

New Mechanism Feasibility Study Final Report

New Mechanism Feasibility Study for Development of Mass Rapid Transit (MRT) Network in Bangkok, Thailand

By Japan Weather Association

1. Structure of Organization for this Study

Domestic:

- Nihon University: Study on quantification of amount of emission reduction and MRV methodology based on Transportation Demand Forecasting model and etc.
- ALMEC Corporation: Study on Transportation Demand Forecasting and MRV methodology based on simplification of CDM methodology
- Climate Consulting, LLC: Study on simplification of CDM methodology, and quantification of amount of emission reduction and MRV methodology based on simplified CDM methodology

Host Country:

- OTP (Office of Transport and Traffic Policy and Planning): Counterpart, provision of data regarding the plan for targeted MRT routes and cooperation on survey

2. Outlines of Project

2.1 Contents of Project

Item	Description
Host country	Thailand
Targeted area of the project and activity	Bangkok Metropolitan Area (1 capital and 5 prefectures)
Content of the project and activity and Scale of the facility	MRT Network Development plan in the Bangkok metropolitan area
Technology employing on the project and activity	Railway Technology
Envisioned counterpart and owner of the project and activity	Counterpart: OTP, Ministry of Transport, Thailand Owner: MRTA, SRT and/or BMA which is a candidate of the operator of planned MRT
Brief summary of the project and activity	MRT network development has never been targeted on CDM approach because of problems on boundary setting. Since MRT network development, however, used to create an improvement effect on local traffic conditions and an effect of modal shift according to increment of subway riders, it has already been recognized as the efficient measure to realize emission reduction in developed countries. On this project and activity, MRT network development is expected to help to reduce emission in the targeted area by reduction of amount of fuel consumption according to modal shift from existing road traffic

	to newly constructed MRT network and improvement of fuel economy according to smoothness traffic flow which is the traffic congestion improvement effect on neighboring area.
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2.2 Situations in Host Country

[The View of Thailand to New Mechanism]

In Thailand, TGO (Thailand Greenhouse Gas Management Organization) has possessed a deep understanding of the design of institutional arrangements on carbon offset mechanism such as New Mechanism domestically based on its capacity building, etc. In contrast, it was found that the difference between New Mechanism and NAMA was not understood by the participants of the meeting among related transportation organization including operators held at MOT during the first field study.

On the other hand, Thailand has been interested in establishment of CDM project in the transport sector and OTP (Office of Transport and Traffic Policy and Planning) has taken the lead in conducting the feasibility studies on establishment of CDM project.

- Feasibility Study on Potentiality and Opportunity of Clean Development Mechanism (CDM) in Transport Sector in Thailand: Development of Baseline for Transportation Projects Applicable to CDM, Phase II (OTP, Ministry of Transport, Thailand, 2009)

On the above mentioned study, OTP studied the case of the extension project of Blue line which is the subway in Bangkok and developed the Draft PDD based on ACM0016. After this study, MRTA (Mass Rapid Authority of Thailand) which is the operator of Blue line applied for the national approval to register the Blue line extension project as CDM project and it was approved by the Thai government.

According to the interview with MRTA about establishment of CDM project for the Blue line extension project on the first field survey, it was confirmed that establishment was suspended because of the problem of the cost for reviewing validation, etc.

Also, the policies which were approved by former government were reconsidered because of change of government at general election on July/2011. While former government depended on foreign demand, new government move their economical measures to economic growth led by domestic demand gradually.

As the measures regarding transport sector, reduction of fuel price for vehicles and huge discount of tax for the people who will newly buy a vehicle. However, those policies will be adequate only one year as tentative measures.

Lastly, according to our interview with Thai side, National Climate Change Committee established under ONEP will decide whether Thai government will be agree to bi-lateral offset mechanism or not.

2.3 Feasibility as New Mechanism

Generally, transport efficiency of MRT is usually higher than that of a passenger vehicle or a bus. Thus, introduction of MRT in the developing country in which transportation demand has increased is expected to reduce GHG emission.

There are many problems on MRV and CDM methodology ACM0016 for MRT project which are proposed in this study. Because of these problems, even MRT project has potential to reduce huge amount of GHG emission, CDM scheme could be applied for MRT project at only limited country or project and it is impossible to produce the credit. Therefore, it is expected to produce the credit by the New Mechanism. Addition to this, MRT project could not be realized without huge investment and technological support from developed country which mostly provided through ODA. MRT operation in the early stage used to be deemed unprofitable.

On the other hand, our government promotes participation to railway development in foreign country. It is expect that huge amount of emission reduction could be obtained if bi-lateral offset credit will be established and it will be applied for railway construction in developing city with technology transfer from Japan. Furthermore, it is expected to have huge merit to improve profitability on operation of the railway to get additional revenue by selling bi-lateral offset credit. Also, it is expected to have great contribution for sustainable development of the host country trough revitalization of the regional economy, improvement of regional environment and so on. Given these facts, it is recognized that this study or MRT construction project has enough qualification for New Mechanism.

2.4 Promotion Measures for the Study and Activity

By establishing MRV approach for a railway project and presenting the thread to apply bi-lateral offset credit mechanism through this study, impact of GHG emission reduction can be used as bi-lateral offset credit at the city in which CDM can't be applied at moment. Also, by improving profitability of railway operation in the early stage by bi-lateral offset credit, it is expected to promote urban railway construction in many countries.

In this study, the approach to estimate future traffic demand based on demand forecasting model was employed. Data which is required to estimate traffic demand has been properly developed in Bangkok comparing with other developing city. Thus, in this study, ideal conditions were presented with the idea of application in other developing city in which data has never been developed properly. By this, it is easy to identify the conditions to apply to other city (what kinds of data should be prepared) and the potential for promoting MRV which was developed in this study to other city will be increased.

3. Contents of Study

3.1 Research Subjects :

We recognized as follows;

- Collection of information for calculation of emission reduction : In the MRT development plan, the number of passengers, modal share, trip length, etc. are examined, and summarized in the feasibility study (hereafter F/S). For development of MRV, these data as well as data on the existing MRT operation should be prepared.
- Understanding the transportation situation to the climate change in Thailand: Although the movement which aims to CDM in the transport sector has been understood, the present condition and principle of the policy should be confirmed.
- Situation of MRT development based on M-MAP: In Thailand, the infrastructure plan often has been changed by change of government, etc. Therefore, FS is carried out again whenever the plan changed. And it is supposed that the released FS is not always the latest one. Thus, collection of the latest information through interview with relevant organizations and observation of the progress of the project by field survey are necessary.
- Handling of Dead-end Soi of Network : Dead-end Soi has never been included on the networks which were developed for existing studies. It is understood that the distance to zone centroid represents access transport but emission was usually not estimated on this part. It is necessary to estimate emission from access transport by setting modal share for access transport by zones.
- Handling of logistics : This is one of problem to carry out transportation demand forecasting.
- Assumptions for Transportation demand forecasting : It is necessary to obtain essential data for transportation demand forecasting such as OD table, etc. from Thai universities and validate them.
- Management for Transportation demand forecasting : It is emphasized on how to verify emission reduction which is calculated as the difference between with and without the project for the development of MRV based on Transportation demand forecasting. And, emission reduction should be estimated in advance.
- Possibility of applying top-down and bottom-up approaches in Bangkok Metropolitan Area : It is necessary to confirm possibility to estimate emission from the transport sector of BMA by applying the top-down approach based on total fuel consumption and the bottom-up approach based on driving distance of each vehicle.
- Handling of traffic congestion reduction effect : Since traffic congestion reduction effect can't be counted on existing CDM methodology, measurement of traffic congestion reduction effect is not approach in accordance with CDM. Thu, it is necessary to explain feasibility of measurement more theatrically.

- Handling of modal-shift effect : Since interview survey, traffic count survey, etc. are not required any advanced knowledge or experience and used to be carried out in Bangkok, those survey techniques are monitoring approaches to apply widely. However, they directory affect workforce and cost so that it is necessary to examine frequency of a survey as well as accuracy carefully.
- Reference scenario Setting : It is necessary to estimate the costs for 2 monitoring methods which were developed based on existing cases and the situation in Bangkok. It is necessary to set up the reference scenario based on the exiting studies regarding future estimation at Bangkok.
- Evaluation of co-benefits : It is feasible to evaluate co-benefit regarding on road side emission spatially which can be obtained from calculation of air diffusion based on travel speed and traffic volume on links from Transportation demand forecasting.
Benefit assessment related to traffic : It is necessary to obtain the basic units to calculate benefits regarding transportation from exiting information and evaluate them quantitatively.

3.2 Study contents:

In this study, field surveys were carried out for above mentioned study subjects and solve each of them.

- Information gathering for calculation of emission reduction: In the MRT development plan, the number of passengers, modal share, trip length, etc. are examined, and summarized in F/S. For development of MRV, these data as well as data on the existing MRT operation should be prepared. Required data was collected with cooperation of Thai counterparts.
- Understanding of the situation of the transport sector to the climate change in Thailand: Although the movement which aims to CDM in the transport sector has been understood, the present condition and principle of the policy should be confirmed. Thus, the situation was obtained through interviews with related organizations.
- Situation of MRT development based on M-MAP: In Thailand, the infrastructure plan often has been changed by change of government, etc. Therefore, FS is carried out again whenever the plan changed. And it is supposed that the released FS is not always the latest one. Thus, the latest information was collected through interviews with relevant organizations and progress of the project was observed by field survey.
- Handling of Dead-End Soi of Network: In this study, emission from Dead-end Soi was not considered. By this, total emission could not be estimated. However, it is not much difference on emission from dead-end soi with and without cases because the number and driving speed of Songtheo or Siro-lek which will be operated on the Dead-end soi will not be change. Thus, it will not affect estimated emission reduction itself.
- Handling of logistics: This is one of problem to carry out transportation demand

forecasting, and arranged it.

- Assumptions for Transportation demand forecasting: It is necessary to obtain essential data for transportation demand forecasting such as OD table, etc. from Thai universities and validate them. Then we carried out Transportation demand forecasting.
- Management for Transportation demand forecasting : It is emphasized on how to verify emission reduction which is calculated as the difference between with and without the project for the development of MRV based on Transportation demand forecasting. And, emission reduction was estimated in advance. On the other hand, data which has to be collected for Transportation demand forecasting was summarized
- Possibility of applying top-down and bottom-up approaches in Bangkok Metropolitan Area : To estimate GHG emission from the transport sector of BMA, the existing studies in Bangkok (e.g. Dr. Nuwong) applied the top-down approach based on total fuel consumption and the bottom-up approach based on driving distance of each vehicle. Also, It is confirmed data regarding fuel consumption can be obtained from “Thailand Energy Statistics 2010” developed by Department of Alternative Energy Development and Efficiency (DEDE) and CO2 emission in Bangkok was estimated based on fuel consumption. Although it is possible to apply the bottom-up approach based on driving distance of each vehicle, emission was not estimated using this approach because driving distance was not measured.
- Handling of traffic congestion reduction effect : Since traffic congestion reduction effect can't be counted on existing CDM methodology, measurement of traffic congestion reduction effect is not approach in accordance with CDM. Thus, it is necessary to explain feasibility of measurement more theoretically. Traffic congestion reduction effect was estimated based on the extent of the impact of MRT project which was obtained as the result of Transportation demand forecasting.
- Handling of modal-shift effect (Monitoring): Since interview survey, traffic count survey, etc. are not required any advanced knowledge or experience and used to be carried out in Bangkok, those survey techniques are monitoring approaches to apply widely. However, they directly affect workforce and cost so that it is necessary to examine frequency of a survey as well as accuracy carefully. In this study, sample size for interview survey was confirmed based on statistic theory. And, monitoring approach which will not use interview survey was examined.
- Monitoring (Monitoring Cost): The costs for 2 monitoring methods which were developed were estimated based on existing cases and the situation in Bangkok.
- Reference scenario Setting: The existing studies regarding future estimation at Bangkok were obtained. And it was confirmed that BaU will be applied as reference scenario
- Evaluation of co-benefits: Co-benefits regarding on road side emission were assessed spatially by calculating air diffusion based on estimated travel speed and traffic volume on

links from Transportation demand forecasting.

- Assessment of benefits regarding transport : To calculate benefits regarding transportation, the basic units were obtained from exiting information and evaluated quantitatively.

4. Results for Investigation of Development of Mass Rapid Transit (MRT) Network in Bangkok

In this study, the Monitoring, Reporting, and Verification (MRV) is carried out by using two approaches such as transportation demand forecasting and simplified ACM0016. The MRV procedure by each approach along with emissions reduction calculation results are shown in below.

4.1 Analysis Results by Transportation Demand Forecasting Approach

4.1.1 Emissions Reduction caused by Implementation of Project

(1) Reason for Emissions Reduction Effect caused by Implementation of Project

By MRT network development, emissions can be reduced by the following factors.

- **Modal-Shift Effect:** Reduction of CO₂ emissions can be expected because a passenger moves to a more efficient means of transport (MRT) from the conventional means of transportation (bus, passenger car, etc.) in which energy consumption and CO₂ emissions are relatively high.
- **Traffic Congestion Mitigation Effect:** The traffic congestion around MRT routes can be mitigated by MRT network development. Consequently, average travel speed of passenger car can be improved and the CO₂ emissions reduction can be expected. If the more MRT network implementation, the more increases in average travel speed of passenger car on the whole road network. In this case, however, it carefully needs to be considered that the consequences of an increase in total vehicle km travel. Therefore, it is necessary to figure out whether it has more CO₂ emissions reduction effect by improvements of average travel speed.

(2) Outline of the Verification Method

For the road and MRT network of the Bangkok Metropolitan Area (BMA), future travel demand is estimated by transportation demand forecasting model. Firstly, the average travel speed and average daily traffic volume of each link are calculated. Afterwards, average daily traffic volume for each link is multiplied with the emission factor which depends on the average travel speed and then calculates the CO₂ emissions of each link for both with- and without-project cases. Finally, the difference in total CO₂ emissions reduction is compared between with- and without-project cases.

In order to estimate future travel demand, this study is adopted the existing methodologies of travel demand forecasting as Standard-Four-Stages model. The current and future OD matrix is estimated by the local government or Japan International Cooperation Agency. The large-scale urban development by MRT routes is not taken into consideration in estimation of OD matrix (although changes of demographic and socio-economic factors are regarded), it is necessary to develop large-scale regional models such as Spatial Computable General Equilibrium (SCGE) model.

The modal shift effect will be taken into consideration in the process of modal split classified by means of transportation, and the traffic congestion mitigation effect will be taken into consideration in the stage of the traffic assignment. However, from the viewpoint of considering the changes of route due to congestion mitigation around MRT route, it is necessary to use user equilibrium state while calculating for traffic assignment.

(3) Methodology for Estimating Emissions Reduction

The amount of CO₂ emission reduction is estimated by using the results of transportation demand forecasting model. The applicability of the results is also demonstrated in this study.

The outline of analysis for the case of using the estimation results by transportation demand forecasting and methodology is as shown in Table 4.1.

Table 4.1 – Analysis Outline and Methodology

	When using the results of transportation demand forecasting model	Overview of Methodology
Emission reduction calculation	<ul style="list-style-type: none"> ✧ Appropriate consideration of the rebound effect ✧ Consideration of local traffic conditions, i.e. egress transportation 	✧ Inclusion of the effect of road congestion mitigation: Measured by simulation method + survey
Monitoring	✧ Limit of verification based on observed values of traffic volume and average travel speed	✧ Monitoring procedures based on average vehicle km travel and fuel consumption
Additional proof	✧ Since stringent conditions imposed by the analysis, it cannot be applied in many countries.	✧ As for further studies, in a new mechanism, whether additional proof is necessary to consider in detail

In order to evaluate quantitatively for the changes in traffic volume from the private car to MRT route, the standard-four-stages model is built and traffic simulation is executed. The road and MRT network for Bangkok metropolitan area (BMA) and OD matrix are developed in the M-MAP formulated by OTP. In addition, VISUM which is travel demand modeling software based on the Standard-Four-Stages method is used in this study in order to estimate existing and future travel demand.

4.1.2 Reference Scenario and Set up Boundary

(1) Setting Reference Scenario

According to "Law-Carbon Society Vision 2030 Thailand" (November, 2010), estimation is performed for 2030 in the BaU scenario and CM scenario with the target year for Bangkok in the future. This project is applied to this future estimation, promotion of the modal shift of the passenger transport in CM scenario. Therefore, in order to be consistency with the existing future estimation in Thailand, the reference scenario of this project is set up as follows.

- Reference scenario: BaU scenario (a MRT project does not exist)
- Project scenario: CM scenario (state which undertook the MRT project in the BaU scenario)

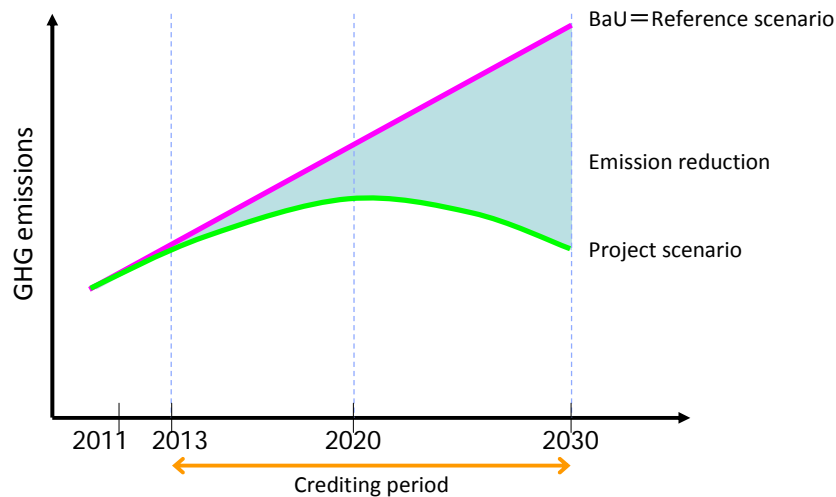


Figure 4.1 Project Implementation Structure

(2) Setting the Boundary

The various measures in the transport sector are planned in Thailand and Bangkok metropolitan area as mentioned above. It is desirable to set up based on preliminary investigation and the influence of these measures, etc. when setting up the boundary. However, in this project, the boundary was set up focusing on the modal shift effect due to MRT network development. That is, because the MRT line to be targeted by this project are spread across five prefectures of Bangkok metropolitan area, the boundary was set as the five prefectures of Bangkok metropolitan area where is affected by traffic conditions.

4.1.3 Monitoring Methodology and Planning

In this study, monitoring method is proposed to consider for the following three aspects.

- **Traffic volume:** After project starts, traffic volume and average travel speed of private car is investigated and the estimated results which obtained from transportation demand forecasting model is monitored. Monitoring is performed only on the main trunk roads on a screen line. Traffic volume of the road section and vehicle travel speed is observed by the traffic volume count survey on weekdays.
- **Fuel consumption:** The annual total fuel consumption by fuel type after project initiation is investigated, and is monitored compared with the total fuel consumption of the project case which obtained from the estimation result of the transportation demand forecasting model.
- **Average travelling distance:** After project starts, average vehicle km travel is investigated by vehicle type.

4.1.4 Greenhouse Gas Emission and Its Reduction

Emission calculation formulas are described as follows. Regarding the estimation of emissions reduction is currently under calculation.

The amount of emissions reduction for the whole MRT network in Bangkok as well as for the whole country can be estimated by applying the following formulas for each project.

In Bangkok, para-transit service is operating as a feeder system to connect the main trunk road with Soi street. Although it has a certain amount of CO₂ emissions, it is not taken into consideration in the transportation demand forecasting model in this study. Since para-transit service is registered at the Department of Land Transport under Ministry of Transport, it can be estimated the amount of emission based on these registered vehicle numbers. Dead-end soi in the network is also not regarded in this study. In case of Sothew or Silo-lek, the number of operating vehicles will not be changed regardless of the number of passengers and average travel speed also has no changes. Additionally, regarding private car use, the amount of CO₂ emissions is estimated based on the generating and terminating traffic volume and distance given to zone centroid.

① Reference Scenario Emissions

(a) Emissions from Road Users

It computes the amount of emission of the target road section which is determined in advance. In here, it is assumed to use daily traffic volume. However, if hourly traffic volume is available, it can also be used for calculation.

$$BE_{road,y} = \sum_i \sum_j (D_i \times TVb_{i,j} \times EF(v)_{KM,i,j} \times 10^{-6}) \times 365$$

$BE_{road,y}$: Baseline emissions from whole road network in year y (tCO₂/year)

D_i : Length of route i (km)

$TVb_{i,j}$: Baseline traffic volume of vehicle j in route interval i (vehicle/day)

$EF(v)_{KM,j}$: Emission factor for baseline travel speed $Vb_{i,j}$ of vehicle j in route interval i (gCO₂/km)

② Project Emissions

(a) Emissions from MRT Operation

The amount of emissions from MRT operation is calculated.

$$PE_{MRT,y} = EC_{MRT,y} \times EF_{grid}$$

$PE_{MRT,y}$: Project emissions from MRT operation in year y (tCO₂/year)

$EC_{MRT,y}$: Power consumption by MRT operation in year y (MWh/year)

EF_{grid} : CO₂ emission factor for electric power system (tCO₂/MWh)

(b) Emissions from Road Users

It computes the amount of emission of the target road section which is determined in advance.

$$PE_{road,y} = \sum_i \sum_j (D_i \times TVp_{i,j} \times EF(v)_{KM,i,j} \times 10^{-6}) \times 365$$

$PE_{road,y}$: Project emissions from road network in year y (tCO₂/year)

D_i : Length of route i (km)

$TVp_{i,j}$: Project daily traffic volume of vehicle j in route interval i (vehicle/day)

$EF(v)_{KM,j}$: Emission factor for project travel speed $Vp_{h,i,j}$ of vehicle j in route i (gCO₂/km)

③ Leakage

Leakage is not particularly counted.

④ Emissions Reduction

Emissions reduction is calculated by the following formula.

$$ER_y = BE_y - PE_y$$

$$= (BE_{MRT,y} + BE_{road,y}) - (PE_{MRT,y} + PE_{road,y})$$

ER_y : The amount of Greenhouse gas emissions reduction in year y (tCO₂/year)

BE_y : The amount of reference scenario emissions in year y (tCO₂/year)

PE_y : The amount of project emissions in year y (tCO₂/year)

Baseline emission from road users for the current condition (2010), reference scenario emissions (BE_{road}) and project scenario emissions (PE_{road}) for year 2020 and 2030 are calculated by using transportation demand forecasting results mentioned above. These emissions amount are shown in Table 4.2.

Table 4.2 – The amount of annual CO₂ emissions by road users (Unit: t-CO₂/year)

Present condition	Year 2020 Estimation		Year 2030 Estimation	
	BE_{road}	PE_{road}	BE_{road}	PE_{road}
13,317,246	18,251,177	12,736,649	25,279,356	17,453,825

Additionally, the amount of CO₂ emissions in Bangkok and the whole Thailand were estimated based on “Thailand Energy Statistics 2010” by Department of Alternative Energy Development and Efficiency (DEDE) and the statistics is as follows.

- The whole Thailand : 58,843,664 t-CO₂/year
- Bangkok : 13,212,094 t-CO₂/year

4.1.5 Monitoring-Reporting-Verification (MRV) Technique for Emissions Reduction Effect

(1) Contents of MRV Technique

① Monitoring

It is as shown in 4.1.1, 4.1.3, 4.1.4. In addition to the monitoring procedures by using traffic volume and average travel speed, the other methods which used fuel consumption and average vehicle km travel is also considered in this study and finally proposed a method which can be implemented.

② Reporting

The process such as pre- and post- report is carried out.

③ Verification

Although verification is necessary for transportation demand forecasting process and the monitored values, it also needs to be considered to link with the current city comprehensive transport system study and person trip survey, etc.

(2) Basis Consideration for the Appropriateness of Proposed MRV Technique

In this study, transportation demand forecasting model which is the prerequisite for MRV is a

research method which has been developed over many years based on logical frameworks such as user equilibrium theory. Moreover, when estimating the impact of traffic demand due to MRT network development in many developed countries, this method is widely used. Therefore, the estimation of CO₂ emissions based on this method can be appropriate. In addition, the monitoring method which includes the surveying method and statistical data is also commonly used; therefore proposed MRV method is reasonable.

(3) Basis Consideration for Acceptable in Host Country for MRT Network Development

Many MRT routes are considered to develop in Bangkok, however, CDM methodology ACM0016 etc., firstly estimate for each route and then accumulated for the whole network. Consequently, the amount of emission reduction will become limited (about 1~2% of the total). For this reason, estimating the amount of CO₂ reduction as the whole network is strongly necessitated for from a viewpoint of measuring against global warming. The Ministry of Transport, Thailand government has also conducted such investigation. However, in the concept of existing MRV technique, the CDM methodology is difficult to estimate the amount of emission reduction as the whole network, and the approved methodology also does not exist. Therefore, as if the proposed MRV technique is appropriate to estimate the amount of emission reduction for such a case, it is supposed to be totally acceptable method in Thailand.

(4) Consideration about whether Proposed MRV Technique adopted International MRV Guidelines

Proposed MRV technique is not basically accepted by CDM methodology. There are several reasons for this. One of the critical issues is accuracy of transportation demand forecasting results. In case of the estimation method based on traffic volume and average travel speed, the accuracy of these estimated results is not high enough for the reliability of the methodology itself especially. These values vary greatly according to season, a day of the week, etc., but it does not estimate for a specific day. Therefore, it is necessary to explain the validity by creating MRV which provide a proper estimation of the amount of CO₂ emission reduction and using more theoretically clear transportation demand forecasting method.

4.2 Analysis Results by Simplified ACM0016 Approach

4.2.1 Emissions Reduction caused by Implementation of Project

(1) Reason for Emissions Reduction Effect caused by Implementation of Project

By MRT network development, emissions can be reduced by the following factors.

- **Modal-Shift Effect:** Reduction of CO₂ emissions can be expected because a passenger moves to a more efficient means of transport (MRT) from the conventional means of transportation (bus, passenger car, etc.) in which energy consumption and CO₂ emissions are relatively high.
- **Traffic Congestion Mitigation Effect:** The traffic congestion around MRT routes can be mitigated by MRT network development. Consequently, average travel speed of passenger car can be improved and the CO₂ emissions reduction can be expected. On the other hand, there is a possibility that emissions can be increased since usage of private car increase by congestion mitigation.

(2) Outline of the Verification Method

- **Modal-Shift Effect:** By referring CDM approved methodology ACM0016 etc. which can be applied to MRT project, questionnaire survey mainly in project area are conducted and method for estimating emissions reduction is certified. Questionnaire survey was mainly focused on MRT passengers to ask their travel patterns including how they get their destination what if there is no MRT lines.
- **Traffic Congestion Mitigation Effect:** The impact on the surrounding roads caused by MRT network development is identified by transportation demand forecasting model. After that, the target road is determined and traffic volume and average travel speed survey are conducted on these roads. Clarifying the difference of the speed between reference scenario and project scenario proves traffic congestion mitigation effect.

(a) Methodology for Verification of Emissions Reduction Effect

Methodology was examined to clarify the issues of the approved methodology ACM0016 which is related to MRT and to increase the feasibility of the project. Specifically, ACM0016 Version 3 was examined with the following issues.

- Simplified calculation method for emissions reduction
- Simplified monitoring
- Improve Additional proof method

4.2.2 Setting up Reference Scenario and Boundary

Setting up for reference scenario and boundary is as shown in 4.1.2.

4.2.3 Monitoring Methodology and Plan

(1) Monitoring Methodology

- Modal-shift effect: Monitor with the data by the questionnaire survey and MRT operating company. The details of each parameter are shown in Table 4.3. Questionnaire survey is consistent with ACM0016. The information about the number of samples are shown in passenger surveys 4.2.3 (3).
- Traffic congestion mitigation effect: Mainly monitor by the traffic census and automobile average speed survey in the reference and project scenarios. In addition, it should be noted that (road section) is determined in advance for transportation demand forecasting model.

(2) Monitoring Items and Frequency

Table 4.3 – Monitoring. Parameter

Parameter	Description	Monitoring Procedures/Frequency
$BPKM_y$	Traffic volume of MRT in year y (passenger-km/year)	Aggregated data by MRT operating company ✂It is assumed that if this data cannot be collected, it will be estimated from P_y and BTDP.
P_y	Total number of passengers of MRT in year y (passenger/year)	Aggregated data by MRT operating company
$MS_{i,y}$	Reference scenario modal share (%)	Passenger Questionnaire Survey: within one year and the fifth year after project initiation
BTDP	Average trip distance per passenger p using MRT (km)	If $BPKM_y$ cannot be obtained, estimated from passenger surveys: within one year and fifth year after project initiation
$EC_{MRT,y}$	Power consumption by MRT operation in year y (MWh/year)	Aggregated data by MRT operating company
$TV_{PJ,hour,i,j}$	Project traffic volume of vehicle type j, interval i (vehicles/day)	Traffic census: carry out less than 1 year and fifth year after project initiation
$V_{p_{h,i,j}}$	Project speed of vehicle type j, interval i (km/h)	Automobile average speed investigation: Carry out less than one year and five years after project initiation.
$EC_{MRT,y}$	Power consumption by MRT operation in year y (MWh/year)	Amount of consumption data by company (measured value or an electric power company bill/invoice)

Table 4.4 –Parameters to be determined in advance

Parameter	Description	Determination method
D_i	Route length of the route interval i (km)	Prepared by Project members
$EF_{PKM,i}$	CO ₂ emission factor per passenger-km of mode i (gCO ₂ /passenger-km)	Official published value in developing countries or prepared by project members
EF_{grid}	CO ₂ emission factor for electric power system (tCO ₂ /MWh)	Emission factor in target countries (According to the method of CDM)
$V_{b_{h,i,j}}$	Reference scenario speed of vehicle type j, the time h, interval i (km/h)	It is an observed value before project implementation or by transportation demand forecasting model before project implementation
$EF(v)_{KM,j}$	CO ₂ emission factor for travel speed v (gCO ₂ /km)	The value in target countries. If it cannot be obtained, international data can be used (for example: EMEP / EEA emission inventory guidebook - 2009) ✂ It is also possible to calculate by (CO ₂ emission factor of fuel × fuel consumption rate).

(3) Passenger Questionnaire

Table 4.5 – Questionnaire Cost and Annual CER Income

No. of samples	Questionnaire cost	Annual CER income	
		Case (i)	Case (ii)
6,500	About 4,800,000	4.30 million Yen (429,730 tCO ₂ /year)	
1,000	About 1,300,000	2.89 million Yen (288,534 tCO ₂ /year)	3.30 million Yen (329,527 tCO ₂ /year)

※Case (i): The amount of emission from taxi is not regarded.

※Case (ii): The value of bus which is the most conservative coefficient is substituted for emission coefficient of taxi.

① survey frequency

Although the survey frequency was annually in Version 2, it has been reduced significantly in Version 3 from twice in the first year and fourth year. However, survey frequency should be twice in the first year and fifth year so that this can also meet Bilateral Offset Credit Mechanism (BOCM).

(4) Monitoring Plan

Monitoring plan for MRT project is shown in Table 4.6.

Table 4.6 – Monitoring Plan

Item	Contents
Project implementation structure	General management : MRT operating company (MRTA etc.) Measurement : MRT operating company or consultant Questionnaire survey : consultant Quality control : MRT operating company or consultant Data aggregation • calculation • creating annual report : consultant
Monitoring items/frequency	As shown in 4.2.3(2)
Questionnaire survey	As shown in 4.2.3(3)
Traffic volume/speed survey	As shown in 4.2.3(4)
Monitoring procedure	1. Specifying data for collection 2. Conducting questionnaire survey 3. Checking the quality of the data 4. Saving data (electronic and hard copy) 5. Calculating the amount of emission reductions 6. Creating annual report (creating monthly report, if necessary) 7. Checking the quality of the annual report

(5) The basis policy which can be carried out in host country and extensive application

There have been conducted similar survey regarding MRT passengers in Bangkok, Thailand and reasonable results have been obtained. Moreover, there are also a lot of researches for traffic volume count survey in Bangkok. Since those surveys are not necessary to have advanced knowledge, monitoring methodology is applied widely. However, since it is directly related with the labor or cost, it needs to be considered carefully while implementing survey to ensure the accuracy for the collected data.

4.2.4 Green House Gas Emissions and Reduction

(1) Calculation Method for Emissions Reduction

① Reference Scenario Emissions

(a) Modal Shift Effect

$$BE_{MD,y} = \sum_i (BPKM_y \times MS_{i,y} \times EF_{PKM,i} \times 10^{-6})$$

$$= \sum_i (P_y \times BTDP \times MS_{i,y} \times EF_{PKM,i} \times 10^{-6})$$

$BE_{MD,y}$: Emissions from other means of transport if there is no MRT (tCO₂/year)

$BPKM_y$: Traffic volume of MRT in year y (passenger-km/year)

$MS_{i,y}$: Reference scenario modal share (%)

$EF_{PKM,i}$: Emission factor per passenger-km of mode i (gCO₂/ passenger-km)

P_y : Total number of passengers of MRT in year y (passenger/year)

$BTDP$: Trip distance per passengers p using MRT (km)

i : 1; Bus, 2; Motorcycle, 3; Passenger car etc.

➤ Determination of the Emission Factor per passenger-kilometer ($EF_{PKM,i}$)

Option 1: Published value for developing countries

Option 2: Estimated and observed the average number of passengers per transport, by the following formula to calculate the CO₂ emission factor per passenger-kilometer

$$EF_{PKM,i} = \frac{EF_{KM,i}}{OR_i}$$

$EF_{KM,i}$: Emission factor per km of vehicle category i in year y (gCO₂/km)

OR_i : average vehicle numbers of vehicle category i (passenger)

(b) Road Congestion Mitigation Effect

It computes the amount of emission of the target road section which is determined in advance and integrated.

$$BE_{CC,y} = \left[\sum_i \sum_j (D_i \times TV_{PJ,i,j} \times EF(v)_{KM,i,j} \times 10^{-6}) \right] \times 365$$

$BE_{CC,y}$: Emissions amount from surrounding roads at the time of reference scenario (tCO₂/year)

D_i : Link length of the route section i (km)

$TV_{PJ,i,j}$: Project traffic volume of vehicle type j, interval i (vehicle/day)

$EF(v)_{KM,j}$: Emission factor for reference scenario travel speed $V_{b_{i,j}}$ of vehicle j in route interval i (gCO₂/km)

① Project Emissions

(a) Modal Shift Effect

The amount of emissions from MRT operation is calculated.

$$PE_{MRT,y} = EC_{MRT,y} \times EF_{grid}$$

$PE_{MRT,y}$: Project emissions from MRT operation in year y (tCO₂/year)

$EC_{MRT,y}$: Power consumption by MRT operation in year y (MWh/year)

EF_{grid} : CO₂ emission factor for electric power system (tCO₂/MWh)

(b) Road Congestion Mitigation Effect

It computes the amount of emission of the road section which is determined in advance and integrated.

$$PE_{CC,y} = \left[\sum_i \sum_j (D_i \times TV_{PJ,i,j} \times EF(v)_{KM,i,j} \times 10^{-6}) \right] \times 365$$

$PE_{CC,y}$: Emissions amount from surrounding roads at the time of project (tCO₂/year)

D_i : Link length of the route Section i (km)

$TV_{PJ,i,j}$: Project traffic volume of vehicle type j, interval i (vehicle/hr)

$EF(v)_{KM,j}$: Emission factor for project travel speed $V_{p,i,j}$ of vehicle type j in route interval i (gCO₂/km)

② Leakage

Leakage emissions are not considered. Road congestion mitigation effect is included in reference scenario emissions and project emissions.

③ Emission Reductions

Emission reduction is calculated with the following formula.

$$ER_y = BE_y - PE_y$$

$$= (BE_{MD,y} + BE_{CC,y}) - (PE_{MRT,y} + PE_{CC,y})$$

ER_y : The amount of Greenhouse gas emission reductions in year y (tCO₂/year)

BE_y : Baseline emissions in year y (tCO₂/year)

PE_y : Project emissions in year y (tCO₂/year)

(2) Estimation of Emission Reductions in Bangkok

① Modal Shift Effect

Emission reductions are calculated for each of the following 3 cases and shown in Table 4.7.

Case 1 : Ferry and para-transit are excluded from the past questionnaire survey results.

Case 2 : With a low sharing rate such as taxi (4.1%) and two-wheeled vehicle (5.4%) are excluded from Case 1.

Case 3 : All are assumed to be shifted from bus.

The average annual amount of emission reduction for base case (Case 1) is 429,730 tCO₂.

Table 4.7 – Overview of Emission Reductions (ER_v : tCO₂/year)

	Case 1 (Base case)	Case 2 (Excluding taxi etc.)	Case 3 (Bus Limitation)
2014	85,021	58,435	29,429
2015	135,436	92,878	46,445
2016	222,186	152,020	75,467
2017	298,247	203,586	100,305
2018	325,817	221,875	108,468
2019	395,563	268,712	130,311
2020	421,010	285,284	137,200
2021	441,488	298,395	142,274
2022	458,536	309,106	146,071
2023	493,266	331,627	155,271
2024	519,851	348,541	161,633
2025	558,705	373,538	171,511
2026	595,627	397,076	180,446
2027	617,512	410,449	184,534
2028	643,294	426,292	189,531
2029	664,123	438,728	192,811
Average	429,730	288,534	134,482

② Traffic Congestion Mitigation Effect

The traffic congestion around MRT routes can be mitigated by MRT network development. Consequently, average travel speed of passenger car can be improved and the CO₂ emissions reduction can be expected. In here, emissions reduction effect for 2020 case is calculated focusing on specific lines (red line, blue line, purple line, and green line) and target area.

Table 4.8 Total Emission Reduction Amount (Modal Shift Effect + Traffic Congestion Mitigation Effect) (tCO₂/year)

	Modal Shift Effect (Case 1)	Traffic Congestion Mitigation Effect	Total
red line	80,931	15,606	96,537
blue line	77,964	12,426	90,390
purple line	65,983	7,960	73,943
green line	53,746	3,914	57,660

4.2.5 Monitoring, Reporting and Verification (MRV) of Emission Reduction Techniques

(1) Monitoring (M)

Points of measurement are shown in below.

① Modal Shift Effect

The reference scenario emissions are calculated based on the annual passenger transported (passenger-kilometre) or the surveyed MRT passengers, reference scenario trip distance per surveyed passenger using MRT, and the net share of passengers in the year y . The annual passenger transported is basically collected from MRT operators. If the data is not available, this parameter will be estimated based on both the MRT passengers and reference scenario trip distance per surveyed passenger using MRT. In this case, the MRT passenger data should be collected from MRT operators. The average travel distance should be determined based on passenger interview survey.

The passenger interview survey is one of the important factors for the calculation of the reference scenario emissions. In order to determine a modal share in the reference scenario, the passenger interview survey will be conducted. As mentioned in 4.2.3 (3), how to set a realistic sample size of the passenger interview survey will be an issue. In order to reproduce the transportation mode such as taxi or motorcycle that has a small modal share, a large number of samples is needed. In case of reproducing a transportation mode whose share is 5%, the sample size will be about 5,000 samples. To eliminate emissions of such a small transportation mode as the conservative approach can decrease in the sample size of the passenger interview survey. In case of the Bangkok MRT project case, if the modal share of passenger car (20%) is set in the lowest share, the sample size could be decreased in about 1,000 surveys.

On the other hand, EF_{PKM_i} (Emission factor per passenger-kilometre of mode i) is also one of the important parameters for calculating the reference scenario emissions. In developing countries, it is considered that default values (Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities (GTZ, 2007), etc.) or emission factors developed in neighboring countries apply to calculations of CO₂ emission. In case of the application of emission factors developed in neighboring countries, it is essential to confirm the similarity of traffic characteristic, vehicle type, vehicle age between the host country and the neighboring country. In Thailand, vehicle emission factors have already developed. Therefore the emission factors can be applied in this project.

Project emissions should be calculated based on the electricity consumption of MRT and grid emission factor. The electricity consumption data by MRT operation should be collected from MRT operator. The electricity consumption data should be collected from MRT operators.

② **Traffic Congestion Mitigation Effect**

The traffic congestion around MRT routes can be mitigated by MRT network development and it estimates the emissions reduction by the average running speed of a car by conducting automobile speed survey and traffic census. In view of maintenance, the roads which are near the MRT route and would be affected by the MRT network development will be chosen as the target of this survey. The survey scale might be extensive.

(2) **Reporting (R)**

As PDDs and monitoring reports in CDM, it is desirable to go through the procedure reporting before and after the survey (hereafter, preliminary report and monitoring report). Content of the preliminary report would follow CDM-PDD and ISO14064-2 "Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements) ”.

(3) **Verification (V)**

Verification of the preliminary report corresponding to PDD and the monitoring report is needed. However, it is desirable to take into account of problems in CDM requiring considerable costs and times as pursuing rigidity. Especially, extreme rigidity in examination such as validation of preliminary report should be mitigated. Credibility could be guaranteed by focusing on demonstration of additionality and description of monitoring in methodology as detailed as possible and practicing the method. It is examined in ex-ante verification if the monitoring has been practiced along the methodology based on monitoring report.

4.2.6 **Basis Consideration for the Appropriateness of Proposed MRV Technique**

MRV technique is considering as a technique which can be quantified appropriately for emission reduction effect by MRT network development. In addition, there are many challenges to accept CDM methodology ACM0016 of MRT, MRV is a method to clear these.

4.2.7 **Basis Consideration for Acceptable in Host Country for MRT Network Development**

Although MRTA, which is one of the responsible organizations of MRT in Bangkok, the optimum CDM of MRT was considered, it is lacking/deficiency in project because of the challenges of ACM0016, and cannot decide on realization. In particular, additional proof of ACM0016 cannot be applied in Thailand. For this reason, if there is new suitable MRV which

was developed in this study, it is fully accepted in Thailand.

4.2.8 Consideration about whether Proposed MRV Technique adopted International MRV Guidelines

This MRV is based on the CDM methodology ACM0016, considering of its logical simplification while maintaining conservativeness. Therefore, international understanding could be gained by explaining it as not only easier but also conservative method equivalent to CDM. However, because of that the traffic congestion mitigation cannot be counted in the current CDM methodology, it could not be the equivalent method to CDM. It should be discussed more in-depth domestically and internationally in future.

4.3 Ensuring environmental integrity

In Thailand, for construction of railroad the ex ante environmental impact assessment is required, in accordance with terms 46 and 47 of the National Environment Conservation Law. The environmental impact assessment for each MRT line which is subjected to concerned project had already carried out, so the environmental integrity is ensured by reflecting the output of the assessment in the project scheme.

4.4 Other Indirect Effect

The new cabinet has positioned this project as a key business, and this project is necessary for sustainable development of Thailand. The environmental impact assessment for each line planned in M-MAP had already carried out, because this project is the target of environmental impact assessment in Thailand. So there seems to be no indirect negative effect on social, cultural and economical aspect.

4.5 Stakeholder's Comment

The following organizations were selected as a stakeholder of the MRT project in Bangkok. Each stakeholder's comment is shown in below.

Table 4.9 Stakeholder's Comment

Organization	Comment
Ministry of Transport (MOT)	There is also interested in crediting of the MRT project as MOT. I would like to share information including the amount of estimated emission reduction, MRV, etc.
State Railways of Thailand (SRT)	Although SRT will involve in the Red Line development plan according to M-MAP, some issues have not decided yet at this moment such as whether SRT serve as an operation company and when the service will be started. Since development plan has changed several times, there is more than one feasibility study is exist.
Mass Rapid Transit Authority of Thailand (MRTA)	MRTA was approved by the government for undertaking extension of Blue line as CDM project operations. It should also be noted that even if political power is changed, there is no any changes in the MRT network development plan and MRTA will involve as well.
Bangkok Metropolitan Administration (BMA)	BMA has been actively involved in the development of the Green line. The development of the MRT network is also included in comprehensive transportation planning in 2010-2020.
TGO	We want to evaluate co-benefits as well as traffic safety in the transport sector and co-benefit guideline is under development.

4.6 Arrangement for Cost

Calculation expense is arranged and it combines with an emission-rights price, and is shown in Table 4-2. By looking at the percentage of monitoring costs and maintenance cost, it accounted for about 0.3% of transport demand bases and others were less than 0.1%. Moreover, the percentage of monitoring cost accounts for the proceeds of emissions rights was seen, it was less than proceeds irrespective of monitoring methodology and time. In addition, among the monitoring costs of a transport demand base, (about 30 million yen) is only for person trip survey cost. In practice, the plan of a survey (management of researcher), property survey (public relations), and administration of the survey, data prior processing, expansion processing of data, etc. are added, and it is about (40million Baht) 100 million yen in total. This means that the period which exceeds proceeds appears. However, a person trip survey can be interpreted to carry out as a national policy rather than as for monitoring investigation of CDM etc. If the point is taken into consideration, significant reduction in person trip survey cost is possible.

Table 4.10 Emission Rights-Price, Maintenance Cost and Monitoring Cost

Year	Proceeds (million baht)			O&M Cost (million baht)	Cost of Monitoring(million baht)		
	Case1	Case2	Case3		Transport demand	ACM0016	ACM0016 Simplification
2009				908			
2010				2,559			
2011				4,211			
2012				5,863	16.32	5.68	2.44
2013				7,515			
2014	34.0	23.4	11.8	9,167			
2015	54.2	37.2	18.6	10,819			
2016	88.9	60.8	30.2	12,470	14.05	5.05	2.17
2017	119.3	81.4	40.1	13,215			
2018	130.3	88.8	43.4	13,959			
2019	158.2	107.5	52.1	14,703		4.62	1.98
2020	168.4	114.1	54.9	15,220		4.48	0.00
2021	176.6	119.4	56.9	15,736			1.87
2022	183.4	123.6	58.4	16,253			
2023	197.3	132.7	62.1	32,821	11.79	4.10	
2024	207.9	139.4	64.7	34,343			1.71
2025	223.5	149.4	68.6	17,803			
2026	238.3	158.8	72.2	18,319			1.61
2027	247.0	164.2	73.8	18,836			
2028	257.3	170.5	75.8	19,352			
2029	265.6	175.5	77.1	19,869		3.44	1.48
2030				19,869	9.59		
2031				19,869			1.39
2032				19,869			
2033				19,869		3.05	
2034				32,031			1.27

4.7 Measures to promote the introduction of Japan Technology

In connection with the economic development of developing countries, the market size in urban railway sector is expanding rapidly. In Ministry of Land, Infrastructure, Transport, and Tourism, it supposes “Growth of Asia is taken by use of private-sector funds” and it has been one of the priority measures to promote the export infrastructure by overseas support of the construction industry. Especially railway technology of Japan is high worldwide rankings.

If MRV technique of railway has been established by this survey and moves towards realization of the project as Bilateral Offset Credit Mechanism, project formation is not only in Thailand but also future formation projects which are going to form the large-scale city network of railways can be expected.

Moreover, a very great significance, such as performing a project which contributes to greenhouse-gas-emission reduction of our countries directly in addition to the revitalization of

the economy by technology transfer, etc., is added. At the same time, significantly contribute to the sustainable development of the host country in terms of improvement of the environment and activation of the regional economy is expected.

Furthermore, practical use of ODA becomes effective for investment for the infrastructure building to city railroad maintenance. When it comes to the big motivation of Japanese-made technical adoption in a candidate country, performing the yen loan by ODA is considered.

In addition, the urban railway development, for investment for its infrastructure development, which it becomes effective use of ODA, are possible to perform by the ODA yen loan, and will be a great incentive for technology adoption in the country made in Japan.

4.8 Future Prospects and Challenges

In this study, we confirmed that the development of MRT network based on M-MAP is generally proceeding on schedule, by observing the construction progress on a field survey and communicating counterparts in Thailand.

Influences of the regime change in Thailand and the large scale flood in 2011 seem to be limited, so the start time of project will almost follow the start-up year of each line planned in M-MAP.

Unfortunately, we couldn't verify the result of estimated emission reduction calculated by traffic demand estimation approach and simplified ACM0016 approach because of lack of time. So in this chapter, we clarify challenges for the future by considering plans of verifying the result of estimated emission reduction and listing tasks for spreading the MRV method to other countries.

4.8.1 Challenges for simplified ACM0016 approach

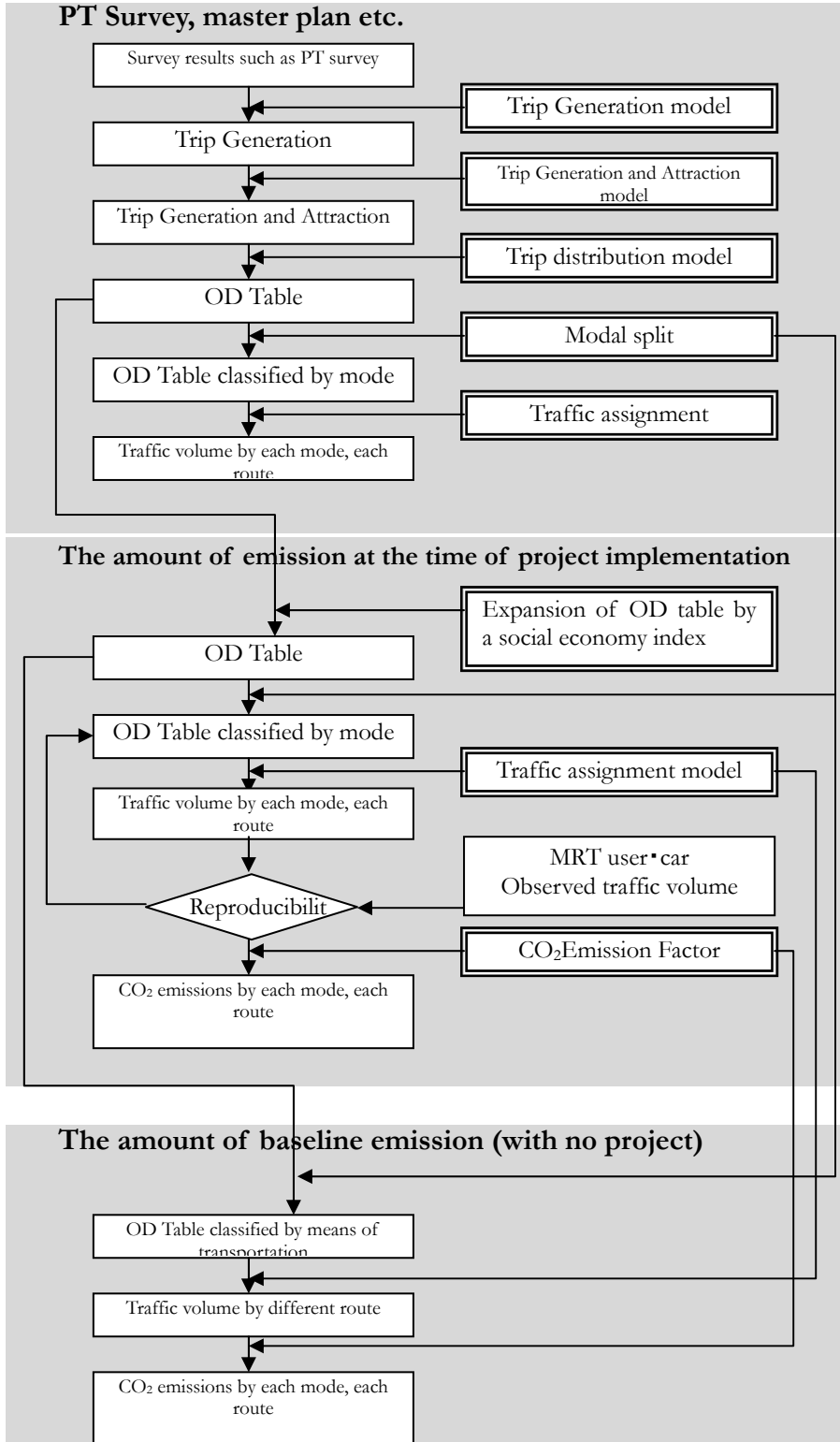
Traffic congestion mitigation effect in MRV of ACM0016 simplification can't be admitted in the present methodology, so this method can't be said to follow CDM. In this study, we estimate this effect by using transportation demand forecasting and setting its boundary. To deepen domestic and international discussions, it is necessary to stack such calculations.

Also, we estimated emission reduction by using simplified ACM0016, but couldn't verify the result because of lack of time. So verifying it and confirming appropriateness of the MRV are challenges for the future.

Moreover, the format of monitoring report is important for establishing BOCM. While we haven't still discussed the format in detail, it is necessary to prepare this coordinating with other projects.

4.8.2 Proposal of Ideal Conditions and Challenges in Transportation Demand Forecasting

The ideal calculation procedure as shown in Figure 4.2 for estimating project emission by transportation demand forecasting model and it can also be applied in developing countries.



【Challenges on application】

■ Checking the contents of survey

- The data acquisition method suitable for the prediction purpose

■ Checking of basic OD table (Traffic distribution)

- Basic OD table is suitable for traffic condition, land use conditions, transportation facility maintenance, etc. (Traffic distribution)

■ Checking of Modal Split

- Present condition reproducibility of modal split

- Proper processing of terminal traffic of a railroad

■ Checking of automobile OD table (OD table for traffic assignment)

- Based on PT, how to convert car-based trip units from the base OD table

- Automobile OD table according to vehicle type

■ Checking of estimation unit time of traffic

- Estimates of traffic volume and speed of another time zone that corresponds to the emission intensity

- Current state of link cost function

■ Checking of interaction between traffic and city

- Transportation facility development impact on the population and land use arrangement

■ Checking of the reproducibility of estimation result

- Reproducibility of traffic, or speed and CO₂ emissions

- Evaluation of emissions from traffic in the zone

Figure 4.2 Calculation Process for Emissions by Transportation Demand Forecasting and Challenges for Application

5. Analysis Results for Co-Benefits

5.1 Items to be evaluated

Items to be evaluated are 4 types of air pollution emissions (NO_x, CO, PM, HC).

5.2 Baseline/Project Scenario

A baseline scenario is a scenario in which MRT network in Bangkok is not improved and emissions of air pollution will continue by the conventional means of transportation (passenger car, bus, etc.). On the other hand, a project scenario is a scenario in which modal shift effect and traffic congestion mitigation effect are brought by MRT network development and consequently emissions of air pollution will be decreased.

5.3 Baseline Evaluation Method and Monitoring Plan

Emissions of air pollution in the baseline scenario are calculated by integrating the amount of emissions of the target road section with the following equation. Emission factors are used the most recent value at the time of evaluation and the other parameters are estimated by using the results of transportation demand forecasting model.

$$BE_k = \sum_i \sum_j (D_i \times TVb_{i,j} \times EF(v)_{k,i,j} \times 10^{-6}) \times 365$$

BE_k : Emissions of air pollution in the baseline scenario (t/year)

D_i : Length of route i (km)

$TVb_{i,j}$: Baseline traffic volume of vehicle type j, interval i (vehicle/day)

$EF(v)_{k,i,j}$: Emissions factor for air pollution for running speed $V_{p_{i,j,y}}$ of vehicle type j, route i (g/km)

5.4 Calculation Process and Result of Trial Calculation (Quantification) before Project Implementation

Similarly, emissions of air pollutants in the project scenario are calculated as follows.

$$PE_k = \sum_i \sum_j (D_i \times TVp_{i,j} \times EF(v)_{k,i,j} \times 10^{-6}) \times 365$$

PE_k : Emissions of air pollution in the project scenario (t/year)

$TVp_{i,j}$: Project traffic volume of vehicle type j, interval i (vehicle/day)

Based on the above calculation, the emissions reduction effect of the air pollution is calculated as follows.

$$ER_k = BE_k - PE_k$$

ER_k : Amount of emission reduction of air pollution (t/year)

CO-benefit evaluation is performed based on the result of transportation demand forecasting model as mentioned in above. In this study, since transportation demand forecasting model is estimated traffic volume for passenger car and bus for present condition (2010) and the future (2020 and 2030), the emission reduction effect of air pollutant is also calculated based on these year. The calculation results are shown in Table 5.1. Additionally, the amount of emissions here represents only the contribution from passenger car and bus and it does not include the contribution by freight cars such as truck. Furthermore, it is necessary to keep in mind that there is a possibility of being overestimated than actual emissions amount since transportation demand forecasting is carried out for peak hours.

Table 5.1 Amount of Emissions and Reduction for Air Pollution from Passenger Car and Bus (Unit : t/year)

	Present condition	Year 2020 Estimation			Year 2030 Estimation		
	BE _k	BE _k	PE _k	ER _k	BE _k	PE _k	ER _k
NO _x	105,193	132,927	100,766	32,161	166,370	128,424	37,946
CO	298,730	413,480	284,301	129,179	569,244	395,955	173,288
PM	787	820	744	76	839	780	59
HC	87,824	138,581	82,118	56,463	213,668	130,232	83,436

6. Survey Result on Contribution of Sustainable Development

6.1 Social and Economic Benefits should be evaluated.

By using the results of social and economic benefits which come from MRT project in Bangkok, cost-benefit analysis was carried out for 30 years evaluation period. In addition, it covers only the bus and passenger cars as road users. It becomes conservative assessment since it does not include other modes such as freight cars which will receive increase in running speed by the project.

From a cost-benefit analysis result, cost-benefit ratio is greater than 1.0; the net present value is a positive value that is larger than the setup social discount rate; an economic internal rate of return is seen to be socioeconomically, and it can be estimated as an efficient project.

Moreover, it contributes to the development of the economy of the host country as it minimizes environment impact by MRT network development in Bangkok. A significant shift from automobile traffic is expected. Reduction of greenhouse gases and air pollution etc. can also be expected along with the traffic congestion mitigation

Table 6.1 Social and Economic Benefits which come from MRT Project in Bangkok

year	year	the factor of NPV based on social discount rate	Cost					User benefit					
			Construction cost	O&M cost	O&M cost every 15 years	Total cost	Total cost after discount	Travel time saving	Vehicle operating cost reduction	Traffic safety	Total benefit	Total benefit after discount	
0	2009	1.0000	46,644	908		47,552	47,552						
1	2010	0.8929	46,644	2,559		49,203	43,931						
2	2011	0.7972	46,644	4,211		50,855	40,541						
3	2012	0.7118	46,644	5,863		52,507	37,373						
4	2013	0.6355	46,644	7,515		54,159	34,419						
5	2014	0.5674	46,644	9,167		55,811	31,669						
6	2015	0.5066	60,350	10,819		71,169	36,057						
7	2016	0.4523	60,350	12,470		72,820	32,940						
8	2017	0.4039	60,350	13,215		73,565	29,712						
9	2018	0.3606	60,350	13,959		74,309	26,797						
10	2019	0.3220	60,350	14,703		75,053	24,165						
11	2020	0.2875	16,811	15,220		32,031	9,208	113,021	95,257	3,877	212,154	60,989	
12	2021	0.2567	16,811	15,736		32,547	8,354	113,021	95,257	3,877	212,154	54,455	
13	2022	0.2292	16,811	16,253		33,064	7,577	113,021	95,257	3,877	212,154	48,620	
14	2023	0.2046	16,811	16,769	16,502	50,082	10,248	113,021	95,257	3,877	212,154	43,411	
15	2024	0.1827	16,811	17,286	17,057	51,154	9,346	113,021	95,257	3,877	212,154	38,760	
16	2025	0.1631	16,811	17,803		34,614	5,646	113,021	95,257	3,877	212,154	34,607	
17	2026	0.1456	16,811	18,319		35,130	5,117	113,021	95,257	3,877	212,154	30,899	
18	2027	0.1300	16,811	18,836		35,647	4,636	113,021	95,257	3,877	212,154	27,588	
19	2028	0.1161	16,811	19,352		36,163	4,199	113,021	95,257	3,877	212,154	24,633	
20	2029	0.1037	16,811	19,869		36,680	3,803	113,021	95,257	3,877	212,154	21,993	
21	2030	0.0926		19,869		19,869	1,839	235,112	129,223	4,619	368,954	34,150	
22	2031	0.0826		19,869		19,869	1,642	235,112	129,223	4,619	368,954	30,491	
23	2032	0.0738		19,869		19,869	1,466	235,112	129,223	4,619	368,954	27,224	
24	2033	0.0659		19,869		19,869	1,309	235,112	129,223	4,619	368,954	24,307	
25	2034	0.0588		19,869	12,162	32,031	1,884	235,112	129,223	4,619	368,954	21,703	
26	2035	0.0525		19,869		19,869	1,044	235,112	129,223	4,619	368,954	19,378	
27	2036	0.0469		19,869		19,869	932	235,112	129,223	4,619	368,954	17,302	
28	2037	0.0419		19,869		19,869	832	235,112	129,223	4,619	368,954	15,448	
29	2038	0.0374		19,869		19,869	743	235,112	129,223	4,619	368,954	13,793	
30	2039	0.0334		19,869		19,869	663	235,112	129,223	4,619	368,954	12,315	
Total			749,727	469,522	45,721	1,264,970	465,642	3,481,322	2,244,795	84,957	5,811,075	602,066	

Social Benefit Ratio = User Benefit / Cost = 1.29

Economical net present value = user benefit – cost = 136,424

Economic internal rate of return = 14.5%

In here, social discount rate: 12.0%; construction cost and maintenance cost, and the management and administrative cost in every 15 years (source: M-MAP).

Moreover, it applies only to passenger cars and buses as road users and freight vehicles are not included.