport sector

There are four strategies that have been agreed in order to push forward the mitigation target:

1. Supporting and promoting means of implementation within related departments in transport sector, including the identification of 3 groups of measures for implementation by agencies in charge.
2. Developing, improving and adjusting laws and regulations in order to support GHG mitigation by facilitating the implementation of measures.
3. Developing a Measurement, Reporting and Verification (MRV) system to assess and monitor the impact of the implementation.
4. Establishing engagement and capacity building of all departments in GHG mitigation following two main targets: 1) increasing the involvement of relevant agencies in driving measure implementation, and 2) enhancing capacity building for MOT staff.

These four strategies feed into a strategic map to support the identification and delivery of measures to “avoid/ reduce”, “shift/maintain” or ‘improve’ in order to reduce CO₂ emissions.

Figure 16: Four Strategies of Transport NDC Action Plan



Source: OTP,2018

Considering transportation as an important contributor to Thailand's GHG emissions, the country developed an action plan of the Nationally Determined Contribution (NDC) for the Transport Sector. Several measures were identified to achieve the country's NDC targets. The proposed measures for CO₂ reduction in strategy 1 are divided into 3 groups:

Group 1: Existing projects and plans where the amount of GHG emission reduction can be assessed and where the measure, report and verify (MRV) approach can be applied. Group 1 encompasses therefore those measures that being developed in transport plans with secured budget, such as rail network expansion, fuel efficiency improvement by CO₂ emission tax, improvement of BMTA buses etc. The potential GHG reduction potential of Group 1 measures has been assessed to amount to 18.67 MtCO₂.

Group2: Projects and plans recommended for further implementation. Measures in Group 2 complement Group 1 measures. However, these measures have not yet be underpinned by specific transport plans, therefore there is no budget being allocated to measures in Group 2. For example, the development of Non-Motorized Transport (NMT) to connect to public transport network, the improvement of buses in other cities outside Bangkok, the development of Transportation Management System (TMS) is all part of Group 2 measures. The potential GHG reduction under Group 2 is expected to be at 16.74 MtCO₂.

Group 3: Projects and measures that have potential to reduce GHG but do not have a baseline database and therefore lack the assessment of their reduction potential. While the GHG reduction potential measures under Group 1 and 2 can be estimated, measures under Group 3 lack the database for the quantification of their mitigation contribution. Measures in Group 3 include e. g., the development of a common ticket system, establishment of a public transport

fund, and improvement of bus concession conditions. Examples of selected urban public transport measures under the NDC Action Plan that have also been prioritized under the TCMP are summarized in Table 8.

Table 8: Selected Urban Public Transport Measures in the NDC Action Plan included in the TCMP

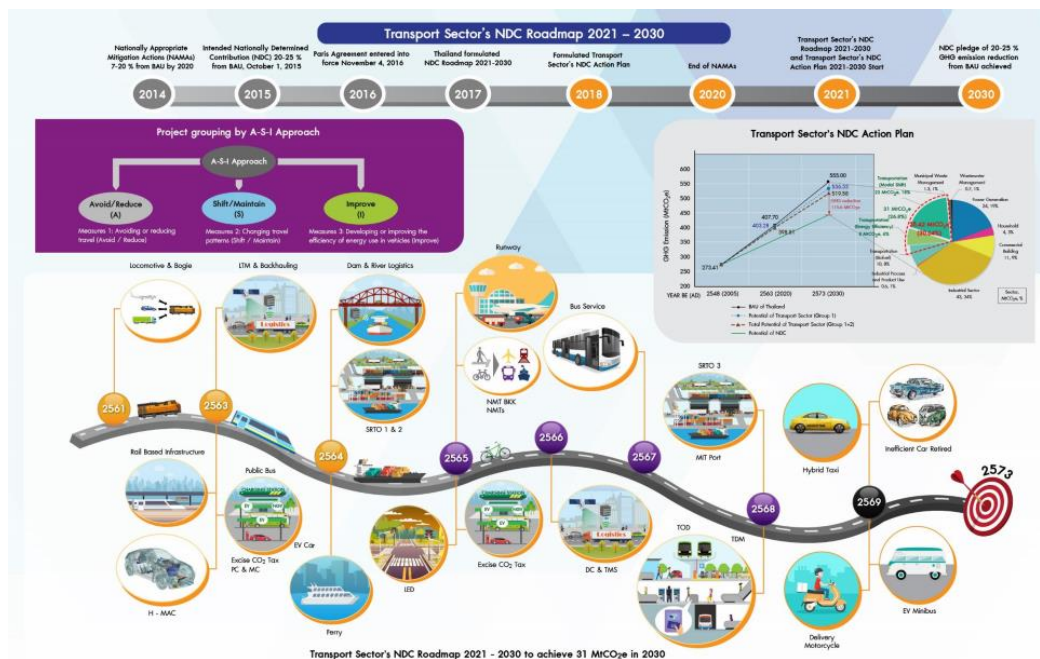
Project/Plan	Duration	Organization	Budget (m THB)	Emission reduction (MtCO ₂)
GROUP 1: Project/ Plan with approved budgets by the government				
Publicly owned public vehicles				
Purchase of 35 EV buses and installation of charging stations	2020-2022 Expected to start test runs in 2022 and collect data of energy consumption	Lead: BMTA Support: OTP, EPPO	571.94	0.0019
Purchase of 1,453 Hybrid buses	2021-2030 Expected to start operation in 2023	Lead: BMTA Support: OTP, DLT, BB	11,624	0.129
Lease of 400 Hybrid buses (7 year)	2020-2030 Expected to start operation in 2023	Lead: BMTA Support: OTP, DLT, BB	4,208.81	0.035
Congestion charge				
Parking charge in congestion areas	2025-2030	Lead: Bangkok, DLT Support: OTP, Traffic officers	100	2
Road charge in congestion areas	2025-2030	Lead: Bangkok, DLT Support: OTP, Traffic officers	500	-
GROUP 2: Project/ Plan required additional funding sources				
Privately owned public vehicles				
Replacement of 4,626 privately-owned vans with EV minibuses	2026-2030	Lead: Private operators on BMTA- sharing routes, EPPO Support: OTP, DLT, Thai Customs	465	0.0279
Encourage public vehicles, taxis, song-thaews to be replaced with hybrid vehicles in BMR and other 6 provinces (Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima, Songkhla)	2026-2030	Lead: Private operators on BMTA-sharing routes, local municipalities Support: DLT	25,130	2.5
Non-motorized Infrastructure				
Promote non-motorized transport (NMT) by improving 140 sidewalks and bike lanes in BMR	2022-2029	Lead: DOH, DRR, Bangkok Support: OTP, Office of the Permanent Secretary	450	2.83
Promote NMT by improving sidewalks and bike lanes in Chiang Mai, Khon Kaen, Phitsanulok, Phuket, Nakhon Ratchasima, Songkhla	2024-2030	Lead: DOH, DRR, local municipalities Support: OTP, Office of the Permanent Secretary	200	0.72

Source: Thailand's NDC action plan for the transport sector (2019)

In the NDC Action Plan for the transport sector, the projects and plans in Group 1 have secured funding from the Ministry of Transport. The projects and plans in Group 2 require additional financing sources yet to be identified. Therefore, the existing plans that cover improvements if the bus fleet owned by the public bus operator Bangkok Mass Transit Authority (BMTA) already have the corresponding budget set aside by the government. The upgrade of privately-owned public vehicles such as vans, taxis, Song-Teaw is not fully funded. However, incorporating privately-

owned vehicles into a fleet modernization plan would be essential because privately-owned public transport vehicles account for the majority of the existing bus fleet. In Bangkok, a majority of the bus fleet operating under BMTA's licenses are actually owned by private sub-licensees. The modernization of these vehicles is not considered in the current NDC plan. Also, the creation of a long-term financing mechanism gives planning and investment security to public as well as private operators.

Figure 17: Transport Sector's NDC Roadmap 2021 - 2030



Source: OTP, 2018

Normally, buses in Thailand are allowed to run for 25 years. Over one-third of the existing fleet (25,500 out of 73,500) has been in use for more than 20 years¹⁷. According to the Department of Land Transport (DLT), the government is developing a bus reform plan, which aims to replace or upgrade 3,000 BMTA buses, 3,000 privately-owned buses, and 4,800 vans. Unfortunately, the bus reform plan does not consider new regulations on the emission standards, which are still based on a EUROII standard introduced in 1995. The lack of new, stringent bus emission standards incentivizes bus and van operators to replace their vehicles with the least costly ones available on the market. The creation of a long-term financing mechanism can (and should) incentivize the uptake of clean technologies. If bus renewal now follows the EUROII Standard only, these buses will be on the road for the next 20 years highly impacting air quality.

Long-Term-Strategy, Net-Zero and Decarbonisation Target

In October 2020, Thailand submitted an updated version of the NDC without increasing the GHG reduction target but laying out the domestic processes to ensure the integration of the NDC target and actions into the National Strategy. Concrete action plans for key sectors' contributions to the NDC target have been further specified, encompassing the energy, transport, industry process, and waste sector. The updated NDC moreover provides detailed information on support needs, categorized into (1) policy implementation, (2) technology development and transfer for mitigation

17 <https://web.dlt.go.th/statistics/>, accessed on the 30th of September 2019.

and adaptation actions, (3) development of mechanisms and instruments to drive effective climate actions and (4) climate information and Monitoring & Evaluation (M&E) systems. In addition, the updated NDC indicates Thailand's plan to formulate Long-term Low Emissions and Development Strategy (LT-LEDS) that will guide the country towards a climate-resilient and low GHG emission development. At the same time, the LT-LEDS will serve as a basis for enhancing subsequent NDCs to be more ambitious.

At COP 26, the Prime Minister announced a new target to reach carbon neutrality by 2050 and zero greenhouse gas emissions by 2065. Moreover, Thailand also set out the ambitious NDC target of 40% GHG emissions reduction by 2030 with international support. In tandem with the EV Roadmap, the National Energy Policy Council (NEPC) approved the National Energy Plan (NEP) to support Thailand in pursuing clean energy and becoming carbon neutral. The approved EV Roadmap and NEP show a positive sign that lays out a solid foundation for decarbonizing the transport sector. For the recent updated NDC, the realization of mitigation ambition requires support to enhance electrification of transport, battery charging technologies and capacity building of relevant stakeholders. These include (1) hard investment in infrastructure and vehicles such as development of public transport electrification for buses, vans, motorcycle taxis, etc and development of charging station infrastructure; and (2) soft investment to improve enabling environment such as strengthening EV market players, creating eco-system for EV auto parts, MRV for transport electrification, financing solutions for EV manufacturers and EV consumers, etc. With international support including financial and technical assistance, Thailand could more effectively implement its mitigation measures, track and report their implementation progress to realistically achieve its pledged target, as well as enhance its mitigation ambition beyond its current 20% target.

EV Roadmap

In 2021, Thailand also announced the EV 30@30 policy with the target of 30% of EVs in the overall domestic vehicle sales by 2030. To reach the EV 30@30 target, the Thai government has assigned the National EV Policy Committee to develop and implement an EV Roadmap, clearly committing to e-mobility as a key measure for NDC and LT-LEDS realization. To promote electromobility in Thailand, the newly established National EV Policy Committee has recently announced a master plan aiming for 100% of the vehicles produced in Thailand to be electric by 2035. The plan also targets 50% of the country's total vehicle production to be EVs by 2030, providing a clear direction for the EV market in Thailand with the car industry being one of the main economic pillars and EV production becoming a strategic industry to be promoted. Linking to this economic development goal, the National EV Roadmap was formulated as the master plan to guide the country's pathway towards electromobility. The EV development is one of the areas covered by the National Energy Plan in formulating the country's Low-term Low-Emissions Development Strategy, which further supports Thailand's NDC as well as energy transition and decarbonization objectives in line with Thailand's announcement at the COP 26 to reach carbon neutrality by 2050 and zero greenhouse gas emissions by 2065 and a new reduction target from 25% to 40% by 2030 with international support.

In February 2022, Thailand's cabinet has approved a package of incentives including tax cuts and subsidies to promote a shift to electric vehicles (EVs) in Southeast Asia's major auto production base. The package includes:

- Subsidies to range between THB 70,000 and THB 150,000 for cars and trucks
- EV motorcycles to get THB 18,000 subsidy
- Proposal would cut excise tax to 2 % from 8 % for cars
- Waive excise tax for trucks
- Reduce import duty by as much as 40 % for completely built cars during 2022-2023

- Waive import duty for key parts of completely knocked down vehicles including battery and traction motors
- Cars priced below THB 2 Million set to get the most benefits

For the import tax reduction, the cabinet approved a package of customs duty and excise tax measures to promote the electric vehicle (EV) industry and reduce carbon dioxide emissions. The cabinet passed a draft ministerial announcement on a reduction in the excise tax rate and customs duty exemption for completely built-up (CBU) units of battery electric vehicles (BEVs). Under the approved measures, BEVs with a retail price of up to THB 2 Million are entitled to a lower import duty of 40%, down from 80%. For BEVs with a retail price of between THB 2-7 Million, import duties dip from 80% to 60%. This reduction is awarded to CBU units only and is expected to cost the government about THB 60 Billion in revenue.

Congestion Charging scheme in Bangkok

Bangkok, like many other cities around the world, is experiencing a variety of traffic related problems that reduce liveability and attractiveness. Major investments in public transportation are being made, but these mostly accommodate the growth of Bangkok and do not reduce current problems. Investing in more car infrastructure may have some short-term benefits but will in the longer term only increase car dependency and all the negative side effects associated with it. So, a central question for Bangkok is how to develop towards a transportation system that is less car dependent and more oriented towards public transportation, walking and cycling. One of the policies that can contribute to the transportation system transformation towards more sustainability and a better integration with energy and emission efficient modes of transport is Congestion Charging. The Congestion Charging introduces a charge for the use of specific roads and/or specific areas within Bangkok, and by doing so, the demand for car trips reduces, lowering congestion, which also benefits bus users, and emissions. Congestion Charging often also generates a revenue stream that can be used to invest in alternative travel options and to compensate for potential negative equity effects. When the use of revenue is not taken into account, the outcomes of Congestion Charging is considered regressive, but when it is, the results can be progressive. The potential congestion reduction for Bangkok, expressed as changes in network speeds within the study area, range from 3% to 13%. PM emission reductions range between 3% and 36% within the investigated scenarios. Even though increasing the use of public transportation was not an explicit objective of Congestion Charging within the pre-feasibility study, it is important to note that the mode shares of public transportation increased for all scenarios. The increases in the mode share ranged from 3% to 25%. This pre-feasibility study did not, however, consider if the public transportation system has the capacity to facilitate these increases in ridership.

2.3 Governance, market organization and relevant stakeholders

The Ministry of Transport (MOT) has direct responsibility to provide both infrastructure and ensure good public transport services to both urban and rural areas across Thailand. Figure 18 presents the key departments within the MOT, with each department focusing on a specific area of responsibility. For example, the Department of Highways is responsible for the planning, design, construction and maintenance of major highways and the motorway network, while the Department of Rural Road (DRR) is responsible for the same tasks but for minor highways and distributor roads. Local authorities such as municipalities, provincial administration organisation are responsible for road network plan, construction and maintenance in urban and rural areas.

Figure 18: Organisation chart Ministry of Transport



Source: GIZ, 2019

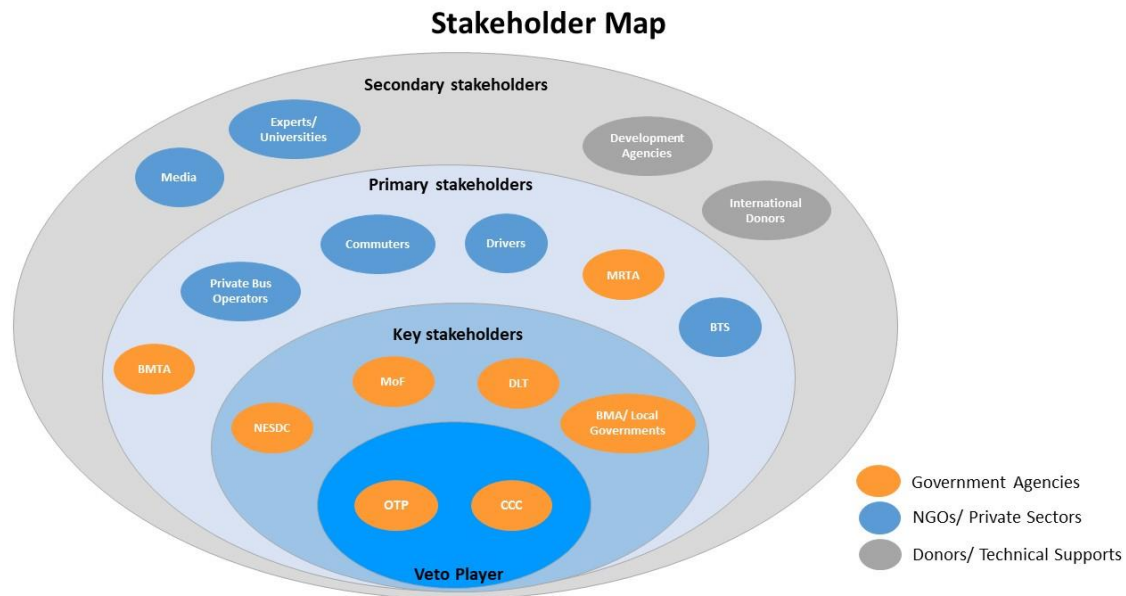
Congestion Charging has been pushed forward by the OTP in combination with the establishment of a clean mobility fund as part of the development of the Thailand Clean Mobility Programme. While the implementation of a Congestion Charging scheme would mainly tackle the reduction of individual car use and the number of cars on the road network in main city areas combined with the shift of travel demand towards means of public transportation, the clean mobility fund would serve as a financing mechanism to use revenue from the Congestion Charging scheme to enhance sustainable transport development.

Figure 19 shows a stakeholder map for congestion charge development and implementation. Stakeholders are divided into 4 groups:

- Veto players: actors whose support and participation are necessary in order to achieve the targeted results of the project or actors who may veto the project.
- Key stakeholders: actors directly involved in the decision-making of the project and who are able to strongly influence the implementation of the project.
- Primary stakeholders: actors directly affected by the implementation of the project;

- Secondary stakeholders: actors that are temporarily or indirectly involved in the implementation of the project.

Figure 19: TCMP Stakeholder Map



Source: GIZ, 2020

Key Stakeholders

Office of Transport and Traffic Policy and Planning (OTP)

OTP is coordinating transport policies and plans as well as coordinating the management of public transport operations. It is OTP's responsibility to prepare transport plans that complement one another and are consistent with broader government policy. However, there is no law or regulation for departments within the MOT or local municipalities or provincial governments to rely on the planning and recommendations of OTP, unless directed to by the Cabinet.

National Committee on Climate Change (NCCC)

The NCCC is led by the Prime Minister, its main roles are to set policies and strategies related to climate change as well as coordinate with international organizations. The NCCC also plays a key role in driving mechanism for climate change by setting measures or approaches, monitoring institutions and implementation, as well as deciding on budget allocation.

Department of Land Transport (DLT)

Under the MOT, the DLT is responsible for the following six key areas of transport delivery:

- Performing duties under land transport law, motor vehicle law, and other relevant laws,
- Improve rail and road safety to bring down the rate of accidents,
- Promote and develop land transport networks,
- Systematize land transport,
- Establish cooperation with other relevant national and international agencies and organizations with regard to the land transport and international conventions and agreements,
- Perform other duties as stipulated by law or delegated by the Cabinet.

The Land Transport Control Board is the regulatory body identified within the Land Transport Act that is responsible for planning and defining fixed route urban public transport services across Thailand. It defines the contractual basis within which bus services are provided, including the setting of fares, determining route alignments, peak vehicle requirement, bus stopping locations as well as other service requirements.

While the DLT is supposed to be responsible for the planning and implementation of public transport services, the Department typically authorizes service providers (either private or government enterprises) to carry out some of these tasks. For example, BMTA (Bangkok Mass Transport Authority) provides bus services within the Bangkok Metropolitan Region, while the TC (the Transport Company) plans and provides intercity bus services.

Ministry of Finance (MOF)

The MOF is responsible for all related fiscal policies/ measures in terms of design, implementation, and monitoring. There are various department under the MOF; the Fiscal Policy Office (FPO) is the main actor who launch and implement new fiscal measures for the country as well as monitor performance of the fiscal policies of other departments, such as new tax, new fiscal mechanism. Another related department is the Comptroller General's Department, responsible for controlling budget of government agencies by monitoring through rules and regulations as well as giving advice related to fiscal budget.

Bangkok Mass Transit Authority (BMTA)

BMTA is the main operator of bus services in Bangkok. As of October 2017, BMTA operated round 2,600 buses, of which almost 1,500 are standard buses and 1,000 are air-conditioned buses. BMTA sub-contracts the operation of some bus services to private operators, which (as of October 2017) operated a total of around 11,400 large and small vehicles. BMTA used to be responsible for managing the private bus operators, however after 2019, this responsibility is being transferred to the DLT, so that BMTA's sole focus is operating bus services.

Local Government

Provincial and municipal governments play a minor role in the preparation of urban transport plans, instead their role centres around obtaining funding for plans that are developed and delivering the plans prepared by other agencies. Local authorities are usually willing to follow transport plans put forward by OTP. The proposed projects in municipal areas will usually be submitted through the Department of Local Authority to the MOI. Funding for transport projects included in the land use and transport plans is received from the MOI and incorporated within the annual budget allocation for the municipality.

When implementing public bus services, usually fixed route and schedule for urban areas outside Bangkok, the Provincial DLT and Land Transport Committee (LTC) are the principal agencies in charge.

Other organisations can also plan and implement public bus or mass transit systems, for instance, Chiang Mai, Phuket or other major municipalities. These municipalities have recognised their own transport issues and have started working on plans to improve their transport networks. Once feasibility studies have been carried out locally with support from Provincial DLT, the proposals are passed on to government for approval for a more detailed design study, if necessary.

All 3 components of the TCMP are driven mainly by the OTP. The OTP in cooperation with GIZ has set up a steering committee together with 3 working groups focusing on the three components of the TCMP, i. e. congestion charge, bus modernisation and clean mobility fund. Main objective of the steering committee together with the 3 working groups is to push forward the development of the TCMP. The committee consists of high-level representatives from key stakeholders, including DLT, MOF, BMA as well as associated participants for special topics. The steering

committee meetings are held two times a year and are led by the OTP director general as a chairman to decide, direct, and give advice to the working groups. The three working groups for each TCMP component compose of key stakeholders related to the topic as listed in Table 9. After the completion of the TCMP, the programme will be integrated into the Level 3 Strategic Plan and proposed to the NCCC for an approval for implementation.

Table 9: Roles and Responsibilities of TCMP key stakeholders

Components	Key Stakeholders	Roles & Responsibilities
Congestion charge (CC)	BMA/ Local governments	- Set up mechanism to implement CC measure - Operate CC measure within the area
	MOF	Govern and monitor financial flow of CC
Bus modernisation	DLT	Design criteria and support for bus operators to change new bus fleet
	BMTA/ Private bus operators	Participate in and support bus modernisation scheme
Clean mobility fund	OTP	Set up mechanism and institution to implement the clean mobility fund
	MOF	Govern and monitor financial flow of the clean mobility fund

Source: Author

2.4 Finance and current business model(s)

Funding transport projects is still mainly focusing on investment of transport infrastructure, including railway, bus stops and lanes etc., but also covers some of the operation costs ranging from rolling stock, maintenance costs etc. Transport service and infrastructure provision across Thailand is centralised under the MOT, however, follows different funding practices depending on the financing purpose as well as the source of the financing.

Central Budget

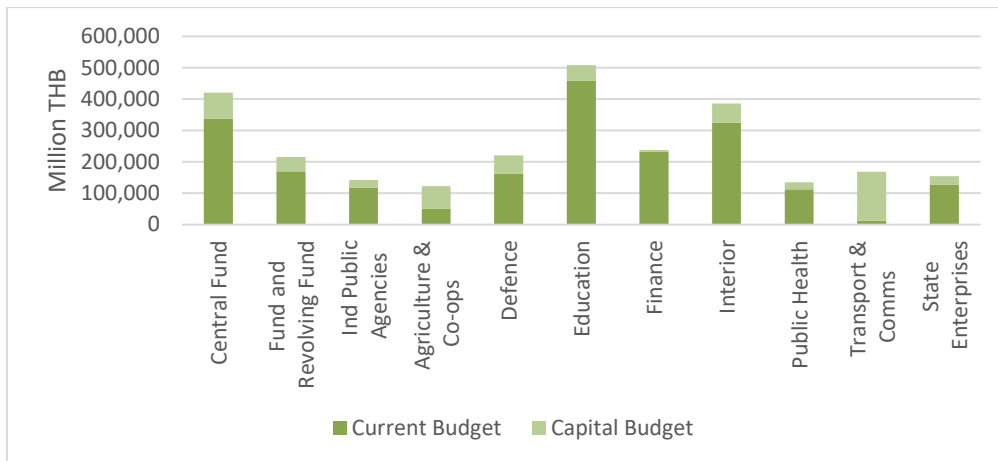
Central government departments play a key role in the funding and delivery of transport networks and services. The central government obtains most of its revenues through taxation and the issuing of bonds and allocates revenue to all departments, of which the MOT is one of the beneficiaries. The central government budget for 2018 was THB 3.04 trillion¹⁸ (approx. EUR 90.7 Billion) of which THB 168.77 Billion (EUR 5.03 Billion) is allocated to the MOT. This accounts for 5.5% of the overall national budget.¹⁹ Figure 20 highlights the funding allocated to government departments receiving more than THB 100 Billion (EUR 2.98 Billion) per year. Transport receives the seventh largest annual funding after the central fund, revolving fund, defence, education,

¹⁸ <http://dataservices.mof.go.th/Dataservices/GovernmentExpenditureEconomyMinistry?language=EN>

¹⁹ By comparison to neighbouring countries, it is notable that in Singapore 12.25% of central government budget is spent on transport whereas in Malaysia 2.8% of the government budget is directed towards transport

finance and MOI. Notably for the Ministry of Transport, 7.25% of its budget is ‘current budget’ whereas over 90% of the budget is ‘capital budget’ to fund the investment in infrastructure. This highlights the focus on investing in transport infrastructure across the Kingdom, but at the same time illustrates its weakness as far as only a minor share is allocated towards operating transport services.

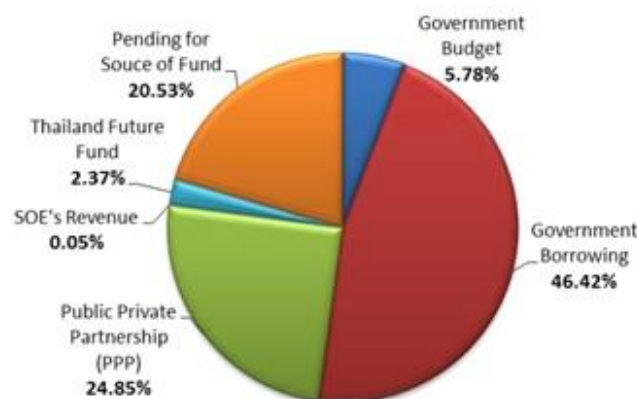
Figure 20: Thai Government Budget in 2018



Source: Ministry of Finance

According to Transport Infrastructure Investment Action Plan in Figure 21 the majority of the central budget has been spent on infrastructure development either on inter-city rail system development or the development of Mass Rail Transit of the M-Map2 in BMR area, while less than 1% were spent on public buses and common ticket development. However, there is not yet official support from the central government for public transport in other cities outside BMR. Local governments of Khon Kean, Phuket, and Chiang Mai for example, have to invest their local budget in the development of the public transport system.

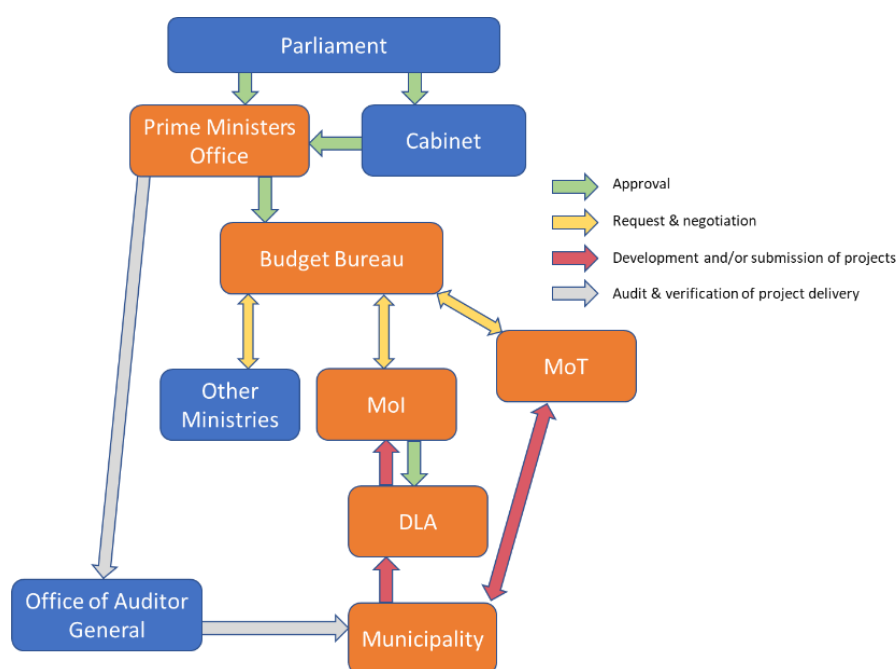
Figure 21: Budget Allocation for the Transportation Infrastructure Investment Action Plan 2018



Source: MOT, 2018

Every year the Bureau of Budget (BB) under the the Prime Minister's Office prepares the transport budget with each transport department of the MOT and MOI. The share of funding dedicated to urban transport is unclear. After thorough discussion between each department and the BB, the BB will discuss the total budget with the Office of the Permanent Secretary of the ministry again and if the total budget exceeds the proposed transport budget initially planned for and received approval from the cabinet by the BB, a round of budget cutting is necessary. At this stage some projects would be taken out or put on pending for cabinet approval again. The criteria for removing projects from the budgeting process is not publicly available, although decisions are likely to be political. This process is shown in Figure 22.

Figure 22: Illustration of decision-making process for transport funding



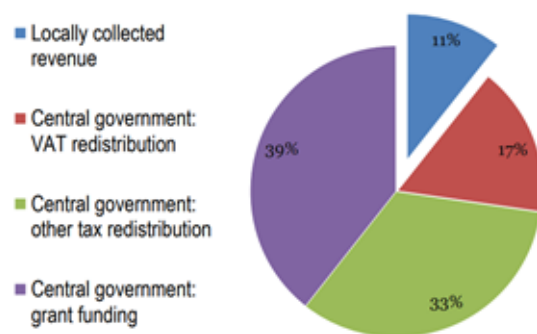
Source: GIZ, 2020

Local Government Budget

The local governments receive revenue from 3 sources:

- 1) **Tax revenue** composed of both shared and local taxes. Subnational authorities can get a share of 1/9th of the VAT collected in its municipality, 10% collected by the state on the specific business tax, 10% collected on excise and alcohol tax, all real estate registrations, and part of mineral and petroleum tax. Along with this shared tax income, local governments collect property and building tax, local development tax, and signage tax depending on language and size of advertisement signages.
- 2) **Grants and subsidies** transferred from the national government to local governments are composed of general operation grants and earmark sectorial grants dedicated to the enhancement of a specific public service provision.
- 3) **Other revenues of local governments** include duties and fees such as the animal slaughtering duty and animal butchering, waste collection fees, as well as driver's licenses, and building permit fees. Figure 23 shows the distribution of local revenue by source in 2016.

Figure 23: Distribution of Local Government Revenue Sources in 2016



Source : FPO, 2016

In addition to tax revenue, local governments receive general operation grants and block sectoral grants dedicated to the improvement of a specific public service obligation. According to the OECD²⁰ 94% of grants are current grants, to cover revenue spending, whereas 6% of grants received by local government are capital grants. It is from these sources of revenue that local governments can fund day to day transport services. However, it is unclear which government departments provide which grants and what share of a municipality's transport budget is made up of grants from the MOT, MOI or other departments.

Considering transport projects of the MOI, the Department of Local Administration (DLA) is responsible for gathering transport projects proposed by the municipality and submitting them to the BB. The transport projects proposed by the municipality, including those projects planned by OTP and DPT as part of the urban transport planning process will be gathered by the office of the Governor and submitted to the DLA. Generally, if the budget is less than THB 50 Million (EUR 1.49 Million), the mayor would assume responsibility and approve the project. If the project is between THB 50-100 Million (EUR 1.49 – 2.98 Million), the Governor is responsible. If it is higher, the Governor and the director of the DLA are responsible. For large (budget > THB 100 Million (EUR 2.98 Million) or extraordinary projects, the proposing organisation would need to discuss the details of the project with the BB.

Aside from funding transport, central and local government benefits from taxation and charges on transport services. The vehicle licence registration fee is collected by DLT each year, and the amount paid depends on the engine size, vehicle type, age, weight, and fuel type. The revenue generated by all existing transport related taxes are allocated to a dedicated area of spending. For example, expressway road tolls are dedicated for the operation and maintenance of existing toll roads and the construction of future toll infrastructure.

Revenue is also generated through fuel taxes. These are levied upon consumers when they purchase fuel for vehicles. Taxes include the excise tax (THB 0.98/litre for gasohol 95 E85, and THB 6.6/litre for unleaded gasoline), which contributes to the general budget, municipality tax collected by each municipality in which petrol stations are located for local developments and range from THB 0.098/litre to THB 0.65/litre and 7% of Value Added Tax (VAT). Two funds have been established that the fuel taxes contribute to:

1. **The Fuel Fund**, used to help stabilize prices during periods of price fluctuations and to subsidize the price of some fuel types such as Gasohol 95 E85.
2. **Energy Conservation Fund** is used for renewable energy promotion in the country.

²⁰<https://www.oecd.org/regional/regional-policy/profile-Thailand.pdf>

In general, fuel taxes are used for generating revenue for general spending with no evident ring fencing of fiscal income for funding transport projects.

The Thai government has been therefore focusing on constructing road and rail infrastructure, with little contribution or subsidy to finance public transport operation. Transport-related public expenditure at the sub-national level in Thailand is difficult to calculate and therefore to aggregate. As land public transport services, including buses, vans and Song-Teaw are normally regulated by the Department of Land Transport, most local governments only perform a minimum of transport-related measures, which involve primarily the maintenance of infrastructure, such as walkways, bus stations and stops, as well as traffic engineering.

The reason for the limited budget of local governments is closely related to the way local government budget is being generated. The two main sources of local governments' income are from central budget and from collection of local levies. The former revenue is allocated in proportion to the people living within the area. Therefore, bigger municipalities always receive more money than smaller ones. As transportation projects are mostly intensive in investment, limited fiscal revenue of medium and small-size local governments restricts their capacity in providing transportation services in their area.

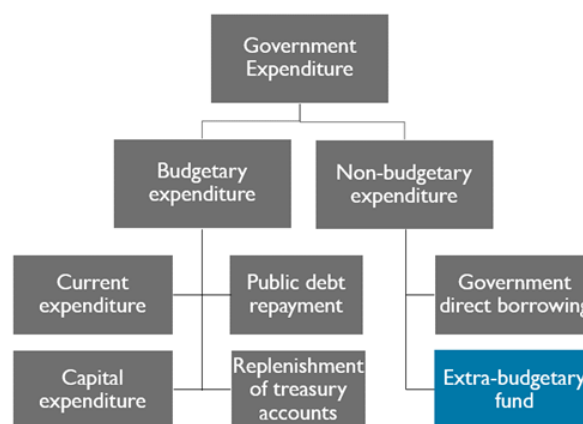
Recently, the private sector has been taking up a more active role in transport infrastructure and service provision, as the Thai government is in favor of Public Private Partnerships (PPP) projects and more initiative approaches such as Thailand Future Fund (TFFIF). However, only profitable projects can attract investment from private investors, while measures that generate low financial benefit and no income such as e. g. bus services and Non-Motorised Transport NMT (bike lanes, walkways, etc.) tend to be neglected.

As public transport services are available only on main routes, NMT plays a key role in first and last mile connectivity. However, the local governments have limited resources to make necessary investment in NMT infrastructure. Only 11% of local government budgets comes from locally collected revenue. Even if local governments have the intention of improving the status of NMT facilities, they do not have the necessary budget authority for such expenditures.

Government Expenditure

There are two options for government agencies to spend their budget, using 1) budgetary expenditure, and 2) non-budgetary expenditure, as shown in Figure 24.

Figure 24: Composition of Government Expenditure



Source: GIZ, 2020

Budgetary expenditure corresponds to the spending of the government under budget appropriation and allocation in each fiscal year. This budgetary spending must be set under the budgetary process laid out in the Annual Budget Expenditure Act.

Non-budgetary expenditure encompasses any other spending outside the fiscal budgetary expenditure designated by law. By definition it is any fund which has been deposited by government offices and organisations with the Ministry of Finance, other than the budget fund, national revenue, any returned excess withdrawn fund, and returned excess withdrawn fund from the previous fiscal year. The non-budgetary expenditure can be further divided into two groups, the government direct borrowing and the extra-budgetary funds.

Government direct borrowing are debts directly created by the central government for specific objectives. According to the Public Debt Management Act, the government can make external borrowings denominated in a foreign currency at a total amount of up to 10% of the annual budgetary appropriation for social and economic development purposes. Such purposes usually involve large infrastructure investments and long-term financing project. For example, loan agreement with the Japan Bank for International Cooperation (JBIC) for the construction of the MRT Purple Line Project.

The extra-budgetary funds (EBFs) or revolving funds refer to funds established for operations permitted to raise revenue for financing their continuing operations. The spending procedure of revolving funds must be based on specific laws. A revolving fund may be funded by national budget or by its own revenue as specified by law. In recent years, due to the limitation of the budget process and the government's increasing need of expenditure, revolving funds have become an important tool for implementing government policies outside the regular budgetary system. Revolving funds are set up for flexibility in policy implementation in order to achieve specific policy objectives. The operation of each fund must be in accordance with government operation through its original affiliation. However, the new State Financial and Fiscal Discipline Act launched in 2018 makes it more difficult for any government agencies to create this kind of fund, as the MOF needs to be stricter on how government agencies spend the money.

Financing of public transport services

While the urban mass rail transit is profitable from charging high fares, the services provide by the government such as the bus service are mostly in deficit, mainly due to imposed price controls leading to a shortfall in revenues as customers pay less than the cost of delivering the service. Price controls can typically have two effects, either excess demand, or shortage of commodity. Regarding bus services in Thailand, excess demand does not seem to be the issue, but the shortage of service supply is, as services cannot be provided in a cost-covering manner.

There are two sides to the equation to assess the economic viability of bus services. Fixed or regulated fares inhibit operators' ability to generate the revenue needed to be profitable or even run their business without losses. At the same time bus services are often inefficiently managed, lacking a streamlined back office and management structure that acts like any other business to maximise revenues and minimise costs. This is also the main reason, why e. g. BMTA is likely to keep making a financial loss and require significant government subsidy to the provision of its services.

In the case of buses under the state-enterprise agency, operating costs are summarised by BMTA as bus operation overheads, administration overheads, other costs and financial costs. The BMTA made a financial loss of THB 4.8 Billion in 2016 (EUR 143.2 Million), which was slightly greater than the loss incurred in 2015 of THB 4.79 Billion (EUR 142.9 Million). Despite the various revenue sources, including significant government subsidy, BMTA continues to make a significant deficit each year, and this makes it difficult for them to modernise the fleet which would require investment.

Finally, it is apparent that bus services are also hampered by factors that are outside of its control. Congestion is a major issue that increases journey times, fuel usage and driver and fare collector costs. One way of supporting bus services in Bangkok, Phuket and elsewhere, would be to provide greater levels of priority over private modes, so that journey times are at least comparable to car journey times. This priority can come in many forms and should be focussed on overcoming the shortcomings faced by buses in specific areas.

Private Sector Engagement

The private sector plays an important role in the funding and delivery of transport projects in Thailand. Private bus operators are involved in the delivery of public transport services under contract to DLT or BMTA. However, they do not play any role in funding transport services, merely operating them and receiving revenue as contractually obliged.

For large infrastructure projects, Public Private Partnerships are encouraged by the Thai government. PPPs are governed by Private Investment in State Undertakings Act 2013, superseding the Public Participation in State Undertakings Act 1992. The Act sets out a framework for the comprehensive planning and quality of PPP projects which includes the development of a PPP policy committee, a PPP fund, a PPP strategic plan and rules on the engagement with experts and consultants.

The PPP Strategic Plan is prepared every five years for the purpose of determining a policy framework around which projects can be delivered. The plan sets government priorities for PPP projects, identifies where investment is required and defines targets and timeframes for the planning and delivery of PPP projects. The purpose of this plan is to encourage participation and investment from the private sector. The plan suggests that allowing the private sector to participate and jointly invest in major infrastructure projects not only helps reduce financial restrictions based on the government budget and decrease the need for government loans, but involving the private sector helps to improve the efficiency of delivering such projects. The current PPP Strategic plan covers the period from 2017 to 2021 and is aligned with the NESDC. Private investment in urban transport is especially promoted in the Development of Urban Rail Transit Lines and Toll Roads in Metropolitan Areas.

National development banks

The Small and Medium Enterprise Development Bank of Thailand acts as a national development bank to support small and medium enterprises to grow and support the Thai economy. The bank aims to support private sector organisations and entrepreneurs, rather than provide funding for large scale projects, mainly covered by international development banks and donor agencies.

Commercial Thai banks play a significant role in financing and investing in projects, often focusing on scrutinising and the financing of PPP initiatives. The PPP process requires a thorough financial investigation with statements of approval from banks and other investors. Most national banks can participate in joint ventures for the bidding of projects, for example, Bangkok Bank is partnering with BTS to invest in the BTS train and will fund most of the land development projects carried out by BTS around stations.

2.5 Related initiatives

Historically, Thailand has received funding from a broad range of donor agencies. However, as the country has developed into an upper middle-income economy according to the World Bank, it receives increasingly less funding from donor agencies. The following provides an overview of donor agencies supporting transport related projects.

World Bank

The World Bank has not funded a transport-related project since 2011 when it provided US\$740,000 (EUR 675,485) towards the Chiang Mai Sustainable Urban Transport Project. Since then, the World Bank has provided little direct funding as Thailand has become an upper middle-income country.

Asian Development Bank (ADB)

The ADB has historically supported Thailand to aid its economic and social development. In the 1980's, ADB supported the country with a loan to upgrade more than 1,200 kilometres of roads. The loan also sought to improve road safety, contribute towards maintenance, as well as other policies needed to sustain a modern national road system.

Since 1966, ADB has invested more than US\$ 6.7 Billion (EUR 6.1 Billion) in 275 loans, grants, and technical assistance projects focused primarily on energy, and transport and communication. ADB has provided no new public sector loans to Thailand since 2010 since it became an upper middle-income country. Instead, ADB has provided policy advice, capacity building, and knowledge support for infrastructure development, social sector reform, financial sector improvement, and regional cooperation. Moreover ADB has been increasingly engaging in private sector development particularly regarding the energy sector including the launch of green bonds with several companies for clean energy.

AFD

Agence Française de Développement supports the Thai government in a number of ways by also providing advice and expertise in transport planning. Between 2016 and 2017, it led workshops and seminars to share knowledge on how to finance transport projects. In 2019 the AFD has started working on technical assistance to accompany the preliminary phases of the envisaged Light Rail Transit (LRT) in Phuket (AFD, 2018).

JICA

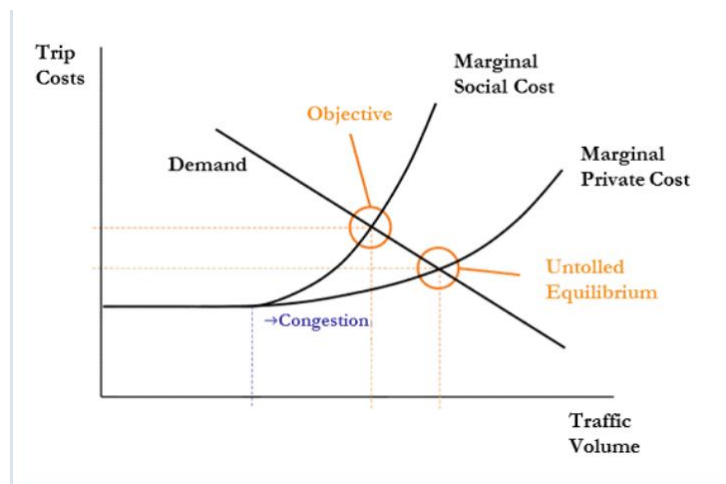
Thailand is now considered by JICA as a non-category country for general grant aid. This is because it is an upper middle-income country. However, JICA provides loans to Thailand for transport projects. JICA has assisted the Thai government in the development of M-MAP of mass rail transit infrastructure in the BMR area, as well as provides funds for the construction of several rail transits lines.

3. Barriers to Congestion Charging in Bangkok

Bangkok, like many other cities around the world, is experiencing a variety of traffic related problems that reduce liveability and attractiveness of the metropolitan agglomeration. Major investments in public transportation are being made, but these mostly accommodate the growth of Bangkok and do not reduce current problems. Investing in more car infrastructure may have some short-term benefits in the longer term but will only increase car dependency and all the negative side effects associated with it. Therefore, the central question for Bangkok is how to develop towards a transportation system that is less car dependent and more oriented towards public transportation, walking and cycling. One of the policies that can contribute to the transportation system transformation towards more sustainability and a better integration with energy and emission efficient modes of transport is congestion charging. Intruding congestion charge in Bangkok could therefore effectively help to mitigate a number of negative effects stemming from excess demand in individual car travel. Congestion charging introduces a charge for the use of specific roads and / or specific areas within Bangkok, and by doing so, the demand for car trips reduces, lowering congestion, which also benefits bus users, and emissions. Congestion charging often also generates a revenue stream that can be used to invest in alternative travel options and to compensate for potential negative equity effects. When the use of revenue is not taken into account, the outcomes of congestion charging is considered regressive, but when it is, the results can be progressive.

The general idea behind congestion charging is each travel decision made has consequences for others imposing externalities and associated costs on other travelers and the overall society. In most transport systems the costs imposed on others are not fully paid for by the individual traveller. Congestion charging is a way to put such costs on drivers. The principle of marginal social cost pricing is displayed graphically below. The vertical axis represents the travel costs while the horizontal axis represents the traffic volume.

Figure 25: Impact of external costs on the demand and supply equilibrium.



Source: ADB and GIZ, 2015

The demand for travel increases when costs decrease and vice versa. This relation is shown by the demand curve. For individual travellers the travel costs can be interpreted as the sum of all costs, such as travel time, fuel costs, parking etc. also referred to as the marginal private cost. Where the demand and the cost curves intersect, the untolled equilibrium is reached. As more travellers enter the system, traffic volumes increase due to excess demand and with constant supply congestion

occurs. This leads to an increase in travel costs mainly resulting from longer travel times due to congestion. The marginal private travel costs do not reflect the external cost imposed on the society as well as other travellers as a result of individual travel choices made by the car driver. The marginal social cost curve however includes these external costs and indicates the cost that each extra vehicle will impose on the driver as well as on the system. The new assumption that all costs would be considered leads to a new equilibrium with a lower overall demand. The objective of congestion charging is to increase the travel costs from the level of untolled equilibrium to the point of optimal equilibrium by imposing a charge. The effects are reduced traffic flows and lower congestion levels.

Barriers to congestion charge are concerns regarding the lack of acceptance among the travellers that will be affected by the measure, weak political will or backing to implement the scheme as well as the overall complexity of the technical and administrative scheme implementation, including the cost of the set-up of the instrument.

Lack of public acceptance

Due to rapid urbanization and economic development Bangkok is experiencing a high rise in travel and transportation demand mainly met by individual motorised transport resulting in negative environmental externalities, i. a. air pollution, GHG emissions and congestion that not only reduce societal well-being, but have severe economic, environmental and climate impacts in the short, mid and long run. Hence, the main behavioural and regulatory barriers are strong car dependency among Bangkok's citizens, the fact that the cost of private car travel does not reflect the societal cost in terms of environmental externalities as well as general lack of an effective regulatory framework to discourage private car use and encourage or incentivize the use of energy and emission efficient modes such as mainly rail based public transportation. The introduction of a Congestion charge in a designated area would internalize the external costs of car travel as well as generate revenue for sustainable transport investment in Thai cities. However, one key barrier to the introduction of congestion charging is public acceptance that needs to be accounted for prior to implementation.

Most congestion charging schemes, if not all, have had to stand at least some public critique. Public opposition is not the same everywhere and the level of opposition typically varies over time. The same distinct dynamic pattern of acceptance development has been observed in implementation processes in several cities. Early in the process, when the discussion is general and the effects of charging are discussed as abstract concepts, there is typically not much formalized opposition from the public. As congestion charging concepts progress towards implementation, more concrete definitions around the scheme design are developed and presented to the public. This may include the definition of the geographical area of charging, toll rates, variance by vehicle type or time of day, etc. The concretisation of the congestion charging will typically make the public worried about negative individual impacts and evoke a vivid public debate. The level of public acceptance will decrease during this phase.

However, after implementation, acceptance will typically increase again. This increase in acceptance can be attributed to a number of factors:

- Travel times improve more than motorists expected,
- Negative consequences (the charge fee or the shift to alternative modes) prove less problematic than what was anticipated, and
- People adapt and accept a new status quo, no longer evaluating it as a “change”.

The acceptance pattern for charging schemes in different European cities revealed in Table 10 (CURACAO, 2009) clearly shows a consistent increase in the level of acceptance over time in all cities although the absolute level of acceptance varies substantially between cities before as well as after implementation.

Table 10: Acceptance of Charging Before and After Implementation in Five European Cities

City	Before	After
Stockholm	21%	67%
Bergen	19%	58%
Oslo	30%	41%
Trondheim	9%	47%
London	39%	54%

Source: GIZ, 2021

Disparities in public transportation, lack of connectivity, and difficulty to access the public transportation in Bangkok

The public transportation system in Bangkok is not inclusive for everyone's conditions in terms of connectivity between modes of transportation, accessibility, and universal design that would address every type of user, as well as affordability of transportation services. To encourage people to shift modes of transportation from private vehicles to public transport, the alternative modes must provide a convenient mobility option that is competitive with private car use. This means the cost should be cheaper than driving a private car, reliable, time manageable. Fares should be sensible when using of public transport services and consistent with the cost of living, lower-income users could afford with enough budget to spend in other parts of living, as well as the overall travel experience should ideally be convenient, from the departure point to destination. But in the Bangkok Metropolitan Region (BMR), people who are living in the suburbs mostly do not have an easy access to public transportation system because public bus services and feeder transport have not been developed where residential areas have sprawled. Therefore, people choose to buy private vehicles and drive into the city instead. Even with ongoing improvements of mass transit, people would still have difficulty accessing the public services due to lack of first-and-last-mile solutions. The reason is that mass transit system in Bangkok is located only along main roads. Without secondary roads or the feeder system, most Bangkok people choose to use private cars instead of mass transits because the existing system is unable to support a door-to-door commute.

The sprawl of Bangkok urbanization

Alleys and secondary roads are not only an issue to public transportation development but also a barrier to implementing the congestion charge scheme. Since the BMR has been growing and extended in residential areas outside the city centre, people have moved to live in the suburbs. Consequently, creating an urban sprawl without proper city planning, roads and alleys had been built, which creates a characteristic of the Bangkok road system where there are deep alleys with a dead-end. Most alleys are usually far from main roads and these small alleys direct toward main roads without secondary roads as the alternative routes, resulting in a superblock city, which is a cause of the current traffic problems. The city's plan issues would be a concern for the congestion charge scheme since this scheme needs designated areas to charge private vehicles driving into high-density areas. But it is difficult for Bangkok city to designate charging zones due to the characteristics of Bangkok city's plan where the city plan has no pattern, alleys and secondary roads are all built up by different authorities and private owners. Also, many alleys and some streets in

Bangkok are owned by the private sector which causes more difficulty for authorities to set up the charging zones. Implementing the congestion charge scheme could cause difficulty in enforcing the law and controlling cars passing on those privately owned alleys. In addition, Bangkok Central Business District (CBD) has no clear boundaries like many other cities, but there is a combination of zones in each neighbourhood area. Many residential areas are located next to commercial areas, meaning that many people who use private vehicles might also live in the target area for a congestion charge zone. However, planning and solving solutions requires sharing of information and cooperation between authorities such as the decision makers involved in public transportation planning, law enforcement authorities, and policymakers. However, cooperation of different authorities is often another major barrier to the congestion charge scheme implementation and also valid in the case of Bangkok.

Integration of institutions and cooperation between authorities

The variety of decisions to be taken in congestion charge planning and implementation usually involves different authorities. In the case of Bangkok various authorities are involving one working scope, for example, to implement the congestion charge scheme, operators, legal, and policy planning authority must integrate to cooperate with each other. Bangkok administration office, police bureau, policymakers, as well as the private sector should work without conflict. But in Bangkok city, not only the public transportation system, but also roads are owned by different authorities e.g., Department of the Highway, the Department of Rural Road, the Bangkok metropolitan administration, and privately owned roads. Each authority has its right on its road. Implementing a congestion charge scheme in a designated zone means the responsible agency needs to have the authorization over each road being part of the charging area and since different roads are under different responsibilities, more than one authority must integrate and cooperate to set up the charging zone as well as enforce the scheme. In legal terms, to enforce law and regulations in the specific case of Bangkok, different authorities also need to be integrated e.g., Police-Traffic department and Civil Service Planning Division, Traffic Division of BMA. However, cross-government cooperation can be a particularly sensitive issue that needs special attention to be properly solved. That is why the integration of institutions must not be overlooked.

Implementation of technology for congestion charge scheme

The efficient congestion charge scheme must come together with an appropriate technological support system. However, using advanced technology means that most likely budget and investment need to be foreseen. There are numerous methods to collect congestion charge revenue, for example, manual toll collection which is the most reliable in the past to enforce people to pay because every car must pass through the gate where there are officers collecting fees. However, this method caused more congestion in peak hours like what has happened in Bangkok's expressways. The paper license is another method that many cities had used to collect congestion or road use charging. Using a paper license comes with low implementation cost, however, it is difficult to control because people could make a fake license while control and enforcement could only be done on random investigation. Electronic charge collection is the most suitable method in the present day. Still, financing and maintenance costs are high, as well as users' and enforcement bodies' familiarity with the technology system might be a concern. In conclusion, the use of camera, detection system or GPS license plate tracking seems as the most suitable solution for Bangkok to charge private vehicles driving into the high-density area. The implementation of the technology will still require from both, enforcement officials and drivers to familiarize and understand the use of the technology. Therefore, the risk is high that lack of transparency and convenience of the congestion charge collection system can easily result in negative criticism and weak public acceptance.. Another issue regarding revenue collection technology refers to users trying to avoid paying the congestion charge. The issue of enforcement is another barrier that authorities must take into critical concern.

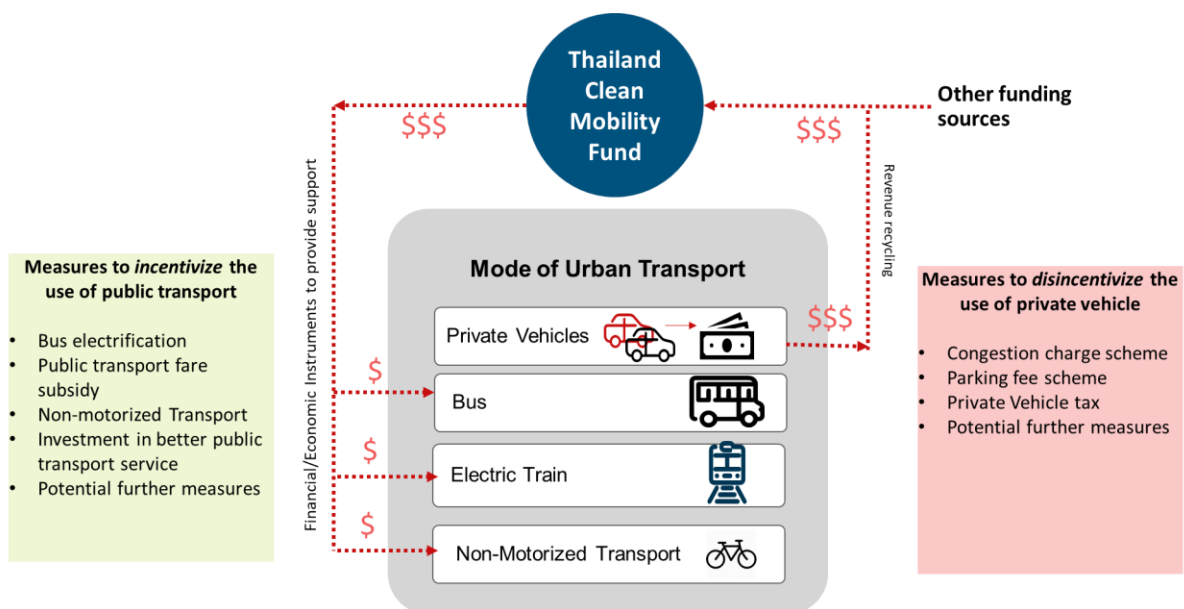
Lastly, privacy and data protection are another principal issues that have to be carefully addressed in the context of congestion charge scheme design and introduction. In Thailand, after the 1st of June 2022, the Personal Data Protection Act (PDPA) enforcement has been introduced. The PDPA aims at increasing the security of personal data, referring in particular to any information relating to a person that enables that person to be identified, for example, phone numbers, household registration, and vehicle license plates. The authorities must obtain their consent and inform the person first before collecting their data. When implementing the congestion charge scheme, data privacy and protection issues need to be ensured. Concerns resulting from the PDPA could easily become a barrier to congestion charge implementation if not adequately addressed and communicated prior to the scheme's introduction. In case data protection could not be properly addressed guaranteeing the protection of privacy data in case of e. g., tracking data, overall acceptance of the congestion charge scheme would be at risk.

4. The Mitigation Action

4.1 Objective and concept

The measure to be introduced is congestion charging, accompanied by the establishment of a clean mobility fund. Both measures are part of the overarching Thailand Clean Mobility Programme (TCMP). The main objective of the TCMP is to mitigate GHG emission and air pollution from urban transport by internalizing part of the actual costs of private vehicle use and at the same time improving public transport modes. Hence, the revenue from the congestion charge will feed into the clean mobility fund to establish a continuous funding source for sustainable urban transport projects in Thai cities – Transport-Finances-Transport. As an overall result, GHG mitigation will be targeted through reduced car travel and increase mass transit ridership (Push and Pull Approach).²¹

Figure 26: Thailand Clean Mobility Programme concept



Source: GIZ, 2020

Congestion charging shall be introduced in an initial pilot area in Bangkok, as the capital city with major importance in terms of percentage of total inhabitants and economy in the country. The scheme can be then replicated to other major cities, as well medium sized cities in Thailand.

Main goals of the introduction of congestion charging in a pilot area in Bangkok together with the establishment of a clean mobility fund are:

1. Reduction of individual car use by shifting travel demand towards public transport.
2. Mitigation of CO₂ / GHG emissions.
3. Reduction of PM_{2.5} levels and overall air pollution in urban areas.

²¹ Experience from other cities shows a reduction of car trips by 20 to 70% and increase public transportation ridership by 20 to 40%.

4. Establishment of a long-term funding source for transport service and infrastructure improvement.

The driving objective behind the introduction of congestion charge in Bangkok is to discourage private car use by at the same time encouraging modal shift to low-carbon modes by public transport system improvement, including the technical study of below approaches;

1. Development of congestion charging scheme
2. Set up of clean mobility fund as an innovative mechanism to support the financing of sustainable transport measures nationwide through the use of the congestion charge revenue
3. Enhancement of sustainable transport through increased low-carbon transport investment.

Table 11: The Mitigation Action at a glance

Contribution to NDC implementation	<ul style="list-style-type: none"> - Reduction of individual car use by shifting travel demand towards public transport - Mitigation of CO₂ / GHG emissions - Reduction of PM_{2.5} levels and overall air pollution in urban areas - Establishment of a long-term funding source for transport service and infrastructure improvement 		
Type of action	National Programme	Subsector	Urban transport - Transport Demand Management (TDM) - Public Transport
Geographical scope	Bangkok Metropolitan Region (BMR)	Type of policy instruments	<u>Regulations:</u> yes <u>Economic instruments:</u> yes <u>Public spending/ investments:</u> yes <u>Communication and information:</u> yes
Organisation	<u>Responsible organization:</u> Office of Transport and Traffic Policy and Planning (OTP) <u>Involved national partners:</u> Bangkok Metropolitan Administration (BMA), Department of Land Transport (DLT), Local governments, Ministry of Finance (MOF)		
Main mitigation measures	(1) Congestion charge (2) Clean mobility fund		
Schedule	<u>Phase 1:</u> Preparation <u>Phase 2:</u> Establishment of framework conditions, pilot-testing, evaluation and communication <u>Phase 3:</u> Full scale implementation		
GHG mitigation effect and other benefits	<u>GHG mitigation:</u> 3.4 MtCO _{2e} between 2027 and 2037; average annual mitigation 0.34 MtCO _{2e}		

	Other benefits: Shift of private car use to public transportation, reduction in overall congestion and related externalities, reduction in local air pollutants and noise emissions, positive economic impact on individual and social welfare, establishment of a constant financing source for sustainable mobility investment
Type of required support	<u>Technical support:</u> <ol style="list-style-type: none"> 1. Technical study on the development and implementation of congestion charge in Bangkok 2. Recommendations on the legal, institutional, administrative and financial set-up of a clean mobility fund <u>Financial support:</u> <ol style="list-style-type: none"> 1. Introduction, deployment and maintenance of a congestion charge system in Bangkok (selected areas)

Source: GIZ, 2019

As Thailand currently lacks sources of money to enhance low-carbon transport, the revenue from the congestion charging together with the establishment of the clean mobility fund will be the financing mechanism dedicated mainly to sustainable urban transport projects. The establishment of the clean mobility fund is an innovative mechanism that allows city to develop its own sustainable measures for the locals, in contrast to the original pattern which are decided by the central government only.

Also, the secured source of fund from the congestion charge will ensure that sustainable transport projects can run in the long-term instead of the conventional project-based approach. This mechanism also creates fairness in that it takes money from the drivers who impose negative externalities on the community, and redistributes this revenue to support transport and mobility system related improvements to benefit the overall society. In addition, the shift towards public transportation is sustainable and comes with environmental and societal benefits by disincentivise the use of private vehicles.

4.2 Scope and the cause-impact chain of congestion charging, the CMF and the TCMP

While the overall objective of the TCMP is to encourage people to shift from private vehicles to rely on public transport and low-carbon mobility, the congestion charge measures will discourage people from using private cars by collecting money when entering the specific zone. The revenue from the road user charging scheme will be then allocated to foster public transport service improvement such as bus modernization, fare reduction, etc. as well as low-carbon modes such as NMT, in order to attract and motivate an increasing number of people to use sustainable mobility modes.

Congestion Charging

Bangkok, like many cities around the world is struggling with its growth that comes along with several challenges, including the transportation system. Congestion, poor air quality, and traffic safety issues are substantial and not easily solved. Different cities have introduced congestion charging to deal with these issues in a successful way. Congestion charging has been able to reduce congestion levels, emissions, and crashes substantially in cities like London, Stockholm, Milan and Singapore.

In a pre-feasibility study conducted in cooperation between the Office of Transport and Traffic Policy and Planning (OTP) and GIZ, seven different policy scenarios were examined with varying charging levels to see what kind of congestion charging zone could work for Bangkok and what kind of traffic, environmental, and equity effects could be achieved. The seven scenarios range in size and in pricing principles (cordon versus area charge). The study found that introducing congestion charging in Bangkok has a large potential to reduce congestion and emissions. The density of the road network in Bangkok makes finding a suitable congestion charging zones a challenge. Larger zones, with less rerouting options may be more effective than smaller zones but will likely come with the downside of increased traffic within the charging zone.

The potential congestion reduction for Bangkok, measured as change in network speeds within the study area, range from 3% to 13%. PM emission reduction ranges between 1% and 17% depending on the congestion zone and scenario selection. Also, the mode share of public transportation use increased for all scenarios, ranging from 3% to 25%.

Low-income households will be affected more by the congestion charges and are likely to experience less benefits from travel time savings. This is a concern that will need to be addressed in further development of congestion charging policies but not necessarily problematic as the use of revenues can enhance the equity outcomes of the scheme.

The gross revenues depending on the scenario considered in the pre-feasibility study range from THB 6 to 40 Billion (EUR 0.19 to 1.3 Billion) annually. The net revenue needs to be determined as different scenarios have different investment and operating costs. Still, the infrastructure funding potential is significant.

Finding the most appropriate zone definition, price level and potential price differentiation for Bangkok will require detailed assessment. One recommendation from the pre-feasibility study was therefore to proceed with the scheme assessment and development process by engaging additional stakeholders beyond the public sector, to also further explore political and user acceptance. Congestion charging could be therefore an important part of a sustainable transition and development of a comprehensive transportation network in Bangkok, where next steps in the development of the policy will require a sound policy design, technical set-up, legal and institutional embedding and establishment of a comprehensive communication and public outreach strategy.

Clean MobilityFund

The examining of national vs. local budget spending towards the transport sector reveals the shortcoming of national budget strongly focusing on infrastructure development, such as construction of mass rapid transit systems, and local budgets being often limited by the fiscal dependency of local governments. Therefore, improvements in bus transit and NMT, the sub-sectors mostly put under the authority of local government, tend to encounter challenges in terms of financing. For rail-based mass rapid transit, the barrier mainly exists on the demand side. There is no significant difficulty in funding infrastructure, which is usually financed through public-private-partnerships (PPP), but the fare level is too high to be affordable to the majority of the citizens because of the uncertainty of demand risk that the operators need to account for in their pricing models. To increase the use of mass rapid transit, additional resources are required to mitigate the demand risk and to allow ticket fares to be cut down. Transport Demand Management (TDM) measures such as the congestion charge can further contribute to shift commuters to public transport, hence, further reduce the demand risk.

For bus transit, the financing barriers are related to both the demand and supply side. On one hand, bus fares have been fixed and regulated at an unsustainable level which largely leads to the incapability of bus operators in accumulating sufficient revenues to keep the business running and

to make investment in upgrading their services. On the other hand, even if some operators are either willing or forced to seek finance for investment, they usually fail to find any funding providers, because of limited capital and lack of profitability. While keeping fares low is essential to make transit affordable to many citizens, financial support is needed to make bus transit an attractive alternative to individual motorized transport.

In terms of NMT facilities, such as bike lanes, parking facilities and sidewalks, which are usually financed by limited local budget, the barrier resides in the lack of available sources of funds. Besides, due to its nature of non-existing revenue streams, it is also difficult to attract private investment to develop or upgrade the corresponding infrastructures. A dedicated public funding stream for NMT will both, allow for NMT infrastructure to be financed and raise local awareness on the importance of NMT infrastructure for a functioning public transport network.

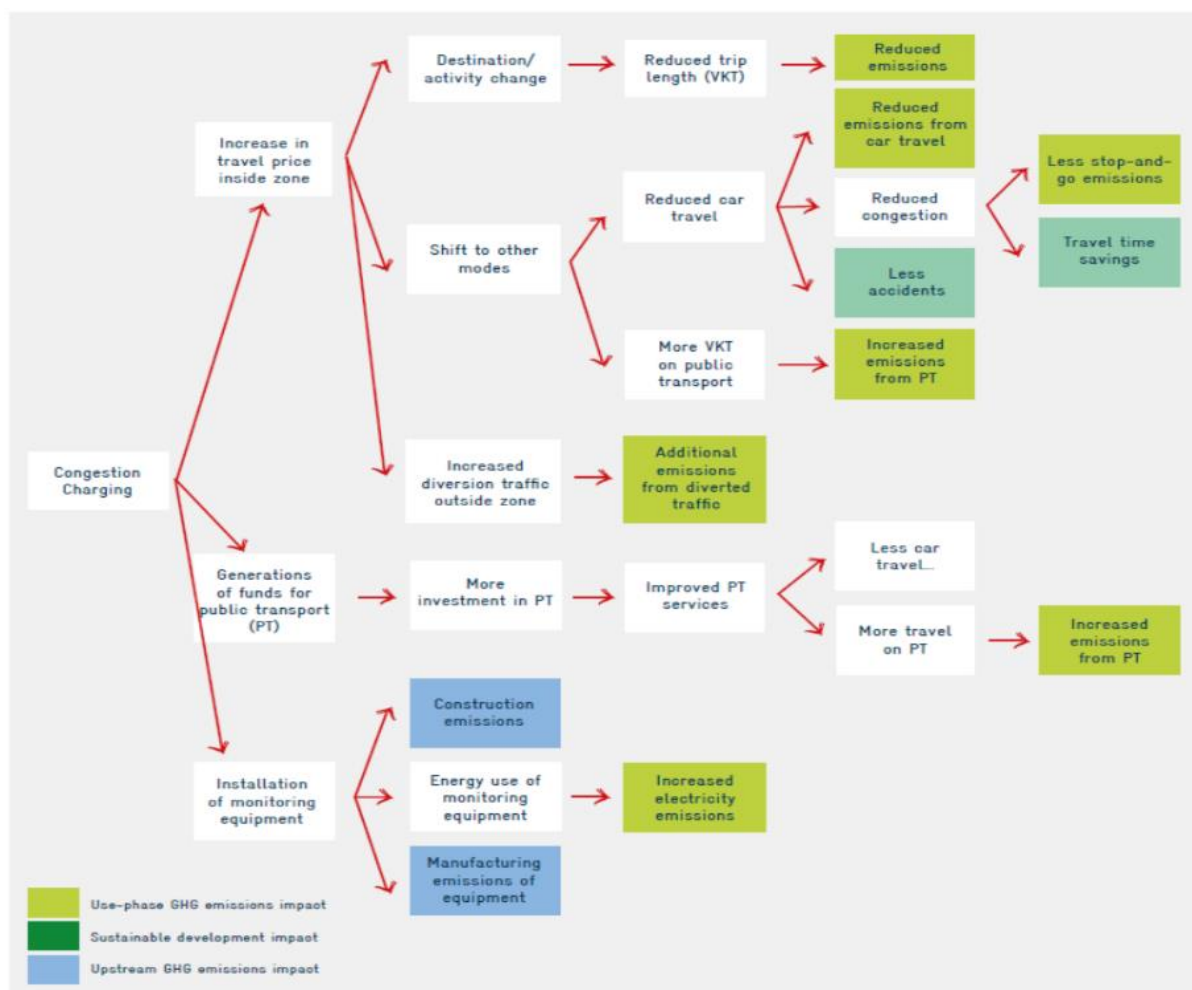
The results of the congestions charge analysis for Bangkok have shown that depending on the implemented scenario the scheme could generate annual revenues of THB 5.9-39.0 Billion (EUR 0.2 – 1.2 Billion), while at the same time generate significant positive economic and social impact, being both financially and economically feasible.

For setting-up a financial mechanism for sustainable transport measures which can be economically viable but not financially attractive to private investors, an approach within the public finance framework has been emphasised. The analysis found that the most suitable financial mechanism for congestion charging revenue collection and reallocation to promote sustainable urban transport in Thailand is to establish a revolving fund, the clean mobility fund (CMF), with its own revenue recycled from the congestion charge or potentially other charges, levies, or fees collected from people's purchase or use of private vehicles. Advantages of this approach include:

- Approach finances itself and no need for government expenditure (transport-finances-transport),
- Follows the polluter-pays principle, which contributes to social equity and eases public communication,
- High flexibility and ability to answer to local specific situations,
- Reduction of transaction costs for the national government as more responsibility is transferred to the local level,
- Awareness raising within city administrations through the creation of a dedicated fund for a sustainable transport development purpose,
- Enhances capacity building within local administrations enabling city governments to plan and implement Sustainable Urban Transport (SUT) projects,
- Generates double impact of congestion charge with revenue generation for SUT project financing and demand increase for public transport use.

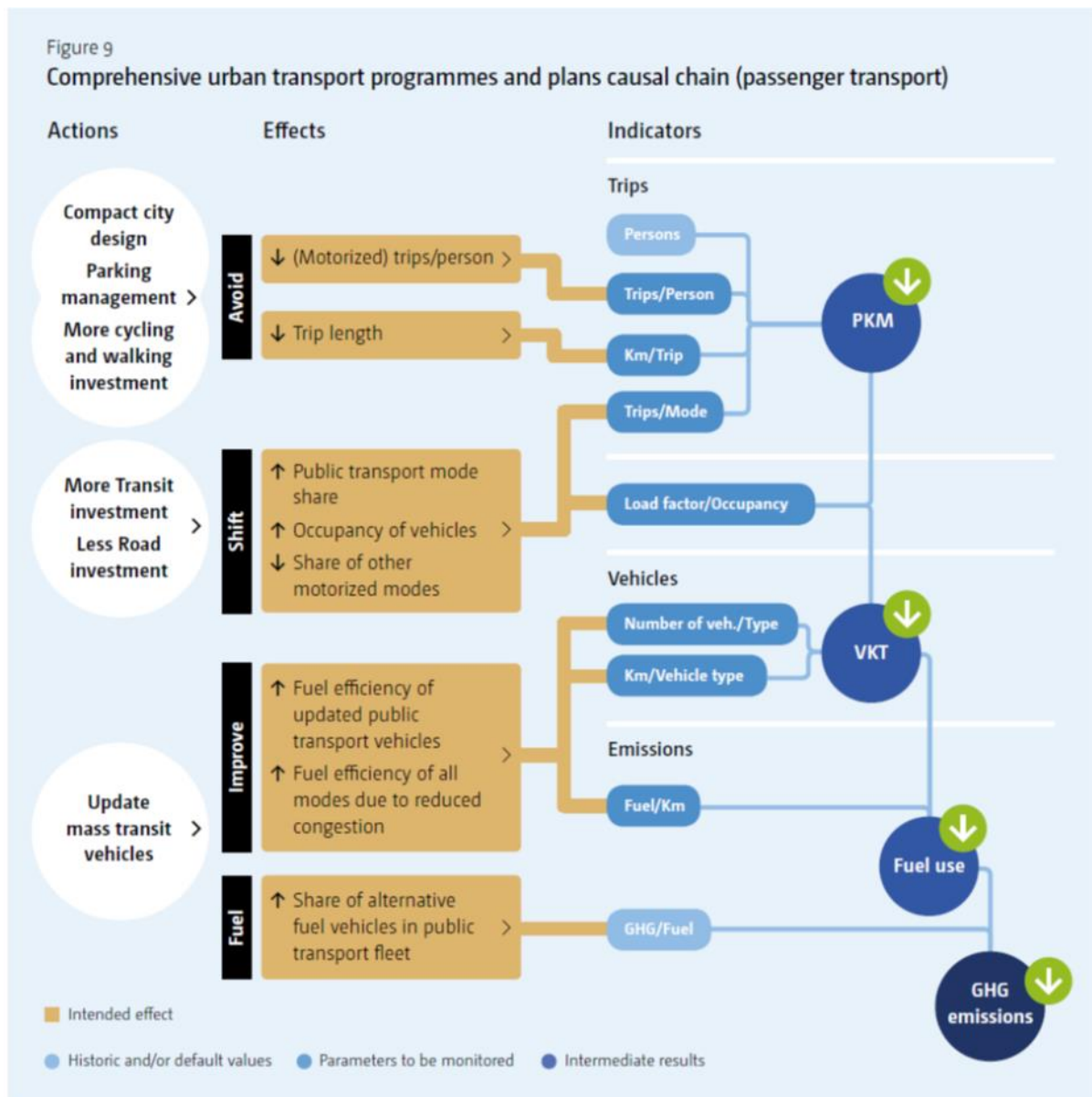
Regarding the impact-chain of the TCMP approach with its main pillars being the congestion charging scheme and CMF establishment, the conceptual logic refers to the fund for revenue collection from the measures that disincentivize people from using private vehicles, such as the congestion charge scheme or parking fees etc., while these revenues are destined for enhancement and support of SUT measures that incentivize people to use public and non-motorized transport. As the fund has the aim to support various Thai cities, it is suggested that it is set up at a national level with OTP acting as the secretariat of the fund. In case that the congestion charge in Bangkok is chosen as the primary revenue source for the fund, it is recommended to feed back/ reserve a certain percentage of revenues for the city to compensate for the comparatively higher burden in revenue collection. Figures 27 and 28 summarise the impact-chain of the TCMP with the corresponding key instruments.

Figure 27: Impact-chain of the congestion charging scheme for the TCMP



Source: GLZ, 2019

Figure 28: Impact-chain of other possible urban transport measures for TCMP



Source: GIZ, 2019

4.3 GHG mitigation actions (direct mitigation measures)

Thailand has on average 275 cars per 1,000 inhabitants, with higher rates within urban areas such as the capital city with a rate of 646 cars per 1,000 individuals. This problem leads to traffic congestion as well as environmental problems e.g., air pollution and GHG emissions. As the number of vehicles has been continuously increasing over the past decade, there is a need to limit the number of cars on the roads especially in urban areas.

It is relatively low costs for people to use private modes of transport in Thailand, because infrastructure (road network) is funded by the government and the existing fuel subsidy keeps fuel prices comparatively low, rendering the car use related operational cost low compared to e. g. public transit use. With relatively low private car use costs, shift to the less convenient public transport is not very appealing and therefore difficult to induce.

Road user charging is a TDM measure that has the potential to discourage drivers from using private vehicles, focusing on particularly congested areas in the city centre or business districts. An initial study was conducted for Bangkok inner districts, identifying seven scenarios within congested areas. The study also divides charging fee into three prices, which generate different levels of revenue and environmental benefits.

Table 12: Estimated benefits from congestion charge in Bangkok

Scenrio	Charge level (Bath/time)	Vehicle kilometres travelled reduction (Million kilometers/year)	Gross rvenues (Million Baht/year)	CO ₂ emissions (tonnes/year)	Charge in consumer surplus (Million Baht /year)
1	50	0.21	5,906	209,750	-116
	80	-0.07	7,639	193,453	-418
	120	-0.27	8,547	184,007	-832
2	50	3.33	8,273	108,643	647
	80	3.35	11,542	110,603	-24
	120	3.22	14,807	101,815	-1,006
3	50	3.74	8,273	146,560	647
	80	3.89	11,542	149,520	-24
	120	3.87	14,807	141,696	-1,006
4	50	16.46	20,027	109,159	863
	80	23.80	29,922	312,405	617
	120	31.69	41,611	658,293	-128
5	80	3.43	21,688	166,558	-973
6	80	4.09	24,115	193,775	-1,066
	120	4.42	32,836	214,439	-2,681
7	80	16.62	29,199	344,251	-243
	120	20.62	39,388	615,098	-1,533

Source: GIZ, 2019

Table 12 exhibits benefit from the different modelling scenarios of congestion charging scheme implementation in Bangkok. Apart from a financial benefit in terms of revenue, the introduction of congestion charging in selected zones in Bangkok would lead to associated climate, environmental and socioeconomic benefits, including:

- CO₂ Emission Reduction

The congestion charge is estimated to reduce CO₂ emissions from reduction of cars usage ranging from 0.5-3.4% per year or equivalent to 101 ktCO₂ per year to 658 ktCO₂ per year.

- PM Emission Reduction

The congestion charge is estimated to reduce PM emissions from reduction of cars usage ranging from 1.7-31% per year or equivalent to 478 to 8,976 tonnes per year.

- Mitigation of congestion

Congestion mitigation shows a substantial socioeconomic benefit. The benefit is calculated based on value of time. The in-vehicle travel time reduction is assumed based on average congestion charge modelling results of each charging level of given scenarios for all years. This analysis yields a socioeconomic benefit of up to THB 41 Billion (EUR 1.24 Billion) for the first year of operation of the congestion charge (GIZ, 2020).

- Accident Reduction

Road accident has been a chronic problem for Thailand's transportation sector for a long time. The congestion charge could help to reduce the number of road accidents by shifting commuters from private car to public transportation, with an estimated positive economic impact ranging from THB 0.2 to 100 Billion (EUR 5.8 Million to 2.9 Billion) per year (GIZ, 2020). The results are calculated based on mode shift assumptions from private vehicle to public transportation leading to an equivalent reduction in car insurance spending. Annual expenditures on car insurance is assumed to be THB 6,570/year/vehicle.

The clean mobility fund aims to support various types of sustainable transport measures, all leading to additional direct and indirect GHG emissions reduction and encompassing the following modes:

- Public Transport
 - City bus / Van / Song-Teaw modernization through replacement of old vehicles with low-carbon or zero-emission vehicles (e. g. EVs)
 - Operational subsidies to bus companies to improve service levels
 - Low carbon first-and-last mile public transport schemes (e. g. electric Tuk-Tuk and motorcycle shuttles)
 - Implementing designated public transport lanes
- Mass Rapid Transit
 - Subsidies to reduce fares for selected traveller groups
- Non-motorized transport
 - Widening of sidewalks
 - Creation of designated cycling lanes and bicycle parking facilities
 - Introduction of city bike sharing services
- Motorized individual transport
 - Subsidies for fleet electrification (delivery fleets, taxi fleets, company fleets) and public charging infrastructure build-up
 - Enhancement of car-sharing services

In the initial phase of the development of the fund, three measures have been prioritised as most urgent need for intervention, i. e. bus modernisation, public transport fare subsidy, and enhancement of NMT.

4.4 Support actions

Congestion charging is often considered controversial, and it is a substantial system change that can have a profound effect on the transportation system. This almost always implies that multiple stakeholders need to be involved and their objectives and constraints need to be weighed and balanced. In most cases, these stakeholders have limited knowledge about congestion charging or traffic flow theory, and as a result, they have limited insights into the effects different policy scenarios may have. This is the field of expertise for transportation planners and modellers.

Therefore, in terms of support actions, enabling framework conditions as well as capacity development are crucial to focus on connecting decision makers with planners so that the political objectives and constraints find their way into policy scenarios and that resulting traffic, environmental and economic effects are discussed and taken into account in the policy design and implementation process. In order to test different scenarios, transportation modeling is used to forecast the traffic, economic and emissions effects and provide the evidence for sound policy making and congestion charging scheme introduction.

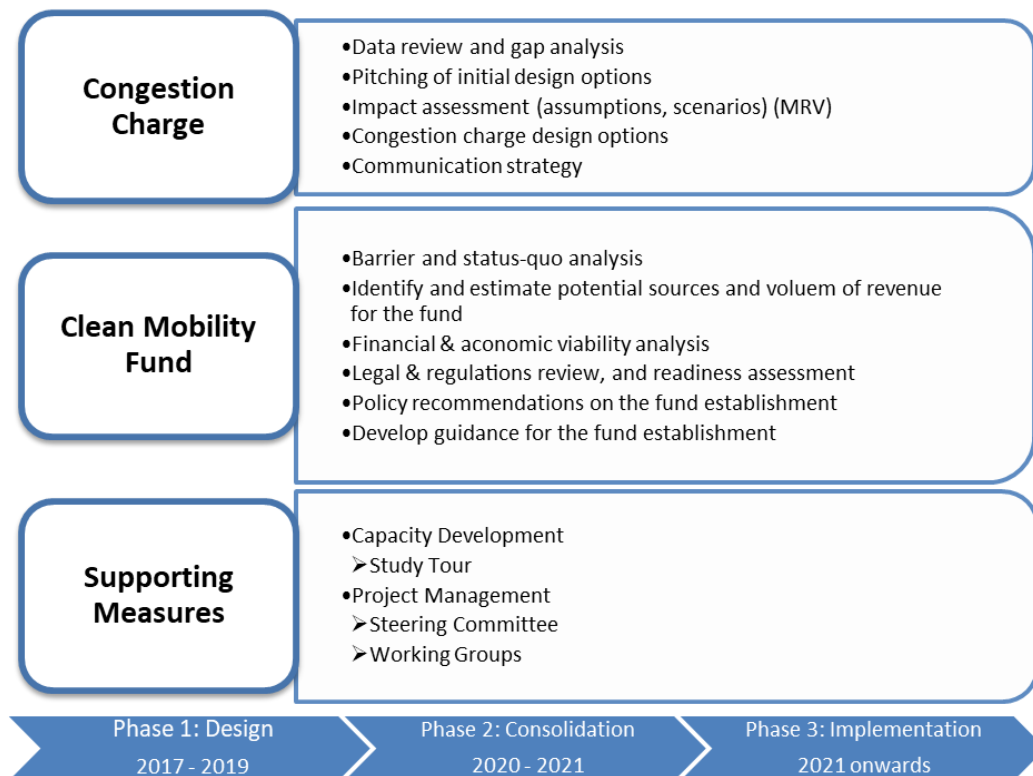
The establishment of the clean mobility fund dedicated to support sustainable transport system development is an innovative mechanism compared to conventional ways of how transport projects in Thailand are currently financed. Therefore, support actions and capacity development are needed to meet in particular the legal and institutional requirements of the fund establishment and to ensure the concrete implementation of the financing mechanism, with a focus on collection and redistribution of the congestion charging revenue.

Legal framework

One main challenge of the establishing a congestion charging scheme refers to the legal framework requirements. According to Thai law all taxes or fees collected by any government agencies should be returned to the central government. However, the mechanism that should ideally be applied to congestion charge revenue collection should transfer the revenue to local governments for further reallocation to beneficiaries related to sustainable mobility such as public transport subsidy. The clean mobility fund would therefore introduce a new approach for transport project financing in Thailand, as it aims to use the revenue from the congestion charge scheme to support sustainable transport development. However, since the Fiscal Discipline introduced in 2018 restricts the earmarking of any kind of revenue an adjustment in the regulation framework would be necessary to allow for dedicating congestion charge revenue to feed into the clean mobility fund.

Key support actions required to accomplish the development and introduction of congestion charging in Bangkok together with the clean mobility fund from revenue collection and redistribution to sustainable mobility development would mainly encompass the creation of legal and institution framework conditions as well as capacity development for sustaining the impact of the intervention measure. Figure 29 provides an overview of the support measures as identified from the initiation of the TCMP.

Figure 29: Support actions to the introduction of congestion charging and the clean mobility fund establishment within the Thailand Clean Mobility Programme (TCMP)



Source: GIZ, 2020

4.5 Implementation arrangements

Public transport in most countries in the world is heavily subsidized to provide sufficient service levels to commuters and make public transport an attractive alternative to individual motorized modes. In Thailand, public transport operators do not receive subsidies for operation. At the same time, for social equity reasons, tariffs are fixed. While this is an important measure to support lower income groups, it also puts operators in a difficult financial position to improve their fleets and services and to transition towards clean technology and convenient service levels through investing in frequency increases, reliability etc. and to finally attract more ridership. If Thai cities want to reduce congestion and improve urban air quality by shifting trips from private to public modes and investing in clean technologies, effective TDM measures such as congestion charging as well as additional funding are needed. With the implementation of congestion charging and the establishment of the fund, use of public transport will be made more attractive with the support from an additional financing generated based on the introduction of congestion charging. Overall improvements will include fare subsidies, technology upgrades, introduction of additional capacities, provision of first-and-last mile services, smart information systems, improvements of walkability and cyclability for the last mile etc.

While the fund can have different funding sources, the main share should come from a congestion charge in Bangkok. Based on initial assessments, a congestion charge introduced in a selected area in Bangkok can generate up to THB 41 Billion (EUR 1.24 Billion) annually as revenue that can be fed into the fund.

The congestion charge has additional benefits for urban transport. It internalizes external societal and environmental costs of driving a car according to the polluter pays principle, including the cost of e. g., additional fuel use, waste of time, road maintenance, air pollution and health deterioration. Car travel becomes therefore more expensive and can incentivize commuters to shift trips from the car or motorcycle to bus and train. In turn, ridership and revenue of the public transport operators is increased and can be used to improve service levels and technology. The congestion charge also frees up road space to make public transport faster and more attractive. A self-reinforcing virtuous cycle towards more attractive public transport is created.

Key players and responsible entities

The public agencies that have duties/ responsibilities related to the public transportation measures and projects in Thailand are:

- **The Office of Transport and Traffic Policy and Planning** - construct a policy framework for national transport and traffic policy, plan, measure, and standard development
- **Department of Land Transport** - promote and develop land transport system networks
- **Department of Rail Transport** - promote and develop rail transport system networks
- **Marine Department** - promote and develop water transport system networks
- **Local government/ Municipality** - provide transportation services and mass transportation systems in local municipality area
- **Bangkok Metropolitan Administration** - provide transportation services and mass transportation systems for Bangkok area

For the introduction and set-up of the congestion charge and clean mobility fund a new institutional and organisational structure would have to be established that would encompass the following roles and responsibilities within the corresponding stakeholders.

The role of the Secretariat would lie within the OTP with its technical expertise in the transport sector. Main responsibility of the secretariat is to gather proposals and select suitable projects to be approved by the Board of Committee, advising on technical aspects, organizing meetings, documentations, as well as helping coordinate with related agencies to facilitate the projects' implementation.

A CMF Office would serve as the implementing body of the clean mobility fund and will be responsible for day-to-day operation of the programmes under the TCMP acting as a focal point for other parties to contact regarding information about the fund. The CMF office will be also responsible for operating the projects carried out under the TCMP and with financial assistance from the fund, including the establishment and implementation of MRV activities to monitor the impact from each project activity. The management and operation of the CMF should be governed by the CMF management framework and regulations approved by the board of committee of the CMF.

The local government plays an important role in driving the congestion charge and clean mobility fund implementation. The local authorities would be likewise responsible for the establishment and implementation of MRV of the congestion charge scheme, in consultation with OTP and the TCMP office.

Management Structure of the CMF

The coordination and management structure to introduce and steer congestion charging and the clean mobility fund within the TCMP shall include the following bodies.

Board of Committee is governing body of the fund. The chairman is the permanent secretary of the MOT with OTP as secretariat together with various members from related agencies. Its role is to provide guidance on strategic level of the fund. The various cross-sector members might consist of representatives from:

- Ministry of Transport:
 - Office of Transport and Traffic Policy and Planning.
 - Department of Land Transport.
 - Department of Rail Transport.
 - Department of Highways.
 - Department of Rural Roads.
- Ministry of Finance:
 - Fiscal Policy Office.
 - Comptroller General's Department.
- Ministry of Energy:
 - Department of Alternative Energy Development and Efficiency.
 - Energy Policy and Planning Office.
- Local Government:
 - Local Administration Office.
 - Bangkok Metropolitan Administration.
- National Strategy:
 - Office of the National Economic and Social Development Council.
- Experts:
 - Public transport experts.
 - Economists.

The CMF committee will be established as the governing body of the fund, composing of 15-20 members from the relevant agencies including transport experts and economists who can provide professional advice on the management of the fund and the planning of sub-programs under the fund to support the prioritised measures. The management committee of TCMF will include:

- Permanent secretariat of Ministry of Transport as the president of TCMF board of committee,
- A representative from Department of Land Transport as a committee,
- A representative from Department of Rail Transport as a committee,
- A representative from Marine Department as a committee,
- A representative from Department of Highways as a committee,
- A representative from Department of Rural Roads as a committee,
- A representative from the Office of the National Economic and Social Development Council as a committee,
- A representative from Fiscal Policy Office as a committee,
- A representative from Comptroller General's Department as a committee,
- A representative from Department of Alternative Energy Development and Efficiency as a committee,
- A representative from Energy Policy and Planning Office as a committee,
- A representative from the Local Administration Office as a committee,
- A representative from Bangkok Metropolitan Administration as a committee,
- A representative from Pattaya City Administration as a committee,
- A public transport expert as a committee,
- A senior economist as a committee,
- A representative from the Office of Transport and Traffic Policy and Planning as the secretariat.

Depending on the nature of each sub-program, the committee might consider inviting other relevant agencies to sit in as non-permanent members for the board meeting whenever needed. Ideally, the president of the CMF should at least hold a high-level position at the Ministry of Transportation, and the Office of Transport and Traffic Policy and Planning can act as the secretariat of the CMF. This structure would allow CMF operation and their supporting measures to align with the Ministry of Transport's policy and plans in promoting and incentivising the use of public transport.

Action plan

The action plan for the first-year operation of the fund should encompass activities as listed in Table 13

Table 13: The action plan for the first-year operation of the fund

Item	Project	Year 2026			
		Q1	Q2	Q3	Q4
Group 1: TCMF operation & plan					
1	Development of TCMF master plan (2026-2030)	X	X	X	
2	Development of TCMF action plan 2027		X	X	X
3	Quarterly meeting of TCMF’s board of committee	X	X	X	X
4	Project monitoring and evaluation			X	X
5	Administrative and other supporting tasks	X	X	X	X
6	TCMF’s financial control and asset management	X	X	X	X
Group 2: TCMF revenue identification					
1	Development of TCMFs revenue identification plan 2027	X	X	X	
2	Feasibility of congestion charge scheme in Chiangmai	X	X	X	
3	Development of proposal to request for funding from national budget	X	X	X	
4	Development of proposal to request for funding from Green Climate Fund			X	X

Group 2: Incentivizing measure to support public transport system					
1	Soft Loan program for bus fleet renew able		X	X	X
2	MRT/BTS fare subsidy			X	
3	Grant to Norm-Motorized Transport (NMT)				X
Group 3: Disincentivizing measure to discourage the use of private vehicles					
1	Congestion charge scheme in Bangkok phase I	X	X	X	X

Source : GIZ, 2020

Implementation concept

The implementation concept of congestion charge and of the clean mobility fund is based on a Push and Pull Approach, that makes public transport more attractive by improving connectivity, reducing fares and improving technology (Pull), and disincentivises car travel by internalising road usage costs and environmental externalities by means of a congestion charge (Push), inducing a shift from private to public modes in a sustained manner.

The revenues of the disincentivising measures will feed into the CMF, which creates a continuous and substantial funding source for sustainable urban transport projects in Thai cities (Transport-Finances-Transport).

The CMF will provide financial support to various financial instruments e.g., grant, loan, credit guarantee to sustainable urban transport measures in Thai cities, including:

- Bus transit:
 - City bus modernization through replacement of Internal Combustion Engine (ICE) vehicles with low-carbon vehicles,
 - On-board IT applications like GPS, Wi-Fi, bus stop proximity notification etc.,
 - Improvement of the bus-stop environment and the signage for timetables, route maps and line services.
- Mass Rapid Transit:
 - Reduction of fare rates or promotion for frequent travellers,
 - Improvement of the connectivity between MRT/ BTS stations and bus stops.
- Non-motorized transport:
 - Improvement of NMT facilities, such as the integration of sidewalks and public transport stations/ bus stops, planning and creation of city-wide pedestrian and bike lane networks,
 - Introduction of city bike sharing services.

- Other modes of transportation:
 - Replacement of ICE vehicles with electric vehicles, focusing on business uses; examples are chartered vans for tourist activities, school buses, motorcycle-taxis, delivery-motorcycles, taxis and Tuk-Tuk.
- Supporting measures:
 - Design single-modal or even multi-modal city mobility apps to help commuters to plan their itinerary by public transport more efficiently,
 - Develop a city-wide integrated electronic payment system to help reduce the transaction cost of public transport passengers,
 - Develop a car-sharing platform to encourage people to use shared travel services,
 - Encourage the installation and operation of EV charging facilities,
 - Launch campaigns and/or demonstration projects to promote sustainable and low-carbon transport.

Depending on the nature of each measure, the eligible criteria and type of financing instrument will differ by local governments, state-owned enterprises, schools, to private companies/operators, self-employed drivers or other.

Monitoring and evaluation

The monitoring and evaluation process will follow 2 approaches i. e., based on CMF annual action plan and the CMF master plan.

Monitoring and evaluation based on the CMF annual action plan will be executed by the Comptroller General's Department (CGD) of the Ministry of Finance. The monitoring and evaluation indicators and criteria of the CMF will be drafted and proposed by the office of CMF, and once in agreement, a MOU between CMF and CGD will be signed laying out main principles and key indicators for monitoring the performance of the fund. The table below shows an expected timeline for the monitoring process of the CMF.

Table 14: CMF monitoring process timeline

Process	Year 0					Year 1								Year 2								Year 3			
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Set the framework for the evaluation criteria.	■																								
Drafting of indicators		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	
Signing of the MOU							→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	
Delivery of Quarterly Performance Reports										→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	
Evaluation of fiscal year-end performance																									
Announcement of outstanding fund award																									
Implementation guidelines for improvement / development / rehabilitation																									

■

All period

→

Fund operation timeline follow normal calendar

- - - - -

Fund operation timeline follow budget calendar

* Budget calendar

Source: GIZ, 2020

Monitoring and evaluation based on CMF's master plan will focus on the progress of the implementation of the master plan and next steps to align the fund's direction and implementation with its goals.

Implementation timeline

The fund is fed by the congestion charge and should exist as long as the congestion charge exists. Implementation is suggested when the mass transit network in BMR completed as planned (2027) and the congestion charge should be implemented in a period of high air pollution. The Thailand Clean Mobility Act as accompanying legislation should also go into effect at the same period.

4.6 Transformational change and complementarity with existing schemes and funding options

A rapid increase in population and economic growth has led to high congestion levels on Thai roads, especially during peak hours. Bangkok has been ranked as the 11th most congested city at the TomTom Traffic Index 2019.²² The transport sector accounted for 25.8% of Thailand's CO₂ emissions. Internationally, Thailand committed to the United Nations Framework Convention on Climate Change in 2015 to reduce 115.6 MtCO₂ until 2030. 41 MtCO₂ are supposed to be reduced from transport and the Office of Transport and Traffic Policy and Planning has included "Congestion Charging" as one of the measures to combat climate change into their Nationally Determined Contributions (NDC) Action Plan.

Main reason of traffic congestion and air pollution from transport in urban areas is the fact that most people still heavily rely on the use of private vehicles. Based on the statistic, it is found that, for example, in Bangkok Metropolitan Region (BMR) there were approximately 11 Million trips per year, of which 80% commuted by private vehicle and only 20% commuted by public transport mode.

Although the government is currently planning to allocate significant investment to the transportation sector, most budgets are dedicated for large-scale infrastructure investments such as double track rail network and mass transit development for the rail transport to expand capacity and network of the transport system. However, the expansion of network and capacity of transportation system alone cannot guarantee that people will shift mode to commute with public transport. There are still other important barriers preventing people from taking public transport such as high fares, insufficient quality of service in terms of coverage, frequency, reliability, and convenience, lack of first and last mile services and poor walkability.

There are a few revolving funds that provide financial support to improve transportation networks. However, none of them provides an overlapped scope and expected financing volume as foreseen for the clean mobility fund. Key revolving funds in transportation, energy, and environmental sectors are:

- **Road transport safety fund** was established to provide support and promote safety regarding road transport and also provide support to victims of car accidents,
- **Revolving fund for vehicle registration plate** was established to produce vehicle registration plates according to the relevant law of road transport; the fund allows flexibility and reduces government direct expenses of national budget allocation to this purpose,
- **Energy Conservation Promotion Fund (ENCON fund)** was established as a revolving fund or subsidy for the implementation of energy conservation projects within government agencies, state enterprises or the private sector. Also, it provides financial support to projects, research, education, and trainings on promotion,

²² https://www.tomtom.com/en_gb/traffic-index/ranking/

information dissemination and public relations in the area of energy conservation, environmental protection; based on the existing mandate of the ENCON fund, it can only provide grants to conduct research in the transport sector and does not have any mechanism to provide funding/ financing to support the investment in public transport measures,

- ***Environmental fund*** was established to support the government, local administration government organizations, state enterprises and private sector working in environment through subsidies and low interest loans, with an aim in helping the promotion and maintenance of the quality of the environment and the conservation of the natural resources of the country in various areas.

Although the government is currently planning to allocate significant investment budgets for the transportation sector, this is mostly dedicated to large-scale infrastructure investments, i.e., to expand capacity and network of the transport system. Infrastructure funds such as the Thailand Future Fund (TFF) focuses therefore solely on investment in large-scale infrastructure projects, and is not designed to incentivize the use of public transport. Hence, rather than competing, the clean mobility fund will be designed to support and leverage private sector investment to de-risk or improve financial feasibility of public transport service investments. The introduction of the CMF will create a new financial mechanism and source to support sustainable transport projects catalyzing a long-term transformation of transport systems towards full decarbonization.

As the budget allocation is decided by the central government, most projects focus on Bangkok as the mega capital city with nearly one-fifth of country's population. The clean mobility fund will foster a decentralized approach by giving other local governments the opportunity to provide sustainable mobility to their people without relying on central budget.

Currently funding of transport projects is decided on a project-by-project basis, without any support after the project end. The consistent revenue from the congestion charge scheme will allow the CMF to support sustainable mobility projects on a long-term basis, without having to worry about the lack of financial assistance.

The congestion charge scheme with its revenue reallocation to sustainable transport development measures will moreover allow to incorporate fairness in the overall approach in that it collects money from the drivers who are responsible for the negative externalities from car use imposed on the society and redistributes this revenue to support low-carbon transportation that will benefit to the overall community.

As the implementation of congestion charge is most likely to induces a continuous shift towards public transportation, it will further enhance climate-friendly mobility and foster the positive impacts from low-carbon transport solutions. Finally, the overall approach of the scheme introduction and the establishment of a funding mechanism for revenue reallocation can be upscaled and replicated within different areas or clean air zones in Bangkok as well as in other Thai cities facing similar challenges in the sustainable and zero-carbon transport and mobility system transition.

Thus, congestion charging as a TDM instrument as well as the establishment and implementations of a clean mobility fund are two innovative measures to be initiated in Thailand to promote the transport and mobility transition towards sustainability and decarbonization of the sector.

4.7 Risk assessment and SWOT analysis of congestion charging and CMF implementation

One of the main risks for the development and implementation of a congestion charging scheme and the CMF under the TCMP programme are political risk in terms of changes within the government, either through shifts in policy direction or in political leadership. Table 15 summarises potential risks as well as appropriate mitigation actions to minimize or eliminate the main risks to the TCMP implementation.

Table 15: Risks to TCMP development and implementation

Risk	Seriousness	Influence ability	Possible risk mitigation actions
Continuity despite of change in local/ national government or other external factors	high	medium	Ensure the programme is fully agreed and understood by partners and aligns with their workplans.
Failure to establish congestion charge	high	low	Engage government agencies/ high-level to commit to congestion charge implementation Create public awareness/ acceptance of the scheme
Failure to establish clean mobility fund	high	low	Engage government agencies/ high-level to commit to the implementation of the funding mechanism Work with relevant agencies to develop alternative mechanisms
Changes in bus/ public transport service planning by the government	medium	medium	Engage public/ private stakeholders to work together to drive the programme' overarching implementation

Source: GIZ, 2020

SWOT Analysis

With reference to a SWOT analysis of Thailand's transportation system and the need for the introduction of the clean mobility fund, the following aspects have been identified.

Strengths:

- The network and quality of road and air-bound transportation infrastructure in Thailand is good.

Weaknesses:

- Network of the rail transport system does not have full coverage, especially regarding the public transport system,

- Lack of linkages or limited linkages to connect different modes of transport,
- Overlapping and unclear responsibilities and roles of different public agencies in policy making, regulation, and operation,
- Laws and regulations related to transportation are not fully aligned with the role of each public agency and do not attract private sector investment,
- The enforcement of the traffic regulations/ laws is not efficient,
- Fare of public transport is considered to be high compared to the standard living expenses of the average population.

Opportunities:

- The congestion charge scheme is an opportunity for the government to generate revenue from charging the use of private vehicles on selected infrastructure segments, leading to the reduction of the overall traffic related problems in the cities,
- Transit Oriented Development (TOD) is an opportunity for attracting private sector investment, in particular along with MRT/ BTS lines; the government can generate additional revenue from the appreciation of land values and commercial development projects to support the public transportation systems,
- Growing urbanization has created an opportunity and demand for urban transportation,
- Use of (big) data and information management technologies can help to increase efficiency and reduce costs of the transportation system operation.

Threats:

- Private vehicle motorization rate has been increasing in the past decades,
- Existing uncertainty in government policy making resulting in a delay of investment in transportation projects,
- Lack of collaboration among public agencies, especially when a project needs across Ministries' approval,
- The demographics in Thailand are changing into an aging society,
- Natural disaster may cause damages to the development of transportation infrastructure, Lack of financing concepts for upscaling of innovative mobility solutions.

Through the implementation of a congestion charge scheme within Bangkok, private vehicle users will be charged for driving in downtown areas. The goal of the scheme is to shift commuters from private vehicles to public transportation, thereby reducing traffic, accidents, air pollutions and GHG emissions and generating additional revenues for public transport operators. The revenue from congestion charging will be collected in an established clean mobility fund and reallocated by the national government into low-carbon transport development measures, including bus electrification. Long-term financial sustainability is achieved by reducing costs and risks for additional investments in sustainable mobility measures and projects by enhancing economies of scale that can be used by future investors. The creation of a long-term financing mechanism for electrification, tariff subsidies and potentially other sustainable urban transport projects by means of the clean mobility fund fed by the congestion charge secures a dedicated funding source for TCMP initiatives in the long run.

4.8 Overview of revenues, expenditures, cost, and benefits of the congestion charge and clean mobility fund

Revenue, expenditures and cost

The annual revenues have been derived from modelling of the congestion charge for Bangkok. They account for THB 5,600-18,800 Million (for a charge of THB 50 per day and THB 11,900-38,800 Million for a charge of THB 80 annually. This may be complemented by additional funding sources, as named above. As the clean mobility fund finances a range of SUT projects and measures according to a whitelist. Funding volumes depend on the specific design of the projects submitted on the fund.

The preferred option for a funding source is the congestion charge revenue, to be collected form the introduction of the scheme in Bangkok. As citizens from all over the country visit the capital city and pay the charge, it can be justified that its revenue is spent nation-wide. Additional potential funding sources for the CMF can include:

- Any charge, fee, fine, tax collected under the Thailand Clean Mobility Act (to be drafted) such as the congestion fee, the parking fee etc.,
- Contributions from excise tax on petroleum products assigned by Prime Minister,
- Contributions from private vehicle tax assigned by Prime Minister,
- Contributions from Energy Conservation Fund assigned by Prime Minister,
- Contributions from National Budget,
- Contributions from private sector in the country and/ or overseas, including intergovernmental agencies and international donors,
- Any interests and benefits generated by the CMF,
- Any other revenue generated by the implementation of the CMF.

Table 16 shows the modeling outputs of the seven congestion charge scenarios within Bangkok. congestion charge revenue, costs, benefits of transportation speed increases, CO₂ reductions, and Particulate Matter (PM) reductions are displayed for each of the seven scenarios.

Table 16: Outputs from GIZ's congestion charge modeling

Scenarios	Charge level (Baht)	VEH-km reduction (million km/year)	PM emission reduction (tons/year)	CO ₂ reduction (tons/year)	Revenues (million baht per year)
Scenario 1	50	0.21	554	209,750	5,906
	80	-0.07	532	193,453	7,639
	120	-0.27	500	184,007	8,547
Scenario 2	50	3.33	756	108,643	8,273
	80	3.35	751	110,603	11,542
	120	3.22	742	101,815	14,207
Scenario 3	50	3.74	718	146,560	8,273
	80	3.89	765	149,520	11,542
	120	3.87	799	141,696	14,807
Scenario 4	50	16.46	5,980	109,159	20,027
	80	23.80	7,765	312,405	29,922
	120	31.69	8,976	658,293	41,611
Scenario 5	80	3.43	479	166,558	21,688
Scenario 6	80	4.09	584	193,775	24,115
	120	4.42	608	214,439	32,836
Scenario 7	80	16.62	4,830	344,251	29,199
	120	20.62	4,899	615,098	39,388

Source: GIZ, 2020

Socioeconomic benefits

In addition to the financial benefits of a congestion charge, associated socioeconomic benefits are to be expected. Four categories of socioeconomic benefits were examined and quantified for each impact category, including reduced congestion as well as accidents, and CO₂ and PM mitigation.

Congestion reduction

Reduced congestion shows a substantial socioeconomic benefit for the congestion charge measure. The benefit is based on a Thailand Development Research Institute (TDRI) article entitled “Value of Time and Service Quality for Bus Travel in Bangkok: Valuation and Policy Implications”. The article valued the “switching cost” for bus riders in Thailand to be THB 76/hr. in 2015. According to the article, waiting time and in-vehicle travel time are assumed to be 52 minutes per trip. Waiting time and in-vehicle travel time are assumed to be reduced based on average congestion charge modelling results for each charging level (THB 50, 80, 120) for a given scenario and for all years. This analysis yields a socioeconomic benefit of up to THB 55 Billion for the first year of operations of the congestion charge. While this socioeconomic benefit substantially overshadows the financial benefits of the program, it is important to note that the analysis remains a conservative estimate. Bus riders are likely to have a lower time-money value than car commuters. Additionally, this analysis does not factor average wages in Bangkok or forecasted GDP development.

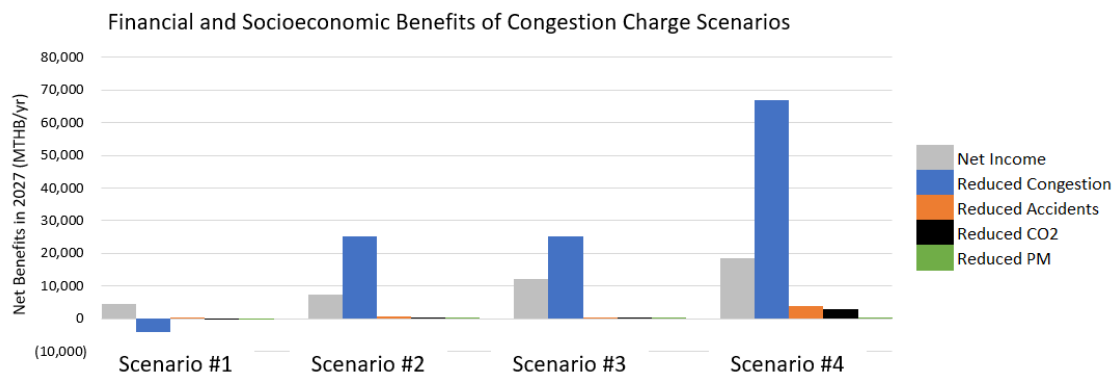
Accident reduction

Road accidents remain a chronic problem for Thailand's transportation sector. The congestion charge should help to reduce the number of road accidents by shifting commuters from private car to public transportation. The exact benefit is difficult to quantify, with estimates ranging from THB 0.2²³ to 100²⁴ Billion per year. This analysis used insurance rates as a conservative proxy for the value of reduced accidents. All shifts from private to public transportation are assumed to reduce an equivalent share of car insurance spent. Annual car insurance expenditure is assumed to be THB 6,570/year/vehicle²⁵. The value of reduced road accidents equals to savings of up to THB 8 Billion on car insurance per year under scenario 4.

CO₂ and PM emission reduction

The reduction of CO₂ and PM emissions after the implementation of congestion charging in selected zones in Bangkok are relatively minor in scale. For CO₂ emission reduction the model uses a \$50/ton price. This assumption includes several secondary and tertiary impacts of CO₂ reduction. The results for Bangkok are in line with findings documented in the article "Carbon tax incidence on household demand: Effects on welfare, income inequality and poverty incidence in Thailand". According to the US study, "Estimates of the shadow price of NO_x and PM_{2.5} Emissions Reductions from U.S. Manufacturing", PM reduction yields a socioeconomic benefit of \$7,800/ton in 2025. Figure 31 provides a summary illustration of financial and socioeconomic benefits from the scenario assessment of CC introduction in different Bangkok areas.

Figure 30: Comparing Financial and Socioeconomic Benefits for Each Congestion Charge Scenario



Source: GIZ, 2020

23 <https://thethaiger.com/hot-news/road-deaths/thailand-aims-to-reduce-road-accidents-by-50-in-2020>

24 <https://openknowledge.worldbank.org/bitstream/handle/10986/29129/HighTollofTrafficInjuries.pdf>

25 <https://www.expatden.com/thailand/car-insurance/>

4.9 Financial and economic viability for the congestion charge

Financial viability, as measured by IRR and NPV, indicates if a measure does or does not require outside funding. Economic viability indicates if a measure's socioeconomic benefits justify outside funding. Both indicators are used to examine the financial and economic viability of congestion charging in Bangkok.

IRR calculations draw on revenue and cost calculation. All NPV calculations are based on a 20-year time horizon (starting in 2022) and a 10.1% discount rate²⁶ back to 2020.

Table 17 details the financial and socioeconomic benefits of the congestion charge measure. The "Government Financial NPV" column in Table 17 shows the net financial impact for the Government. This sets the cost of scheme implementation and operation against the revenues generated by the scheme. Each congestion charge scenario has a positive "Government Financial NPV", demonstrating that the discounted revenue streams generated by the charging scheme more than offset the costs of implementation and operation. Therefore, each congestion charge scenario is financially viable as a stand-alone programme. The IRR for all congestion charge scenarios greatly exceeds any potential hurdle rate for Government infrastructure investments.

The societal net present value considers the societal cost of implementation equating to the government financial costs. The societal net present value is being then set against the wider societal benefits delivered by the scheme. These include the benefits outlined above, namely travel time savings, accident, and emission reduction.

The magnitude of the societal NPV is generally greater than the magnitude of the government financial NPV because the value of the scheme generates positive societal benefits which exceed the charges paid by users.

The societal benefit NPV in Table 17 reflect the summation of all nonfinancial (socioeconomic) benefits²⁷ net of congestion charging user payments

Every measure should be evaluated against its impact on society. The societal cost benefit ratio is commonly used as an indicator of value for money. In the case of schemes which generate significant revenues, such as the congestion charge, the Benefit-Cost Ratio (BCR) can be misleading, as societal costs can be negative. The societal net present value is a better indicator under these circumstances. It is defined as follows:

$$\text{Societal Net Present Value} = \text{Societal Net Present Benefit} - \text{Societal Net Present Cost}$$

A positive net present value indicates that the forecasted socioeconomic benefits of the congestion programme will exceed the societal costs for paying congestion charges. Congestion charge scenario 1 shows the unique case of a negative net present value, indicating that the programme has negative socioeconomic benefits.

The net present value can also be used to evaluate the relative efficiency of achieving socioeconomic objectives. Based on the results of the model analysis, the Congestion charge

²⁶ Comes from the average rate of inflation in Thailand at 2.1% and assume an average expected return at 8.0%

²⁷ This analysis does not assume any revenue recycling benefits. In practice, the additional revenue could be used to supplement programmes that have additional socioeconomic benefits.

scenarios 2, 3 and 4 demonstrate positive societal benefits, with scenario 4 demonstrating the largest societal benefit.

Table 17: A summary of the statistical results of the analyzed revenue sources

Revenue Source	Government Financial NPV (MTHB)	Government FIRR	Societal Benefit NPV (MTHB) ²⁸	Societal NPV (MTHB)
Congestion charge scenario 1	33,029	63%	-108,334	-75,305
Congestion charge scenario 2	55,600	64%	136,626	192,225
Congestion charge scenario 3	90,692	65%	167,565	158,257
Congestion charge scenario 4	141,068	67%	440,840	581,909

Source: GIZ, 2020

Regarding the congestion charge scheme and clean mobility fund implementation as measures of the overarching TCMP, the main logic behind the approach is to generate revenue from disincentivizing measures to discourage private vehicles, while reallocation the revenue to incentivize and promote measures to support urban public transport systems.

The financial analysis of the disincentivizing measure shows that revenues from the congestion charge scheme (e.g., if implemented in Bangkok alone) is estimated to range from THB 5.6-39.0 Billion per year, therefore, it is financially feasible. From the economic analysis, the result shows that in most scenarios of the congestion charge can generate positive socioeconomic benefits NPV and therefore are economically feasible, except Scenario 1.

Regarding the incentivizing measures, the financial analysis shows that both the bus modernization and MRT/ BTS fare subsidy are not a financially feasible investment and therefore need financial support to be implemented. The model shows that for the bus modernization there is roughly a THB 4 Billion funding gap to convert Bangkok's 2,834 private bus fleet to EV. The annual financial cost of the subsidy to public transport fares (BTS/ MRT) ranges from THB 5 Billion to THB 9 Billion per year. Therefore, for TCMP's incentivizing measures, financial support around THB 9.0-13.0 Billion per year are needed. The economic analysis shows therefore that both measures are economically feasible since they can create extensive positive socioeconomic benefit NPV that outweigh their financial cost.

In summary, the analysis shows that the congestion charge is both financially and economically feasible. While the bus modernization and the BTS/ MRT fare subsidy are not financially feasible, they can create positive socioeconomic benefits. If all of the above TCMP's measures are implemented as a package i.e., congestion charge, bus modernization and BTS/ MRT subsidy, they

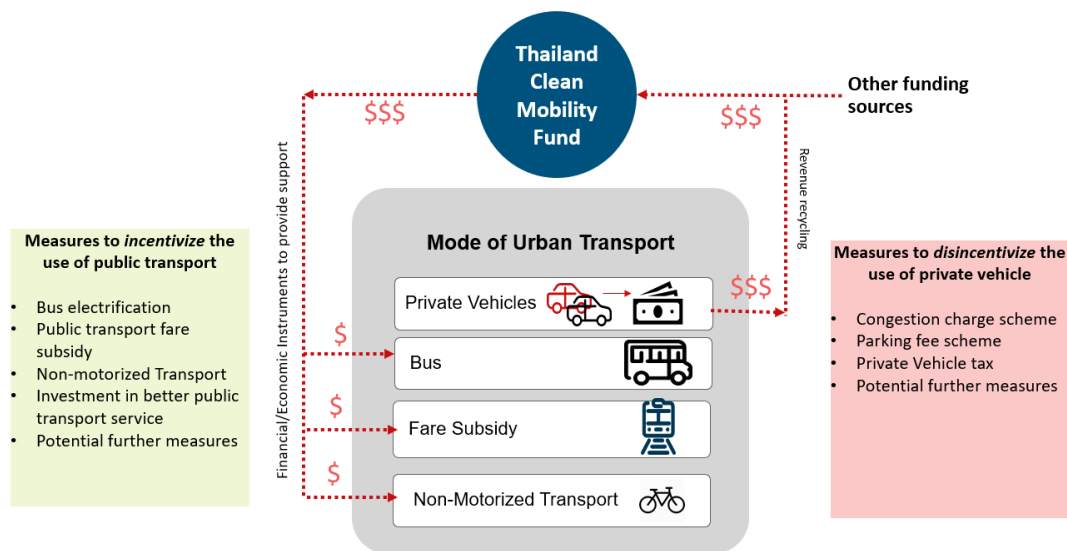
²⁸ Includes reduced congestion, traffic accidents, CO₂ emissions, and PM emissions.

will be both financially and economically attractive, because the revenue from the congestion charge scheme can sufficiently support the expenses of the bus modernization and BTS/ MRT subsidy. It is estimated that these measures will generate revenue at THB 5.6-39.0 Billion per year, while the expense is estimated at THB 9.0-13.0 Billion per year. Thus, it is highly likely that the TCMP's measures could self-fund themselves without the need to rely on the budget from the national government.

4.10 Financing mechanism and structure

The clean mobility fund can be established by the Thai Government as a revolving fund fed by the revenues of a congestion charge scheme, or other tax revenue from car use and should be specifically designed for supporting sustainable urban transport measures. Figure 33 shows the general concept of the CMF. The revenues of a congestion charge in Bangkok or any other travel demand management measure are fed into the revolving fund, which will be established at national level. Municipalities can access this fund to finance sustainable transport measures within their jurisdiction according to priority criteria and the pre-established whitelist of sustainable urban transport measures eligible for funding.

Figure 31: Thailand clean mobility fund as a financing mechanism for sustainable urban public transport measures.



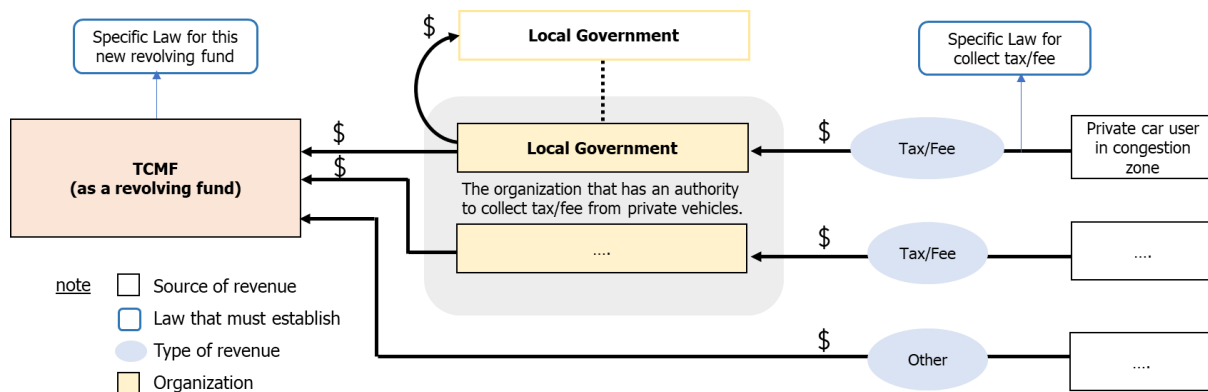
Source: GIZ, 2020

From a legal perspective, to set up the CMF as a revolving fund, it must be governed under a specific public transport act. The new public transport act will be the framework to govern CMF establishment and implementation, while laying out the objectives of having such a fund, as well as its framework and designated sources together with the fund allocation principles and mechanism. Technically, the CMF would be managed by a public entity at the national level, and the designated sources of recycling revenues must be able to be channeled back into the CMF under the newly designed legal framework. However, earmarking of public revenue such as taxes or levies has been prohibited since the enforcement of State Fiscal and Financial Disciplines Act B.E. 2561 (2018), which limits the possibility of designating a specific and independent source of funds for the CMF. Therefore, it is necessary to get a special approval from the Ministry of Finance in this regard in order to earmark any potential revenue for the CMF. This could be drafted in the

new Thailand Clean Mobility Act, which must be reviewed and agreed by Ministry of Finance, to ensure that it complies with State Fiscal and Financial Disciplines Act B.E. 2561 (2018).

In addition, the idea of collecting fees or charges from private vehicle users e.g., congestion charge, parking fee etc. in a given administrative area such as Bangkok as sources of revenue to be fed into the CMF implies that the corresponding local authorities are held responsible for revenue collection based on their authorities and duties. Figure 34 outlines the structure and working mechanism of the CMF.

Figure 32: Operational Framework of the CMF



Source: The Creagay Company (2020)

Under the existing regulations, it is to be noted that revenue collected at the local level is to be fed back to the local government's treasury rather than to a national authority. While the funding source in the case of the congestion charge will be at local level of the city of Bangkok, the fund shall be however established at the national level for the following reasons:

- Thai citizens from all over the country are using the streets of Bangkok and thus pay the congestion charge. Other cities should therefore also benefit from the payments, and it is justified to collect the revenue at the national level and make it available to SUT projects throughout the country, an approach that had also be taken by Sweden, when implementing congestion charging in its capital city Stockholm. In order to reflect the higher burden on Bangkok citizens, the governing law could establish a minimum percentage that has to be fed back to the city e.g., min. 30%.
- The fund supports a variety of different SUT projects, some of them, e.g., subsidies to MRT / BTS fares, being of national responsibility. The Ministry of Transport further has the lead role in the design and investment for the congestion charging scheme infrastructure and is in general responsible for larger infrastructure projects.
- Revenues from the congestion charge in Bangkok, may be complemented by further non-local sources, including e.g., funding from international climate finance, which requires a fund management at national level.

Hence, the main source of revenue for the clean mobility fund is from the congestion charging scheme as well as other additional measures if possible. The revenue will be collected by the local government in the area where the congestion charge instrument is being applied with part of the revenue going to the TCMP Office to assist the local government in initiating and implementing sustainable transport projects. The fund should also reserve a certain budget for soft measures, such as awareness raising campaigns, technical advisory to city administration and training

measures to mainly tackle also the key barriers to the scheme implementation, such as overall acceptance as well as technical and financial capacity of implementing agencies.

5. Expected effects and modelling approach to ex-ante congestion charging impact assessment for Bangkok

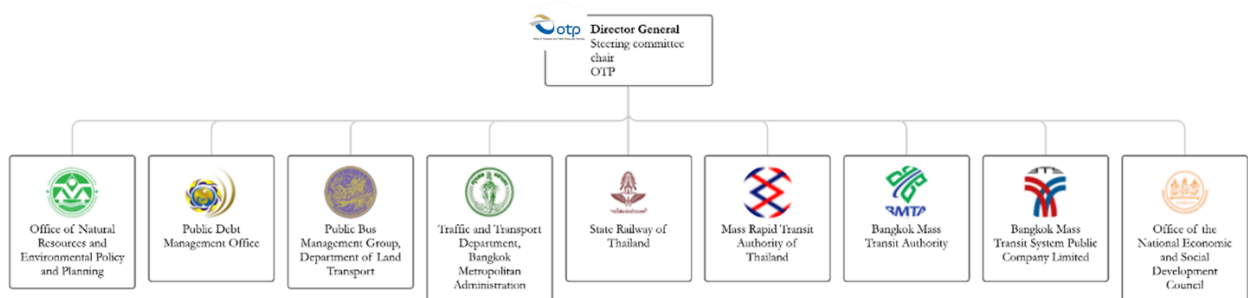
During the congestion charge working group meeting congestion reduction and air quality improvement have been identified as the primary objectives of a congestion charging scheme implementation. Based on the assessments of where congestion and air quality are most problematic, four congestion charging policy scenarios were identified. These four scenarios varied in size in order to understand the consequences of rerouting around the charging zones within the dense Bangkok's Road network. A transportation model was then used to assess the effects of these scenarios, and the results were discussed in a follow-up working group meeting. The main evaluation criteria for the comparison of the scenarios included changes in speeds, mode shares, CO2 reductions, PM reductions, revenues and system costs. One of the major results from discussing scenarios 1-4 was that equity effects and the availability of public transportation in and around the zones are equally important assessment criteria. It was also apparent that zones need to be rather large in size in order to produce a noticeable positive effect.

Given these new political directions, more detailed analyses were conducted to visualise the areas where congestion reduction, air quality improvement, positive equity outcomes and good access to public transportation could be met. These analyses led to the identification of scenario 5 and, after repeated iterations, of scenarios 6 and 7.

5.1 Steering group and working group

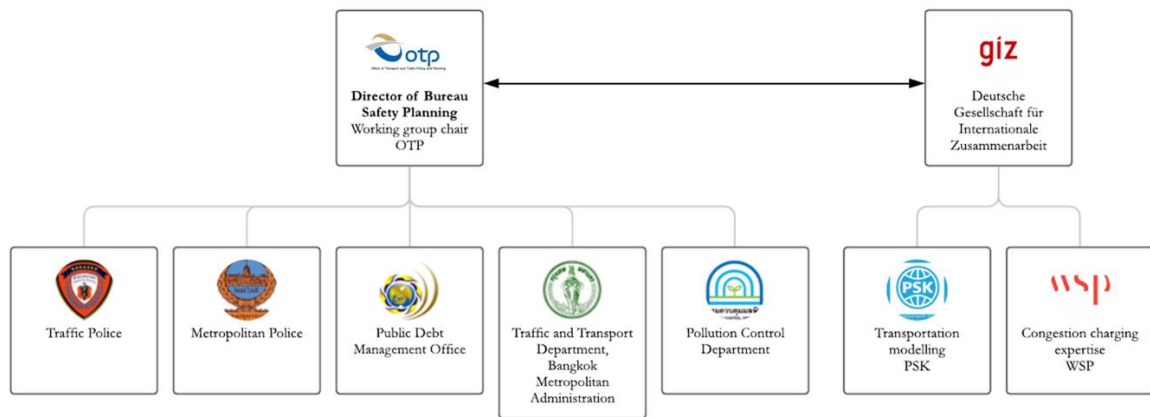
For the impact assessment of a congestion charging scheme implementation in Bangkok, a steering group as well as a working group have been identified and appointed in order to have all the relevant stakeholders included in the policy design process. Figure 35 shows the organisation of the steering group and the stakeholders that were included. Figure 36 shows the organisation for the working group and expert team.

Figure 33: Steering group organisation



Source: GIZ, 2021

Figure 34: Working group organisation



Source: GIZ, 2021

5.2 Evaluation criteria of alternative congestion charging policies

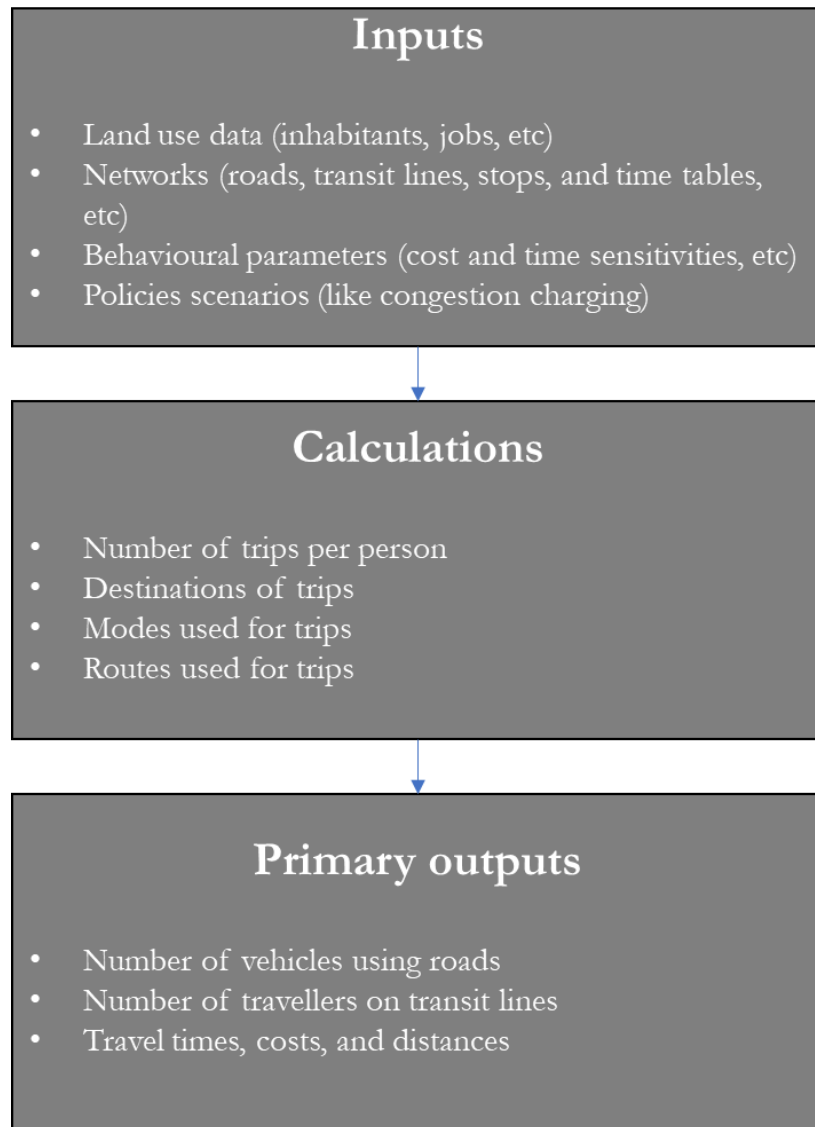
Congestion charging does not by definition provide benefits for cities. Especially in cities with dense networks and widespread congestion, there is a risk of a congestion charging policy leading to rerouting and causing even more congestion than it solves. Bangkok could face this problem. Hence, finding a suitable zone definition could be difficult. In addition to the direct congestion effects, mode changes, equity effects and emission reduction need to be examined. To ensure the intended positive outcomes from a congestion charging policy, a tool is required that allows for an ex-ante assessment of both how people will react to congestion charging as well as what changes in traffic will occur as a result of the measure implementation. The tool applied to conduct a sound ex-ante congestion charge impact assessment is a transportation model for Thailand developed on behalf of OTP.

Methodological approach

The Thai transportation model eBUM was used to examine effects of congestion charging by modeling different scenario for the years 2017 and 2027. A model is always a simplification of reality; therefore, some of the limitations of the model with regards to modelling congestion charging policies are further illuminated.

Figure 37 presents a transportation model processes on a conceptual level. The transportation model divides the entire area of Bangkok into smaller areas (zones). For each zone data is gathered on how many people live there, how many jobs exist as well as household characteristics. Using these data and behavioural models, the model determines 1) how many trips people will make, 2) where they will go, 3) what mode they will use and finally, 4) the route they will take. The choices people make depend on their own characteristics (income, gender etc.), the purpose of the trip (work, shopping etc.) and the characteristics of alternatives (travel time, cost, comfort etc.).

Figure 35: Conceptual modelling process



Source: GIZ, 2021

When congestion charging is introduced, the costs of travel by car will increase. Travellers may choose to pay those extra costs and just continue to drive, or they can change their travel behaviour. The most common recognised dimensions of behavioural change after congestion charge implementation are as follows:

- Move (buying/renting a house at a different location),
- Combine activities or order in activities during the day,
- Change destination to other locations which costs lower,
- Carpool,
- Change modes of transport,
- Change departure time,
- Change routes.

Clearly some of these behavioural changes are more substantial and difficult to determine than others. A transportation model typically produces forecasts for when the new situation has

stabilised and all possible behavioural changes have occurred. The eBUM model for Bangkok includes some, but not all, of the potential behavioural responses. It only models change in destination, mode and route and thus underestimates the effects of congestion charging.

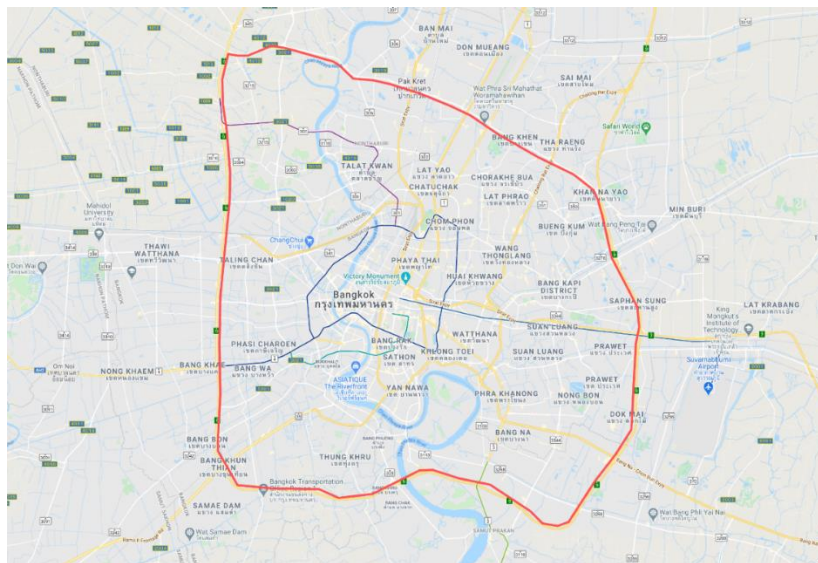
Another issue with the eBUM model is how route choice is modelled. Queues that occur when the demand is higher than the capacity build up stream upwards of where the queue starts. This build-up of queues is not modelled by the eBUM model, but instead, the increased travel time for people travelling on that road is estimated and added to the road segment where the queue starts. This is an approximation that many cities use, but it does neglect the effect of blocking traffic in other directions. The route choice model also does not consider delays from traffic signals. Lastly, the model assumes that in terms of route choice, all travelers have equal sensitivities to cost and time while in reality, this is much more heterogeneous. The downside of this is that once a congestion charge reaches a certain threshold many travellers will shift routes while in reality the shifts between routes is much more gradual.

Overall, the modelling techniques that are used in the eBUM are commonly used in many cities. The model captures the most important behavioural responses towards congestion charging, but it is likely to underestimate them to some extent. The model is likely to underestimate the benefits of travel time from the decreases in demand as congestion is modelled in a simplified way.

Congestion Charge area definition

In the process of assessing the effects of different congestion charging scenarios and comparing them against each other and against the Business As Usual (BAU) scenario, many of the effects of congestion charging scenarios occur in the immediate areas around the congestion charging zone/area. Bangkok's greater area is large, and many of the trips will not be affected at all by congestion charging. In order to ensure that the effects of congestion charging remain visible and do not average out when all roads are included, a study area is defined for which some of the evaluation criteria will be calculated. This study area reflects the anticipated area of the influence of congestion charging. The chosen study area is shown in Figure 38

Figure 36: Study area for congestion charging scenario evaluation criteria



Source: GIZ, 2021

Congestion charge evaluation criteria

One of the main objectives of the congestion charging for Bangkok is to reduce congestion. In order to assess how congestion changes and compare different congestion charging scenarios, congestion evaluation criteria need to be set. The identified evaluation criteria account for two purposes: 1) to identify severely congested areas as those most suited to introduce the scheme and 2) to assess changes in congestion levels as a result of congestion charging.

For assessing where congestion is most severe in Bangkok and where charging would be most effective, the volume-to-capacity ratio (V/C-ratio) is used as the congestion indicator. The V/C-ratio describes how much of the available road capacity is used by dividing the current traffic volumes on a road segment by the capacity of that road segment. If the volumes are close to or over the capacity, congestion will occur. Since each road segment has a volume and a capacity, it can be mapped where congestion is most severe. Table 18 shows how to interpret the V/C-ratio values. With the V/C-ratio below 0.85, the volumes are well below the capacity, and there may be some minor delays but no congestion. Between 0.85 and 0.95, the traffic volumes are getting close to the capacity, and travel time will increase. With higher V/C-ratio, the demand will be higher than what the road segment can accommodate. As a result, queues and congestion will accrue and travel time will sharply increase. Under these conditions, gridlocks are the consequence.

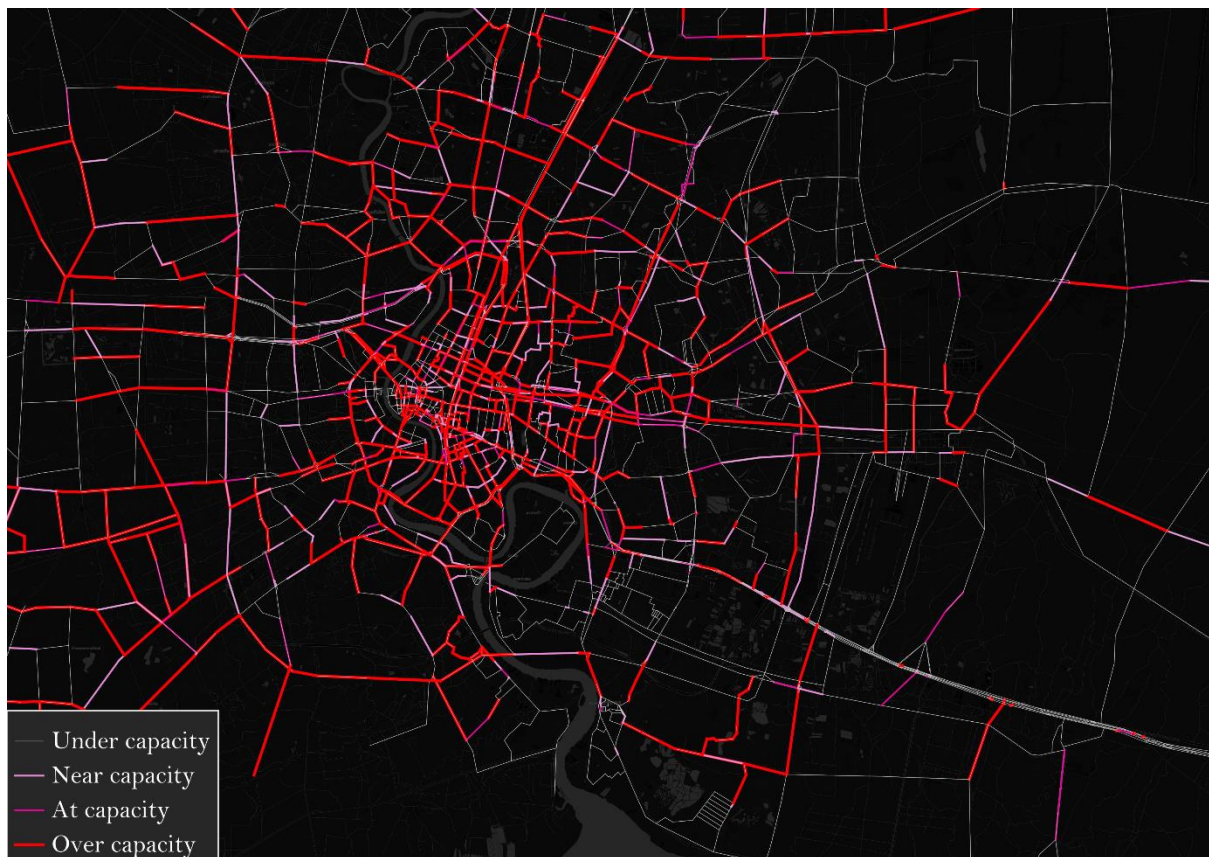
Table 18: Road congestion condition related to V/C-ratio

Condition	V/C-ratio
Under capacity	< 0.85
Near capacity	0.85 – 0.95
At capacity	0.95 – 1.00
Over capacity	> 1.00

Source: GIZ, 2021

Figure 39 shows the daily V/C-ratios for different roads in Bangkok. Red and purple colours indicate severe congestion. These are situations where speeds are very low and gridlocks occur, causing significant delays for travellers. As can be seen, congestion is widely spread throughout the network and on some of the ring roads and arterial network segments. Congestion is oriented towards the centre and decreases moving outwards. From a congestion perspective, charging in a larger area in or around the centre seems promising. Suitable smaller charging areas may be difficult to identify since they will almost certainly result into rerouting towards already congested roads.

Figure 37: Congested areas in Bangkok



Source: GIZ, 2021

While the V/C-ratio maps provide insights into the severity and locations of congestion, the comparison of maps to draw conclusions about the overall net changes is not as straightforward as simply contrasting two congestion charging scenarios. Some roads may improve while others will deteriorate, and the net effect of those changes need to be captured and well understood. In order to assess the performance of different congestion charging scenarios, the following evaluation criteria will, therefore, be used:

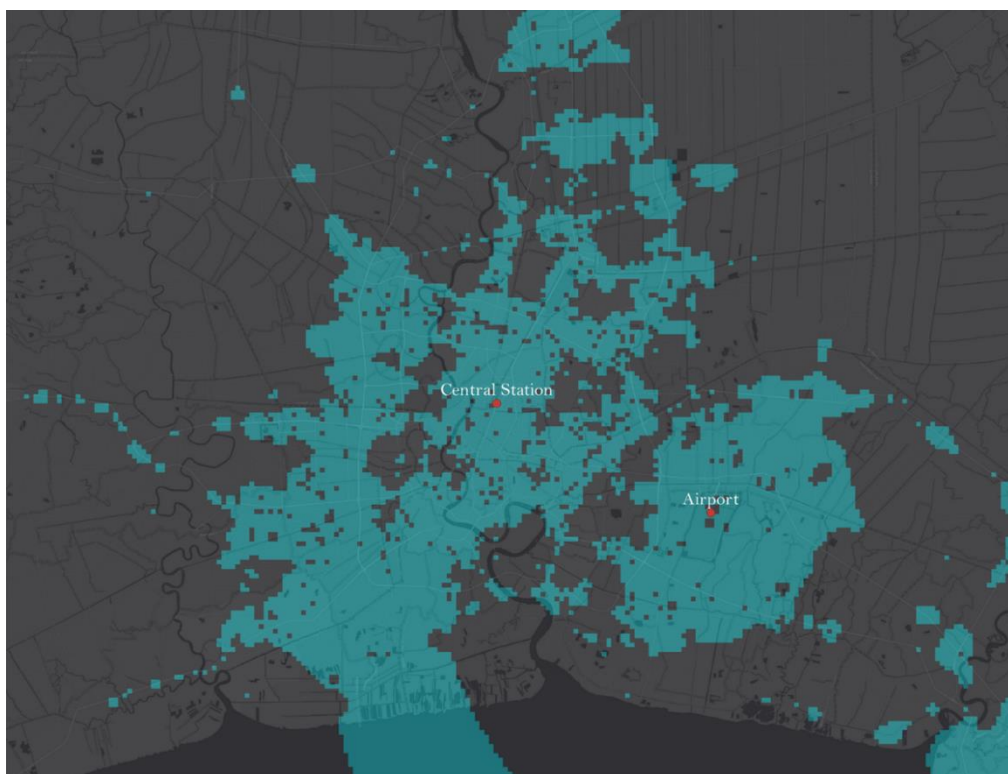
- Difference in volumes between the congestion charging scenario and the business as usual (BAU) scenario without congestion charging; increases in volumes are shown in red and decreases in volumes are shown in green,
- Difference in speeds between the congestion charging scenario and the BAU scenario, where increases in speeds are shown as green and decreases in speeds as red,
- Average network speed weighted by volume over all network links or road segments for the entire network and the study areas in Bangkok,
- Changes in consumer surplus, which show the net benefit of changes in costs and travel time for travellers expressed in Baht; consumer is defined as the difference between what consumers might be willing to pay for a service and what they actually pay; generally, the economic impacts of improvements in a transportation system can be evaluated in terms of consumer surplus and can be represented as the area under a demand curve and a shift in the supply curve.

Emission evaluation criteria

Besides congestion, air quality improvements are an important objective of congestion charging implementation. Determining the effects of congestion charging on air quality is not easy and requires sophisticated air dispersion modelling. However, the approximate values of the impacts from congestion charging on emissions can be calculated by comparing the emissions between different scenarios together with an emission model applied to calculate the CO₂ and PM emissions depending on traffic conditions, vehicle types and emission factors.

Therefore, in order to identify suitable areas or road segments for congestion charging implementation, the volume of traffic on a road segment was used as a proxy for emissions. These emissions were then dispersed using a distance decay function. The further the distance from the road where the emission takes place, the lower the value. Figure 40 shows in green-blue the areas where traffic volumes lead to higher emissions.

Figure 38: Emissions from traffic Evaluation criteria for comparing scenarios



Source: GIZ, 2021

After identifying suitable congestion charging scenarios, the impacts on defined indicators are compared against the BAU scenario and against each other. These comparisons can be based on the model results and the actual emission calculations as mentioned before. The evaluation criteria used to assess the air quality and climate impact of different scenarios are:

- PM_{2.5} emissions in the entire Bangkok network and the study area,
- CO₂ emissions in the entire Bangkok network.

Equity evaluation criteria

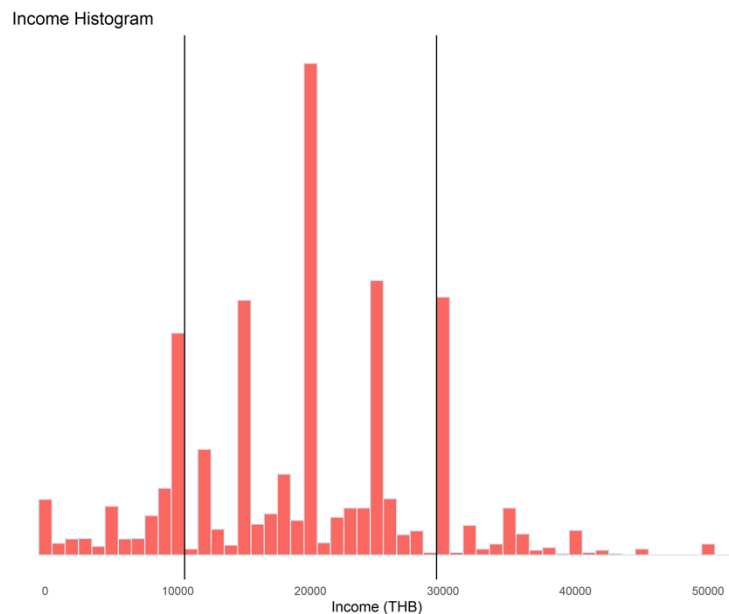
After the evaluation and discussion of the first four scenarios, equity became a more important political concern. Depending on the design of the scheme, congestion charging can increase

existing income inequalities. While equity can and should be defined across multiple dimensions, including gender, age, ethnicity, income, equity is considered from the private household income perspective.

When considering household income equity in identifying suitable congestion charging scenarios, the objective is to avoid charging travel relations²⁹ in which low-income households are overrepresented. Figure 41 shows the income distribution for the Bangkok's greater area from the latest travel diary survey (2018). Based on this distribution, low-income households are defined as households with an income of THB 10,000 (EUR 276.6) per month or less and high-income households with an income of THB 30,000 (EUR 829.9) and higher. In order to define 'overrepresentation' the average share of trips of low-income households was analysed. On average, about 12% of the trips made to an area are made by low-income households. We consider destinations to which more than 12% of the trips are made by low-income households as less suitable for congestion charging.

Taking on the reverse perspective by location travel relations where high-income households are overrepresented would indicate fewer sensitive zones for congestion charging implementation. This requires again that the meaning of 'overrepresentation' is defined, following a similar approach as for low-income households. On average, about 19% of the trips leaving an area are conducted by high-income households. We consider origins from which more than 19% of the trips departing are made by high-income households as more suitable for congestion charging.

Figure 39: Income distribution for Bangkok 2018



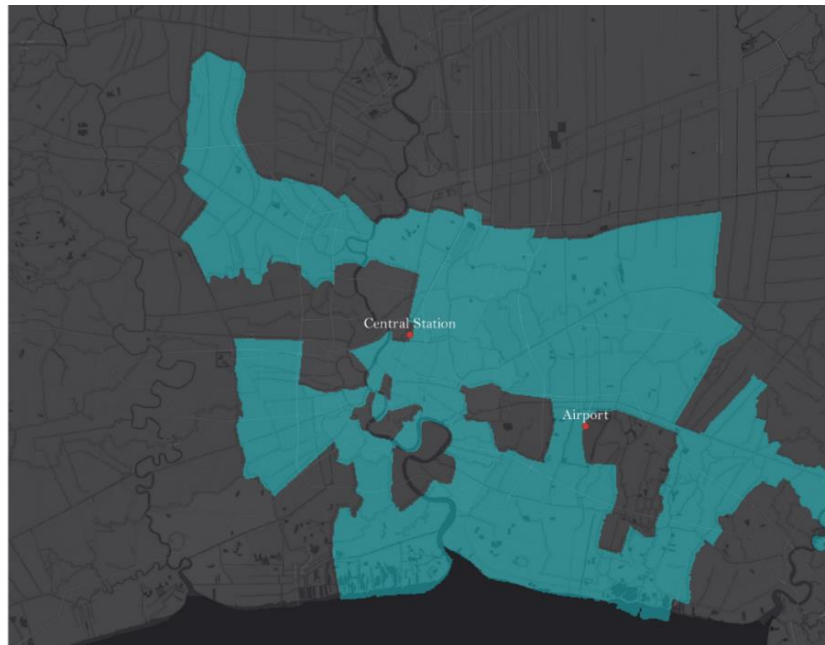
source: Travel diary survey

Given the definitions of overrepresentation for low-income and high-income households, areas that are more suitable for congestion charging from the income equity perspective have been mapped. These areas are shown in Figure 42 and Figure 43 for low-income and high-income households, respectively. The area that charging is supposed to be avoided because of the overrepresentation of low-income households is substantially larger than the area where charging

²⁹ Travel relations mean the combination between origins and destinations. From where to where are people travelling. Strong travel relations are those where a lot of people travel between the same origin and destination.

is more appropriate. Even in the centre of Bangkok, this is the case. This will make it more complex to design congestion charging without deteriorating equity conditions. The use of the congestion charging revenues will be an important part of the policy design to account for equity concerns.

Figure 40: Less preferred destinations due to overrepresentation of low income households



Source: GIZ, 2021

Figure 41: More suitable areas for congestion charging based on overrepresentation of high income households



Source: GIZ, 2021

In order to compare scenarios, the model results from different scenarios are linked to the travel diary survey data so that an analysis can be done on how conditions would change for households in the survey if congestion charging was introduced. Within the travel diary survey, low, middle and high-income groups are distinguished, and the amount each group pays in congestion charges, both absolute and relative to income, is calculated. The latter provides insights into whether a scenario is regressive or progressive.³⁰ Furthermore, the distribution of travel time benefits between different income classes can be analysed. A boxplot diagram visualises the distributions.

Public transport shift evaluation criteria

Congestion charging will increase the cost of travel for users of private vehicles and increase the use of public transportation. These are some of the desired effects of congestion charging, and with better public transportation, the shift from car to public transportation will be enhanced for travellers. Therefore, change in mode shares resulting from congestion charging will be one of the evaluation criteria for scenario comparison. From the perspective of public acceptance, as well as for identifying effective scenarios, it is desirable to align the locations for congestion charging with locations where good public transportation is available. The perception that congestion charging is introduced in areas where good travel mode alternatives are available increases the acceptance for congestion charging.

In order to identify congestion charging zones, areas with good quality public transportation stations and bus stops with more than 30 departures per hour were localised. For each of these stops, a catchment area or areas of influence around it with a radius of 500 m were included. Lastly, it has been taken into account that not all public transportation modes are valued equally by travellers. Normally, rail-bound services are valued higher than buses. Therefore, they have been weighted higher as shown in Table 19.

Table 19: Weighing factors for different modes of transportation

Mode of transportation	Weight
Rail (MRT, BTS, etc.)	3
Bus	1
Boat	0.5

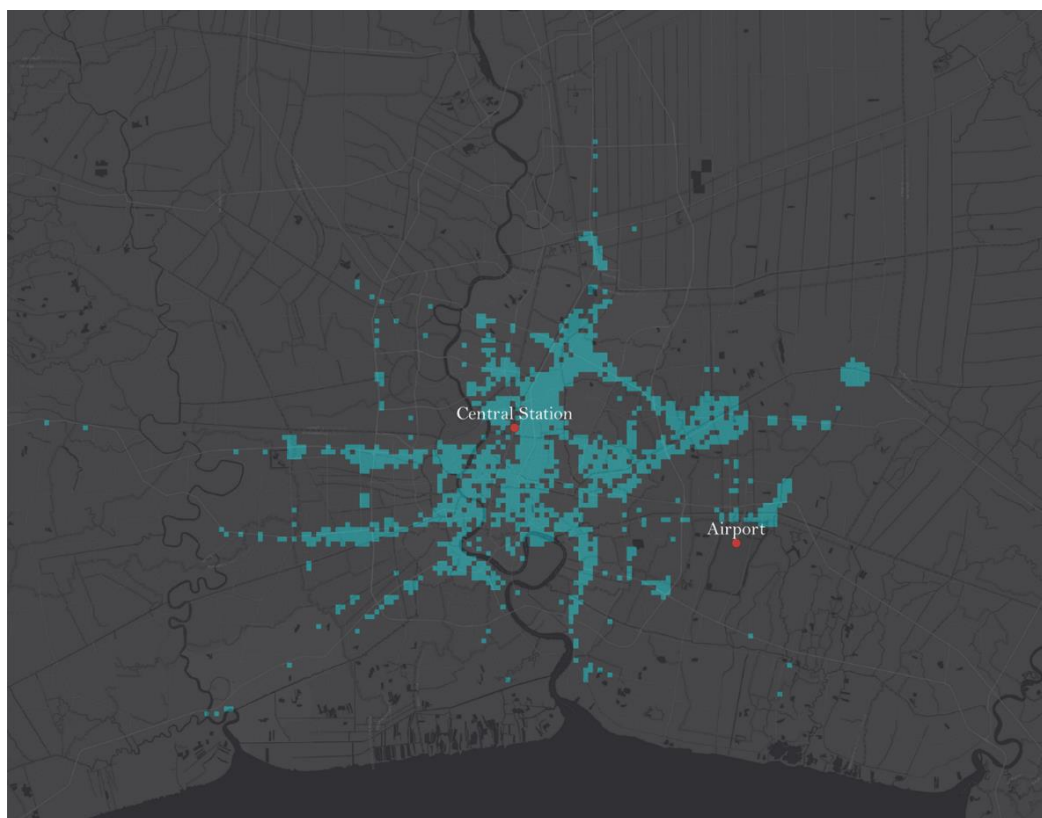
Source: GIZ, 2021

With these assumptions, we are able to identify locations with better public transportation that would be more suitable for congestion charging introduction. Figure 44 shows the appropriate

³⁰ A progressive tax is a tax in which the tax rate increases as the taxable amount increases. The term progressive refers to the way the tax rate progresses from low to high, with the result that a taxpayer's average tax rate is less than the person's marginal tax rate. The term can be applied to individual taxes or to a tax system as a whole. Progressive taxes are imposed in an attempt to reduce the tax incidence of people with a lower ability to pay, as such taxes shift the incidence increasingly to those with a higher ability-to-pay. The opposite of a progressive tax is a regressive tax, such as a sales tax, where the poor pay a larger proportion of their income compared to the rich [source: Wikipedia]

locations on the map in green. As expected, the quality of public transportation is better around the centre of Bangkok.

Figure 42: Public transportation stops with a high frequency of departures



Source: GIZ, 2021

In order to assess the impacts of congestion charging scenarios on public transportation, changes in mode shares on trip basis are used as the main indicator.

5.3 Congestion charging scenario identification

To identify and assess the effects of different congestion charge scenarios for Bangkok an iterative process was adopted, with a strong emphasis on the involvement of relevant stakeholders. Usually, the process starts with a phase of divergence, where very different scenarios are tested while towards the end of the process the analysis becomes more focused on convergence and fine-tuning of promising solutions. This description of the identification of different congestion charging scenarios for Bangkok will be followed by the presentation of the scenario assessment results. Overall, the impacts were calculated for 7 different congestion charging scenarios, where the first 4 were of a more divergent character while scenarios 5 to 7 were more converging in nature. Between these two groups of scenarios, the political constraints and objectives were further revised, and access to public transportation and equity were explicitly considered.

The most important design objectives for a congestion charging scheme in Bangkok were congestion reduction and air quality improvements. With these objectives in mind, 4 scenarios were identified, located in the centre of Bangkok, where congestion and air quality were identified as most problematic. The steering committee has already identified one scenario of interest, which included two smaller cordon charges. This scenario was an important starting point for identifying

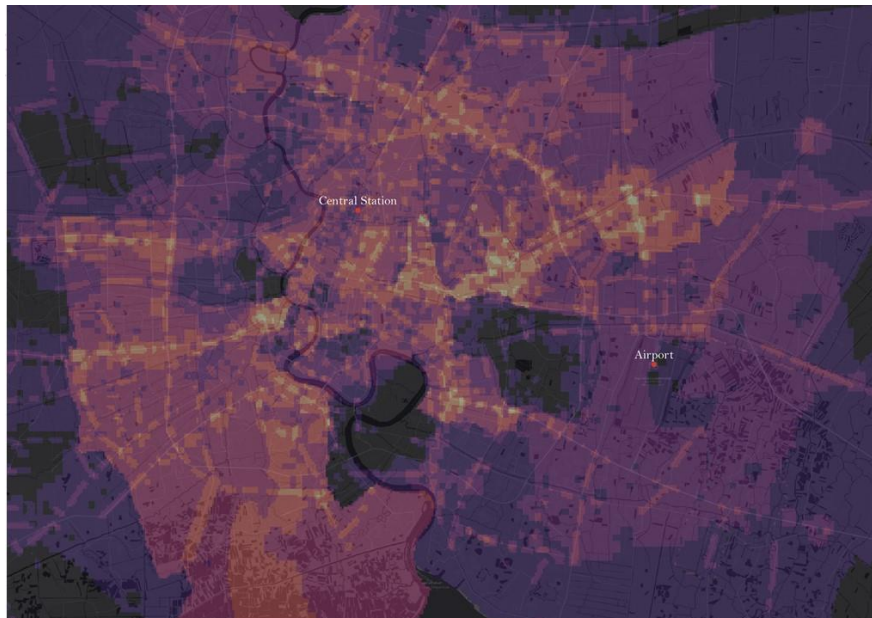
the other three scenarios, which mostly varied in size to assess how sensitive different sizes of congestion charging areas were to 1) negative rerouting effects that increase congestion outside the cordon and 2) negative effects as a result of uncharged internal traffic within the cordon.

All four scenarios were defined as a cordon charge, where vehicles pay when they enter the cordon. No vehicles were exempted from the congestion charges at this point. Also, the charges were not yet differentiated in terms of place or time. For each scenario, three different charge levels were tested, namely THB 50, 80, and 120 (EUR 1.4, 2.2 and 3.3, respectively) per passage. The THB 50 charge fee was chosen as the lowest charge rate in this study as it is equal to the toll rate on existing toll roads. The effects of the tolls on demand and congestion levels were perceived to be low. The THB 120 charge fee was chosen as an upper bound and it is expected to impact car use, mode choice or travel behaviour in a more substantial way.

After the effects of the first four scenarios were presented and discussed within the steering committee and working group, the identification of scenarios 5 to 7 occurred in a slightly different manner. First, access to public transportation and equity were included as congestion charging objectives. This meant that identifying new scenarios became more complex as four competing objectives needed to be balanced in each scenario. Secondly, rather than identifying different scenarios at once, this time only one scenario was identified at a time so that the lessons learned could be included in each new scenario and the process would start to convert.

In order to identify new scenarios, given the four key political objectives, a methodology was used, where evaluation criteria for each of the objectives as discussed in previous sections, were overlaid upon each other. Using this overlay, it was possible to visualise how many objectives are met at different locations in Bangkok. Figure 45 shows a map illustrating how well selected criteria representing the underlying objectives are met, assuming equal weights between the objectives. The lighter the colour is, the more the objectives are met and the more suitable that location is for introducing congestion charging.

Figure 43: Overlay of evaluation criteria per policy objective



Source: GIZ, 2021

With introduction of differing weights for the different objectives new results were calculated and mapped to identify new congestion charge scenarios with new charging zones. Table 20 shows the

two sets of weights that were used to refine the scenario assessment and zone identification. In the first set, aligning the congestion charging policy with access to public transportation is the priority objective, and reducing emissions the second. In the second set of weights, emission mitigation is the key objective, and congestion reduction comes second.

Table 20: Agreed suitable weights for the policy objectives

Objectives	Option 1	Option 2
Congestion	1	2
Emission	2	4
Equity	1	1
Access to public transportation	4	1

Source: GIZ, 2021

Based on the two sets of weights, new overlay maps were created as shown in Figure 46 and tSource: GIZ, 2021

Figure 44: Resulting map with weights from option 1.



Source: GIZ, 2021

Figure 45: Resulting map with weights from option 2.

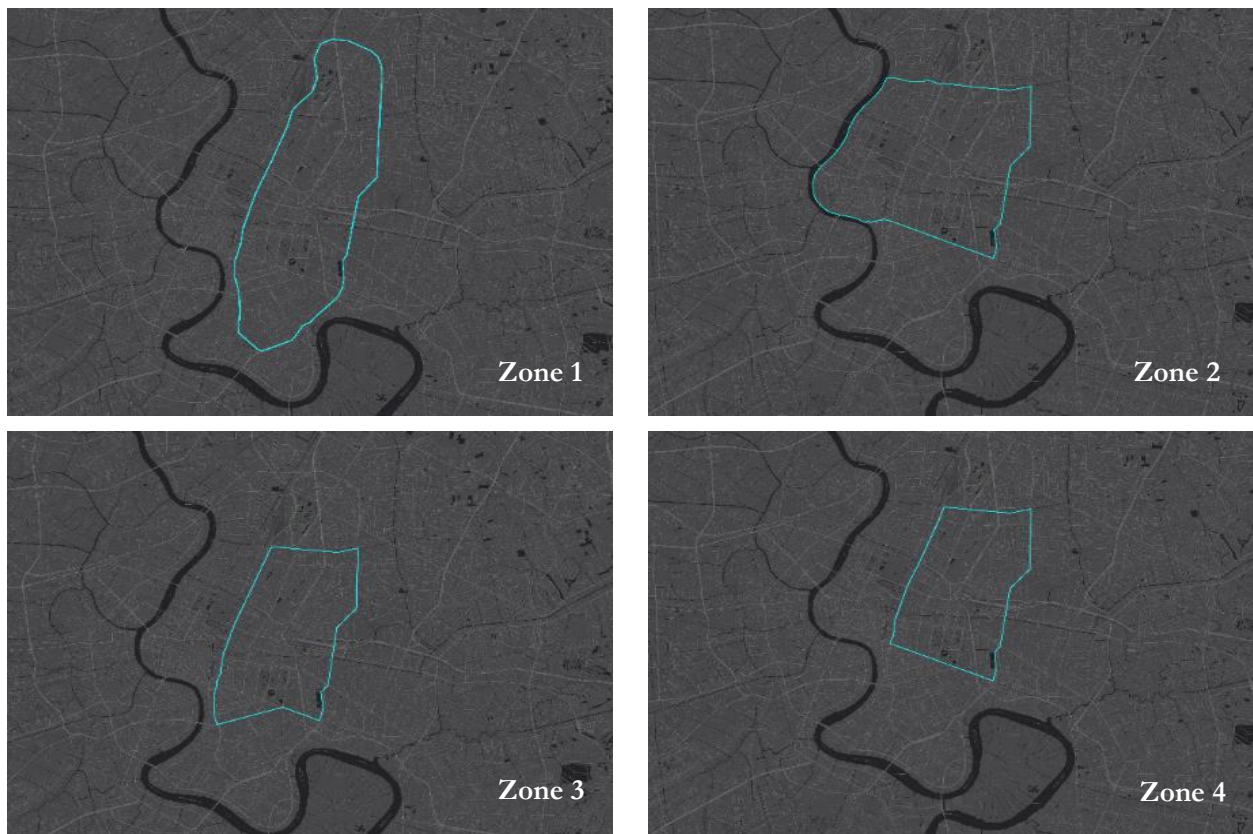


Source: GIZ, 2021

The resulting maps show some differences but also some similarities. One of the main differences is that the map with the weighting set 1 (where public transportation alignment is the most important) shows fewer areas that are highly suitable for charging. The suitable areas are also more concentrated in the centre area. In the centre of Bangkok, the two sets are more similar, which provides additional confidence that this is the most suitable area for congestion charging. In comparison with the previous scenarios, the maps further indicate the inclusion of the more northern part of the central area of the initial scenarios.

The overlay maps were discussed in the workshop and new congestion charging zones were proposed by the participants. The rationales behind the proposed zones were often the combination of information resulting from the overlay maps and more local knowledge about Bangkok. Figure 48 shows some of the proposed alternative charging zones. As can be seen, all of them are located in the centre but include more areas in the northern part of the central area than the four initial scenarios.

Figure 46: Potential congestion charging zones based on the objective-overlaid maps



Source: GIZ, 2021

After discussing the potential congestion charging zones, zone 4 was chosen as the most promising and has been used for scenario 5. The results of the scenario 5 analyses led to the definition of scenarios 6 and 7.

Figure 49: Scenario 5



Source: GIZ, 2021

5.4 Concluding evaluation of congestion charging scenario impact assessment

Congestion charging has a great potential to reduce congestion and emissions

To evaluate the effects of congestion charging implementation in Bangkok 7 different scenarios of congestion charging were assessed and compared. Charge rates, the size of the charging zones, the location of the charging zones, and charging principles – cordon or area – were examined. Except scenario 1, all scenarios led to congestion and emission reductions. With smaller zones, the results become more sensitive to the charge rate as more drivers will try to avoid paying the charge, causing additional congestion by rerouting. The potential congestion reduction for Bangkok, expressed as changes in network speeds within the study area, range from 3% to 13%. PM emission reduction ranges between 3% and 36% depending on the investigated scenario.

Changes in use of public transportation

Even though increasing the use of public transportation was not an explicit objective of congestion charging of the pre-feasibility study, it is important to note that public transportation mode shares increased in all scenarios, except scenario 1. The increases in mode shares range from 3% to 25%, without further examination of the capacity of the public transportation system to accommodate of the increases in ridership resulting from the introduction of a congestion charge.

Equity effects of congestion charges are an issue

Even though congestion charging can be a powerful policy instrument that contributes to political objectives, none of the scenarios improved the income equity situation. Low-income households will be affected more by the congestion charges and are likely to experience less benefits in travel time savings. This is a concern that will need to be addressed in further development of congestion

charging policies. This is not necessarily problematic as the use of revenues can enhance the equity outcomes of congestion charging.

Revenues

The gross revenues in the scenarios that were considered in the pre-feasibility study range from 6 to THB 40 Billion (EUR 1.19 Billion) annually. The net revenues need to be determined as the different scenarios have different investment and operating costs. Still, the potential for infrastructure funding is significant.

Rerouting of car drivers to avoid paying charges is an issue

The density of the road network in Bangkok makes finding a suitable congestion charging zone a challenge. All the scenarios, except scenario 4, have issues with drivers rerouting to avoid paying the congestion charge. Some of these negative side effects can be mitigated with adjustments to street design, traffic signals or traffic management measures, but it is likely that some roads around the congestion charging zone will experience some additional congestion. The general impression is that the smaller the charging zone, the larger the rerouting issues.

5.5 Scheme design and implementation outlook

Based on the assessment of different congestion charging scenarios it has been shown that the implementation of the scheme in selected areas in Bangkok can lead to substantial reduction of congestion and emissions. In the next steps more specific policy design issues need to be addressed determining the “best” congestion charging policy for the city. Hence, an important step in developing and implementing a congestion charging policy is to study four key issues in more detail so that clear policy recommendations can be made.

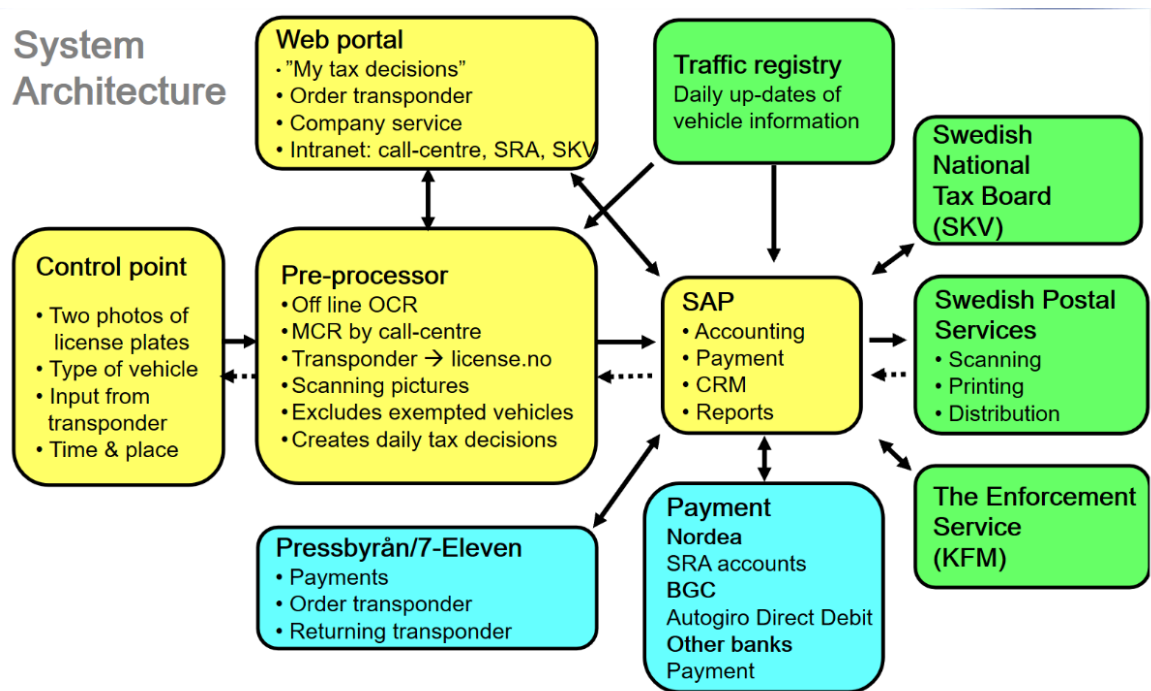


First, the functional design of the congestion charging policy needs special attention. Given the political objectives and constraints, where, who, when, and how much needs to be charged? Will discounts, exemptions, rebates etc., be needed? Answering these questions will ideally follow an iterative design process between decision makers and transportation planners and modellers. Besides the congestion charging policy itself, the functional design needs to include mitigating and/ or support measures that improve the efficiency of the policy. In particular also the use of revenues needs to be addressed in more detail.



Second, the technical system that detects, identifies, charges, invoices and enforces payment needs to be designed. There are multiple technological options for the roadside equipment and vehicle identification part of the system. For the back-office functions of the technical system, there are many more design options and market solutions. All these technical components together need to support the operation of the desired functional design of the congestion charging policy. Figure 50 shows the system architecture of congestion charging pilot in Stockholm. From the roadside equipment or control point, data stream from either the camera or the vehicle transponders are generated and interpreted. It is then decided if congestion charges need to be assigned to the vehicle. All the other components relate to invoicing, payment, and enforcement.

Figure 470: System architecture of congestion charging pilot in Stockholm



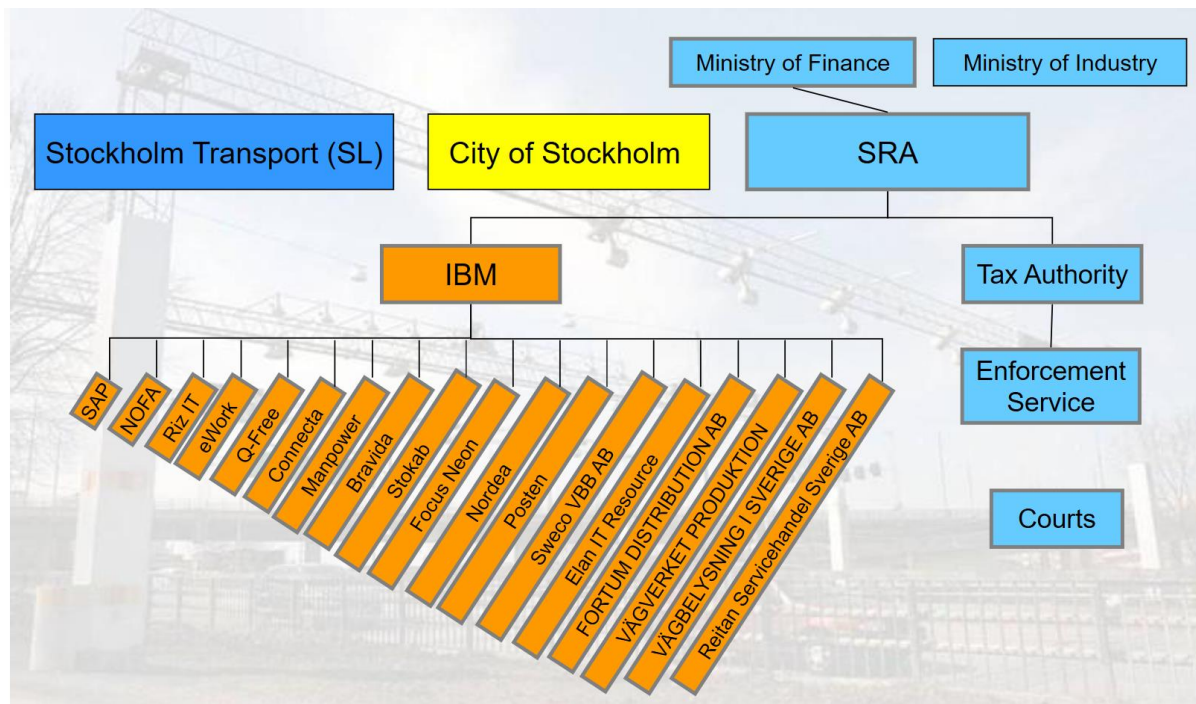
Source: GIZ, 2021

There may be specific legal and institutional issues that either restrict or prescribe the use of certain technologies. Some technical solutions may also be so expensive that the desired functional design becomes unrealistic. In other words, there is a need to coordinate functional design, technical design and institutional design. The technical design study should result in a recommended technical solution that fits the functional design and provides a set of procurement specifications for technical systems.



Third, the institutional and legal barriers towards congestion charging can be substantial. New legislation or institutions may be needed, or existing legislation needs to be adapted. Some countries do not allow license plate images as legal proof while other countries require it. Some countries want a specific new public company or agency to operate the congestion charging policy and collected the revenues while in other countries, the congestion charges are a national tax. The institutional study also needs to recommend how to procure and operate the system and what are the relationships between public and private sector actors in that process. Figure 51 shows the organisational structure of the congestion charging pilot in Stockholm and how it is operated. It involved cooperation between around 20 actors, of which many were subcontracted by IBM. For Bangkok, a similar organisational structure that corresponds with the technological design and the function specifications needs to be setup.

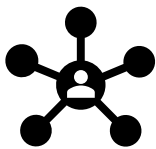
Figure 48: Organisational structure of congestion charging pilot in Stockholm



Source: GIZ, 2021

Typical questions that would need to be answered within this design task are as follows:

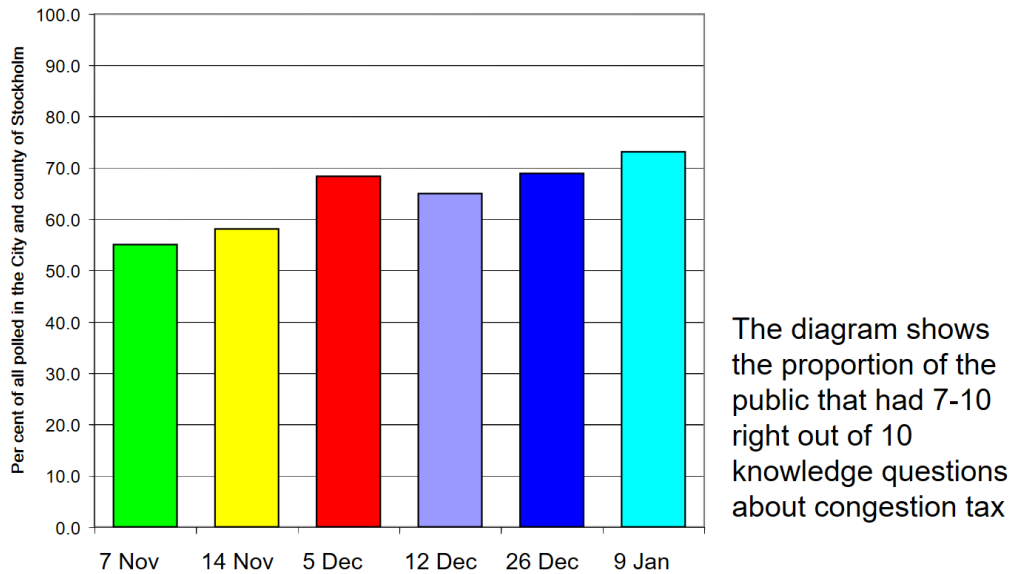
- Under what legislation can vehicles be automatically detected and identified?
- Under what legislation the owner of the identified vehicle be charged with a congestion charge selected roads?
- Under what legislation can vehicles be prevented from using the congestion charge area and/or payment of the congestion charges be enforced?
- What organisational set-up will be best for the implementation and operation of the congestion charges?
- What type of procurement of technical systems will provide the best value for money with low political risks?
- What organisation has the power to change the congestion charging policy?
- What organisation is responsible for collecting the revenues and how these are spent?



Fourth, a communication strategy and plan for creating the necessary problem awareness, congestion charging as a solution, and how to use the system will be of major importance. It is also not uncommon that a communication team drives part of or participates in the functional design process if external stakeholders and citizen opinions are included. While communicating about problem awareness and congestion charging as a solution are important components of democratic decision-making processes, communicating about how to use the system is of extreme importance if the congestion charging policy is actually going to work in practice. Figure 52 shows the example of how the National Road Administration monitored to what extent road users understood how the system would work. Do travellers understand where, when, and how much they will need to pay? Do travellers understand how they can pay and what happens if they do not pay? In order to monitor this, people are surveyed weekly on a number of key technical functions. The data were analysed for different segments and the communication strategy was adjusted

weekly. What do people not yet know well? Are there specific groups that do not yet understand sufficiently?

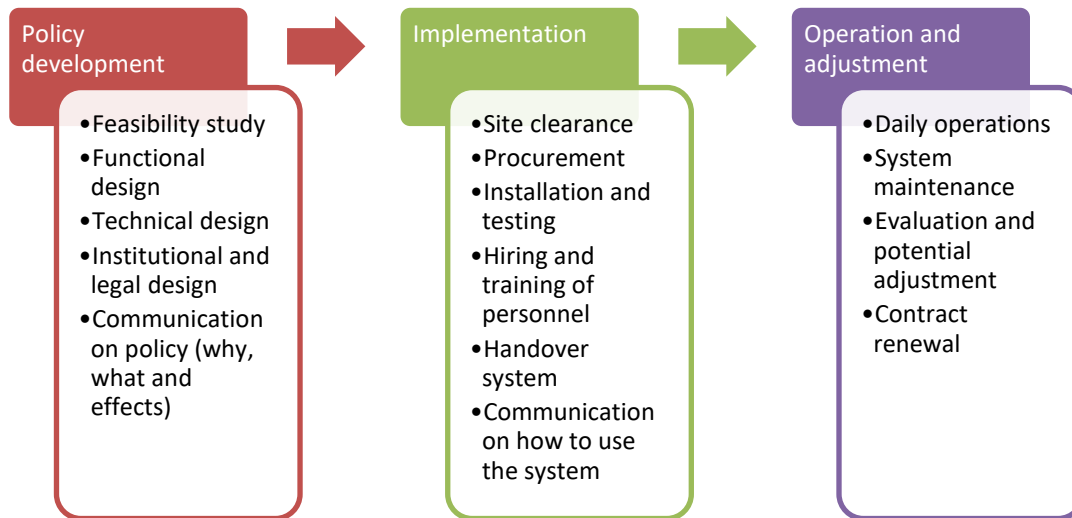
Figure 492: Monitoring if road users understand how the system will work in Stockholm



Source: GIZ, 2021

These four elements together define the congestion charging policy and road map for its implementation. Based on these studies, a clear and detailed policy recommendation can be put forward to policy makers, and if they decide favourably, the implementation and operation phases may follow as shown in Figure 53. The content of these phases depends on the results from the design phase, where also as a part roadside equipment needs to be procured and installed, a back-office needs to be built and personnel needs to be trained. Communication needs to be intensified and focus on how to use the system. Once the system is in operation, maintenance is needed, the effectiveness needs to be monitored and evaluated, and potential adjustment of the system needs to be planned and communicated.

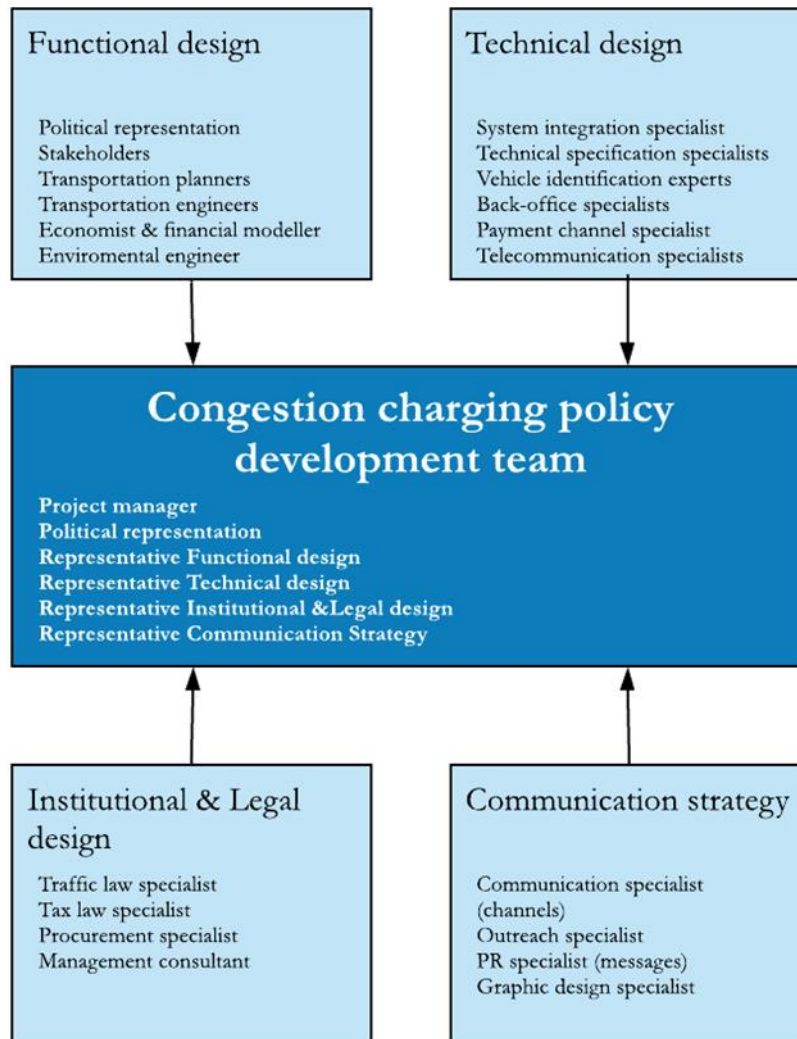
Figure 503: Getting to an implementation of congestion charging



Source: GIZ, 2021

Figure **Error! Reference source not found.**4 summarises the phase of designing a congestion charging policy regarding organization as well as assignment of roles and responsibilities in each of the four tasks or working groups.

Figure 514: Organisation and roles in congestion charging policy development



Source: GIZ, 2021

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Annex 1: Assumptions of the integrated financial and economic model

Table 21: List of assumptions of the integrated financial and economic model

No	Description	Comments	Category
1	Cost-benefit analysis based on a 20-year time horizon (starting in 2022) and a 2.1% discount rate back to 2020 THB. Fund forecast tabs displays values in real THB. Cost inflation is 2.1% which is the average rate of inflation in Thailand since 2000, according to the World Bank ³¹ .	Discount rate seems reasonable based on Thailand's BBB+ credit rating (S&P)	Model
2	Congestion charge revenue, costs, benefits of transportation speed increases, CO ₂ reductions, and PM reductions based on the average of each charge level (THB 50, 80, 120) for a given scenario. Net income, benefits of transportation speed increases, CO ₂ reductions, and PM reductions assumed to increase at 3% per annum due to increased ridership.		Congestion charge
3	Congestion charge pricing remains flat at either THB 50, 80, or 120 over the 20-year time horizon.		Congestion charge
4	Startup costs are based on the projected net income and ROI for the congestion charge.	Adjusted on Feb 14, 2020	Congestion charge
5	Benefit of reduced congestion based on "Value of Time and Service Quality for Bus Travel in Bangkok: Valuation and Policy Implications" article and congestion charge modeling results. Wait time and in-vehicle travel time assumed to be 51.6 minutes per trip. Wait time and in-vehicle travel time assumed to be reduced based on average Congestion Charge Modeling Results of each charge level (THB 50, 80, 120) for a given scenario for all years. Value of commuter's time assumed to be THB 76.2/hr. in 2015, and indexed to inflation. Number of	Yields very large benefits, even under conservative estimations	Congestion charge

31 <https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG>

No	Description	Comments	Category
	road trips assumed to be 11,426 Million/yr based on 2018 eBum results, assumed to increase at 3% per year based on increased ridership.		
6	Benefit of reduced traffic accidents based on Department of Land Transport statistics on private vehicle ownership in Bangkok, eBUM's forecasted increases in public transportation usage, and car insurance rates. All shifts from private to public transportation are assumed to reduce an equivalent portion of car insurance spend. Annual spend on car insurance assumed to be THB 6,570/yr/vehicle ³² . Ridership based on 2018 eBUM model, assumed to increase at 3% per year based on increased ridership. The socioeconomic benefit of reduced traffic accidents is assumed to be the equivalent reduction in total car insurance spend.	<p>Socioeconomic benefits of reduced accidents ranged from THB 0.2 to 100 Billion/yr. The most conservative estimation was used in this model. Alternative estimates include:</p> <p>1) THB 0.2 to 17 Billion based on comments from Deputy PM Prawit Wongsuwan³³.</p> <p>2) THB 0.6 to 56 Billion based on a 2015 study in Vancouver³⁴, index to inflation. CAD to THB conversion based on 23 Sept, 2019 value of 22.96 CAD to THB. Total benefit of reduced accidents is THB 50/trip for each increase in transit use.</p> <p>3) Up to THB 9 Billion based on 2013 study³⁵ measuring the impact of reducing alcohol related accidents.</p> <p>4) Up to THB 100 Billion based on 2018 World Bank article on reducing traffic fatalities³⁶</p>	Congestion charge
7	CO ₂ reduction yields a socio-economic benefit of \$50/ton in 2019 according to the Environmental Defense Fund ³⁷ . This figure is found to be aligned with the article entitled "Carbon tax		Congestion charge

³² <https://www.expatden.com/thailand/car-insurance/>

³³ <https://thethaiger.com/hot-news/road-deaths/thailand-aims-to-reduce-road-accidents-by-50-in-2020>

³⁴ <https://www.citylab.com/transportation/2015/04/the-social-costs-of-driving-in-vancouver-in-1-chart/389805/>

³⁵ [https://www.valucinhealthjournal.com/article/S1098-3015\(12\)03931-9/pdf](https://www.valucinhealthjournal.com/article/S1098-3015(12)03931-9/pdf)

³⁶ <https://openknowledge.worldbank.org/bitstream/handle/10986/29129/HighTolofTrafficInjuries.pdf?sequence=5&isAllowed=y>

³⁷ <https://www.edf.org/true-cost-carbon-pollution>

No	Description	Comments	Category
	incidence on household demand: Effects on welfare, income inequality and poverty incidence in Thailand". Conversion assumed to be THB 30/USD.		
8	PM reduction yields a socio-economic benefit of \$7,800/ton in 2025 according to a US study "Estimates of the shadow price of NOx and PM2.5 Emissions Reductions from U.S. Manufacturing". Conversion assumed to be THB 30/USD.	Another source measures the cost of emissions in PPB ³⁸	Congestion charge
9	Base case BTS/MRT ridership based on eBUM model. Assumed to increase by 2.8% based on modelled growth since 2015. Reduced fare scenario forecasted to increase ridership by 4% based on price elasticity model in congestion charge analysis.		BTS/MRT Fare Subsidy
10	Base case fare price assumed to be THB 30/ride. Reduced fare price assumed to be THB 15/ride.	Other "lost" revenue estimates have been THB 4 Billion/yr. ³⁹ . Other estimates of the subsidy costs are THB 0.9, 4, and 10 Billion/yr.	BTS/MRT Fare Subsidy
11	BTS/MRT operating costs based on 2018/19 Net Profit Margin ⁴⁰ . Cost assumed to be the same between base case and reduced fare scenario. Costs assumed to escalate by 2.8% per year with increased ridership.		BTS/MRT Fare Subsidy
12	Socioeconomic benefits of reduced congestion, accidents, CO ₂ and PM emissions based on scenario 2 and 3 from the congestion charge modeling. The increased public transportation usage for these scenarios is similar to the forecasted demand increases under a reduced BTS/MRT fare scenario.		BTS/MRT Fare Subsidy

38 https://www.pier.or.th/wp-content/uploads/2019/02/seminar2019_WitsanuAttavanich.pdf

39 <https://thethaiger.com/hot-news/transport/bts-15-baht-flat-rate-fare-is-nothing-new>

40 <http://www.btsgroup.co.th/en/investor-relations/financial-information/key-financial-ratios>

No	Description	Comments	Category
13	The Bus Modernization measure assumes complete electrification of all buses over a 10-year period. All buses start running in 2022 and are in service for 10 years. Leased buses from BMTA are used for 7 years according to a Bangkok Post article: "The agency will ask the BMTA board on May 23 to approve THB 7 Billion for leasing 400 hybrid buses, fueled by both diesel and electricity, and 300 natural gas vehicle (NGV) buses. These buses will be in service for seven years." Grutter's Comparison Hybrid and Electric with Diesel Bus tool recommends 12 years.		Bus Modernization
14	Overall bus fleet size assumed to increase 3% per year with increased ridership.	Congestion charge might drastically alter this projection	Bus Modernization
15	Electric and hybrid (conventional) buses cost THB 16.3 Million and THB 8.0 Million, respectively, based on a Bangkok Post article ⁴¹ .		Bus Modernization
16	Battery prices are assumed to continue reducing by 18% per year ⁴² . Battery prices currently account for 45% of the overall EV price according to "Innovative Financing for BRT and Market Opportunities for Indonesian Bus Builders". Capital costs are modeled to decrease over time with decreasing battery price.		Bus Modernization
17	Operational costs for conventional buses based on a 2018 Slovakian benchmark ⁴³ . Operational costs for EV buses assumed to be 70% of the conventional benchmark according to "Innovative Financing for BRT and Market Opportunities for Indonesian Bus Builders".		Bus Modernization
18	CO ₂ reduction for bus modernization based on Jimmy O'Dea's analysis ⁴⁴ . Assuming 60,000 km/yr based on the Grutter tool.		Bus Modernization

41 <https://www.bangkokpost.com/thailand/general/1674272/bmta-to-add-2k-buses-amid-fare-outcry>

42 <https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/>

43 <http://www.nasemore.com/wp-content/uploads/2018/11/20.-Potkany-Hlatka-Debnar-Hanzl.pdf>

44 <https://blog.ucsusa.org/jimmy-odea/electric-vs-diesel-vs-natural-gas-which-bus-is-best-for-the-climate>

No	Description	Comments	Category
19	PM/CO ₂ reduction ratio assumed to be proportional to the findings in the congestion charge analysis.		Bus Modernization

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