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PRELIMINARY STUDY ON ESTIMATION OF ANCILLARY BENEFITS FROM POTENTIAL CLEAN DEVELOPMENT MECHANISM (CDM) PROJECT IN TRANPORT SECTOR

Otkur GOJASH
Doctoral Candidate
Graduate School of Science and Technology
Nihon University
7-24-1 Narashinodai, Funabashi-shi,
Chiba 274-8501, Japan
Fax: +81-47-469-5355
E-mail: otkurnihon@yahoo.com

Atsushi FUKUDA
Professor
College of Science and Technology
Nihon University
7-24-1 Narashinodai, Funabashi-shi,
Chiba 274-8501, Japan
Fax: +81-47-469-5355
E-mail: fukuda@trpt.cst.nihon-u.ac.jp

Yosui SEKI
Researcher
ALMEC Co.Ltd.
1-19-14 Aobadai, Meguro-ku,
Tokyo 153-0042, Japan
Fax: +81-3-5489-3210
E-mail: seki@almecgw.almec.co.jp

Abstract: Clean Development Mechanism (CDM) is one of the three mechanisms of Kyoto Protocol that aims to stabilize Greenhouse Gases (GHG) in the atmosphere. As transport sector is a main source of GHG and other air pollutants emissions, it is imperative to apply the CDM in transport sector. However, there are some obstacles to adopt the CDM in transport sector. These include technical problems of project boundary certification, baseline setting and monitoring as well the uncertainty of economical viability of projects based on the return of Certified Emission Reduction (CER). Knowing that the GHG mitigation policies for transport sector have generated ancillary benefits other than climate change, this paper intends to take ancillary benefits into account on transport sector CDM project's economical analysis that never be done before. In order to enhance CDM projects in the term of economical viability, two case studies CDM projects in Bangkok, Thailand were conducted.

Key Words: Kyoto Protocol, Clean Development Mechanism, Certified Emission Reduction Ancillary Benefits.

1. INTRODUCTION

Developed countries, which have GHG abatement obligations in the Kyoto Protocol, must fulfill theirs commitments by the first commitment period of 2008 to 2012. They have recognized the urgency of the situation, as the first commitment period is not so far from the present. For example, with the 6% of GHG emission-reducing commitment in the Protocol, Japan also has realized that relying on the domestic actions exclusively, cannot assure the 6% of reducing below the 1990's level. It was forecasted that by the end of first commitment period, 4.4% reductions could be reached by strictly domestic actions; the rest part of reductions must get help from international actions including CDM (Nat source Japan 2004).

The transport sector is responsible for 25% of CO_2 emissions worldwide. It was estimated that in developing countries, CO_2 emissions from transport sector would be more than double in next two decades by the increasing rate of 3.2% per year (World Energy Outlook, 2001). It implies that transport sector in developing countries will be a big market for developed countries to gain CER with the CDM for fulfilling their Kyoto Protocol commitments.

CDM could be a new way of funding transport sector projects, it may represent a crucial opportunity to foster sustainable transport sector in developing countries through increased funding flows, enhanced capacity and expanded technology transfer opportunities. Current, of the over 100 projects in the CDM pipeline, only 6 of them are the transport sector projects and no any transport sector CDM projects has been accepted by CDM Executive Board (EB) yet. The reason is, existing significant methodological and financial barriers for transport sector CDM projects due to the natures of transport sector.

Among the CDM criteria, system boundary certifying, baseline setting and monitoring are the big challenges for transport sector CDM projects, while these elements directly related to how wide emissions sources are concerned, how emissions are estimated and what amount of emissions are reduced, all that can be the proofs for project's credibility. From a practical point of view, high uncertainty both in baseline determination and in projections of the emission reduction impact of project is likely to be largest obstacle to CDM implementation in transport sector. The CDM criteria are shown in Table 1.

Table 1. CDM Criteria

Additionality	Environmental Additionality	Positively different from the baseline, forecasted emission levels in the absence of the project.
	Financial Additionality	Not resulted in diversion of ODA.
	Investment Additionality	Economically less attractive than other alternative activities without the revenue from sale of CERs due to a lower rate of return or higher risk.
System Boundary		All activities under control of project participants.
Baseline		The baseline for a CDM project activity is the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity.
Monitoring Plan		Monitoring emission reduction by project pace.
Risk Management		Assessing the risk of the emissions reductions not occurring.

Also from a financial point of view, CER is a driving force of CDM and investors want to know how amount of CER will be available and at what cost. Though GHG emissions from entire transport sector seem to be big, however, emissions from a project, however, are not so big that leads the CER from transport sector CDM projects is not big enough to impact the projects economic viability. Therefore, as a business mechanism, CDM projects in the transport sector seem to be no attractiveness to the investors comparing to the CDM projects in other sectors, because of a high rate of implementing cost and a small rate of CER return.

Excluding transport sector projects from market-based mechanism due to existing obstacles is not fair while extremely high growth in transport-related GHG emissions was projected already. Though there have been many studies on estimating ancillary benefits from transport sector GHG mitigation policies and those showed that ancillary benefits are very significant comparing to policies primary aim of mitigating climate change. However, there have been no attempts to consider ancillary benefits in the CDM framework.

In order to enhance attractiveness of transport sector CDM projects, in this paper, ancillary benefit consideration and ODA involvement schemes that had been not considered within the current CDM framework, were proposed as remedies for alleviating a financial obstacle. As a part of this study, GHG and other air pollutants emissions mitigating mechanisms were presented and GHG mitigating measures were qualitatively evaluated based on the CDM criteria. Though, solving technical problem in transport sector CDM projects is not our intention in this paper, the utility of some empirical transportation engineering methodologies were mentioned also.

Section 2 of this paper describes ancillary benefits and CDM opportunity in Transport sector, while Section 3 depicts our attempts on improving current CDM approaches, and Section 4 explains utility of some empirical models for CDM projects, Section 5 gives the case studies. Conclusions and discussions are given in Section 6.

2. ANCILLARY BENEFITS AND TRANSPORT SECTOR GHG MITIGATIONS

2.1 About Ancillary Benefits

Ancillary benefits are the effects of climate change mitigation policies or measures on problems other than GHG emissions, such as reductions in local and regional air pollutions of carbon monoxide (CO), nitrogen oxides (NO_x), suspended particulate matters (SPM), volatile carbon compounds (VOC) and sulphur oxides (SO_2), that associated with the reduction of fossil fuels (Cifuentes, L.A. 2001). Ancillary benefits from GHG mitigation measures generally consisted of effects of below: reducing other pollutants that are jointly produced with carbon dioxide; reducing other harmful impacts such as traffic noise, road accidents, and community severance; possibly increasing employment levels relative to some baseline in which the climate policy is not adopted and possibly stimulating technological change.

Several researches have been done in recent years about estimates of ancillary benefits (mainly health benefits that occupy over 85% of overall ancillary benefits) from GHG mitigation projects (Burtraw and Toman, 1997; Burtraw et al 1999; OECD, 1999). Researches of ancillary benefit estimation from GHG mitigation policies in Europe, USA and Developing countries (China and Chile), that applied different methodologies, assumptions and different scenarios, have presented the ancillary benefits of 12~267 US$ per ton-C reduction with the 30~800US$ per ton-C abatement costs, and have showed the cost benefit ratio (B/C) range of 0.1~3.7. In developing countries, the cost benefit ratio has kept greater than one. In the opposite, in developed countries, it has kept less than one.

The ancillary benefits of GHG reduction policies in transport sector consist of two main types: time savings for decreasing in road traffic volume and savings external cost of traffic accidents, roadside air pollution and other intangible resources. The ancillary benefit types from different GHG mitigation policies are vary and saving external cost from road side air pollution seems to be a common item in the most mitigation policies.

Health benefits are typical ancillary benefits from reducing roadside emissions, such as NO_x, PM10 and SO_2. The health benefits here include the benefits associated morbidity (illness) and mortality (death). The World Bank study on damage costs of air pollution in six cities of Bangkok, Krakow, Manila, Mumbai, Santiago and Shanghai showed that the health costs occupy 64% of total damage costs while climate change costs are 28% and the non-health costs are 8%. Also, showed that in the health costs, the cost for premature death occupies 40% while the chronic bronchitis is 25%, the respiratory symptoms is 25%.

Though, estimating ancillary benefits lies in very wide ranges, it is worthwhile to mention that the ancillary benefits could be comparable in the size to the climate change benefits. Therefore, not taking ancillary benefits and costs into account (in the monetary terms or not) would lead to an incorrect identification of "no regrets" level of GHG mitigation actions (Burtraw et al 2000).

2.2 Transport Sector GHG Mitigation Policies and CDM

The air pollutants from transport sector like NO_x, Particulate Matters (PM) can be controlled trough standard tailpipe emissions controls and vehicle inspection. However, such controls are unlikely to be able to control the CO_2 of the main GHG. There are five main potential activities being recognized to be able to mitigate GHG emissions as well as other air pollutants in the transport sector. They are 1) Changing the fuel efficiency of vehicles (e.g. through vehicle efficiency or through traffic management/infrastructure changes); 2) Changing the type of fuel that vehicles use (e.g. from petrol/diesel to biodiesel, CNG, electric vehicles and fuel cells); 3) Switching a transport mode to one that is less GHG-intensive (e.g. changing the modal split or traffic management/infrastructure, increasing public transport infrastructure such as light rail); 4) Reducing transport activity (e.g. through town planning, road tolls, tele-working); and 5) Increasing the occupancy rate of vehicles (e.g. through car sharing, subsidized public transport).

All potential CDM projects within the transport sector must aim to affect at least one of the five elements above. However, projects in the transport sector, which act to reduce GHG emissions are so diverse that often the same goal can be reached using a variety of different policy and investment actions. Generally, the five project activities mentioned above can be reached by two ways, one is behavioral changing, and another is technological changing way.

As, there are many policies and measures, through which CO_2 and other air pollutants from vehicles can be reduced. However, the policies and measures' practical possibility of being CDM projects mostly relies on the certainty of their outputs that also must meet the requirements of CDM criteria. In order to clearly see what kinds of projects seem to have high possibility of promptly implementing, it is useful to qualitatively evaluate the potential GHG mitigation projects in transport sector in the view of CDM criteria, as well as respecting to the practical applicability of transportation engineering methodologies and technologies. Figure 1 shows natures of potential GHG mitigating policies being CDM projects.

The figure 1 is very subjective and just tries to explain the current states of transport sector CDM projects under the requirements of CDM. From the point of CDM criteria view, potential GHG mitigation projects that belong to the technological changing category mostly seem to be accepted as pilot CDM projects in transport sector due to technological changing generally having occurred with objecting certain vehicle modes that make grasping and forecasting the traffic condition comparatively easy. In other words, that kinds of projects have the advantages of easily calculating emission factors, assessing average vehicle speed and can measuring emissions directly by fitting fuel consumption and CO_2 meters to vehicles. For example: Biodiesel and CNG bus, taxi operating etc. On the other hand, behavioral changing mostly leads to complicated changes on traffic condition while accurately grasping traffic conditions still has been a main task in transport sector.

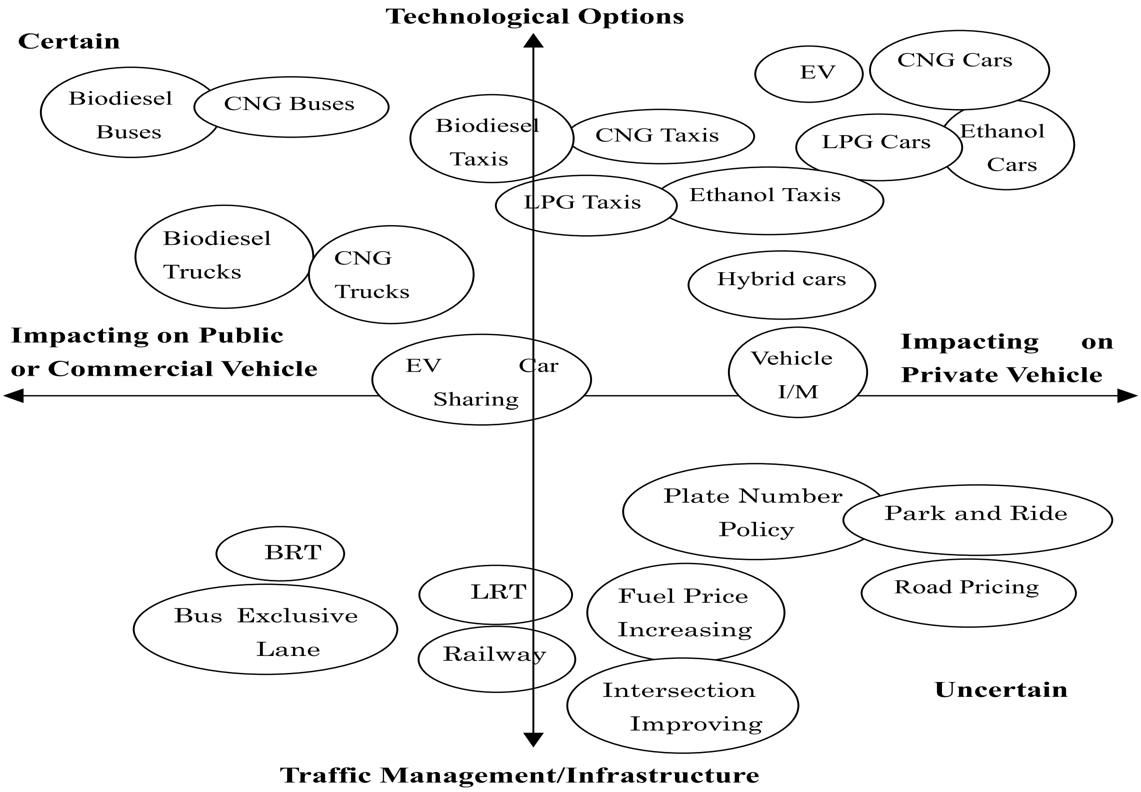

Figure 1. Transport Sector GHG Mitigation Measures Possibility of Being CDM

Note: CNG: Compressed Natural Gas, LPG: Liquefied Petroleum Gas, I/M: Inspection and Maintenance, BRT: Bus Rapid Transit, LRT: Light Rail Transit

3. ATTEMPTS FOR ENHANCING VIABILITY OF TRANSPORT SECTOR CDM PROJECTS

3.1 Ancillary Benefits Consideration

In the current CDM framework, CER is recognized the only additional benefit against to a baseline. Also, CER is a critical element to decide economical viability of a CDM project. However, the fact is even with CER, the most transport sector CDM projects could not reach the market threshold that means these projects have no economical viability. However, the projects could still be attractive from a social perspective because of ancillary benefits that transport sector GHG mitigation policies can generate substantial ancillary benefits, which are additional to the benefits, derived from policy’s primary aim and, consequently, raise the policies attractiveness. Most transport sector CDM projects seem to belong to the previous three types of projects, which are depicted in Table 2.

Table 2. Economic Viability of CDM

Projects with negative rates of return.	Clearly not viable without concessional financing resources or carbon offsets available.
Projects with rates of return below normal market threshold.	Probably not viable without concessional financing resources or carbon offsets available.
Projects with rates of return above normal market threshold, but below risk premium for project type, technology, and country.	Marginal with private finance only, viable with concessional finance or carbon offsets available.
Projects with rates of return above normal market threshold, including applicable risk premium.	Viable with private finance only; concessional finance unnecessary. Carbon offsets precluded by lack of additionality

Poor roadside air quality is one of the most serious environmental problems in urban areas around world, especially in developing countries and the levels of exposure and the associated health burdens are much higher in developing countries than in developed countries. These country-specific problems interact with a growing concern about global climate change, which has no boundaries.

As, CDM has twin objectives of fulfilling GHG reduction commitment of developed countries and promoting Sustainable Development (SD) of developing countries, it is noteworthy that evaluating CDM projects must take both CER (carbon benefit from GHG reduction) and SD benefits (non-carbon benefits) into account. On a project level ancillary benefits generally tally with sustainable development criteria of a project. Also, it implies that certifying ancillary benefits in monetary term could enhance transparency of sustainable development contribution of a project.

Therefore, without taking ancillary benefits from a transport sector CDM project into account as important as climate change benefits seems to be not appropriate either from the point of sustainable development view or respecting to the current fact that developing countries have get more pressure on reducing local air pollutants than mitigating GHG.

The integration of ancillary benefits in the economic analysis of CDM can increase policies efficient level, however, in the benefits incidence flow, ancillary benefits are incurred to host countries' side and current most developing countries are willing to pay for alleviating health burden from air pollutions. Therefore, it has propriety to propose a burden-sharing scheme for transport sector CDM projects on which some concessional financial recourse could be from host country in the terms of subsidies or from invest country in the terms of ODA based on the ancillary benefits from the projects.

3.2 ODA Application

International climate negotiations have specified that ODA cannot be used for direct acquisition of CER from CDM projects, but it can be operated in the field of CDM institution and capacity building for the CDM. However, from the fact of both CDM and ODA have the objective of further sustainable development of the target country, more attention must be given to the practicalities of the relation between ODA and CDM.

In respect to the fact that recent ODA has been widely used for transport sector projects and the trend has kept up. The rationale for looking into direct ODA involvement in CDM projects is that it may increase the chance to attract private sector investment in neglected regions and in specific project types and modalities with contribution to sustainable development, but which would not be economically feasible for private investment alone (most CDM projects in transport sector are likely). This may be due to the high CDM transaction costs, to a lack of institutional capacity, to small project size and so on. If ODA agencies were not allowed to participate CDM process, decades of valuable project experiences would be lost.

There are some options for regulating ODA use for CER acquisition. One is the CERs' value will be deducted from ODA according to the ODA share of investment, the other is distinguishing between an ODA-financed baseline project and a CDM added project. Applying which one would be depended on the project nature and also negotiation between host and investor countries.

4. EMISSION ESTIMATION MODEL FOR TRANSPORT SECTOR CDM PROJECTS

4.1 Introduction

Before modeling emissions from road traffic, it may be beneficial to review briefly the factors that affect the rates and concentrations of GHG and other pollutants from road vehicles. The purpose of the review is, initially, to provide an understanding of the emission situation to be modeled; and secondly, to identify the key factors and relationships that should be included in the model.

Emissions from road vehicles with fossil fuel engines arise mainly from three sources (Mazen I.Hassounah et al 1994): the crankcase, the fuel system and exhaust. The crankcase emission is mainly HC. In new vehicles and also from diesel vehicles the crankcase emissions are minimal. And emissions from fuel system can be categorized into two types: diurnal evaporation caused by the gradual heating of the fuel tank during warm days and spillage of vapors from tank during refueling; and hot soak emissions caused by the rapid evaporation of the fuel left in the carburetor while the engine is still hot after having been turned off. Fuel system emissions consist mainly of HC. Exhaust emissions from road traffic contain the products of combustion of fossil fuel. The emissions consist mainly of CO_2 emitted by complete combustion of fossil fuel, CO and HC as products of incomplete combustion of fossil fuel, NO_x formed by oxidation of atmospheric nitrogen inside the cylinder, Particulate matters (PM) which consist of solid carbonaceous compounds and Sulphur dioxide (SO_2) (in small quantities) due to burning of sulphur-containing fuels.

And, in general three categories of factors have been figured out to affect the level and concentration of emissions from traffic vehicles: vehicles characteristics, driving conditions and weather and meteorological conditions. These elements must be concerned carefully as much as possible in the emission estimation process. Table 3 shows the air pollutions from vehicles and theirs impacts

Table 3. Air Pollution from Vehicles: Summary of Impacts

Pollutant	Type of Impact			Source of Pollutants	Health Effect of Pollutants
	Local	Regional	Global		
	High Concentration	Acidification	Direct GHG		
PM	x			Products of incomplete combustion of fuel; also from wear of brakes and tyres.	Irritates mucous membranes; Respiratory/ pulmonary effects; Carcinogenic.
CO	x			Incomplete combustion product of carbon–based fuels.	Reduced oxygen carrying capacity of red blood cells
NO_x	x	x		Formed during fuel combustion at high temperatures.	Irritated lungs; Increase susceptibility to viruses.
SO_2	x	x		Combustion of petroleum Products.	Reduced lung function/impairment of respiratory system
VOC	x			Combustion of petroleum products; also evaporation of unburned fuel	Irritated eyes, causes intoxication; Carcinogenic.
CO_2			x	Combustion product of carbon based fuels	
CH_4			x	Leakage during production, transport, filling and use of natural	
N_2O			x	Combustion product of fuel and biomass, also formed in catalytic	

Having known that transport is a significant contributor to urban air pollution, intentions must be given to evaluate alternative instruments to reduce impact. Briefly the issue can be concluded into tree objectives: Fewer vehicle kilometers traveled in total; Less fuel use per vehicle kilometer traveled and Less pollution per unit of fuel used. Three important observations can be made. First, each has both technical and behavioral components. Second, most transport users are subject to and respond to strong economic and financial constraints and incentives. Third, environmental improvement is likely to be more easily achieved by working, rather than against, the economic incentives. For reaching the efficient mitigation level, having to answer a sequence of questions to identify what needs to be targeted is a framework for policy appraisal. The questions are what are the most serious pollutants? What transport activities do most damage?

Based on the framework, answers for above two questions in Bangkok are that Bangkok has suffered from heavy air pollution and mobile sources have been the major emitters of NO_x (80%), CO (75%) and particulates (54%), among them heavy-duty vehicles and motorcycle vehicles have been the significant contributors of NO_x (61%) and PM10 (48%). Available data indicate that the most damaging health impacts are PM10 and NO_x (causing serious respiratory illnesses and premature death). Residents of Bangkok spent about 12.5% of theirs total medical expenses on respiratory illnesses alone. With understanding the most serious pollutants and their sources, next step is to select efficient policies to mitigate them. Table 4 shows some key policy options in each category.

Table 4. A Framework for Policy Selection

	Technological	Administrative	Economic
REDUCING VEHICLE KILOMETERS			
Increase private vehicle occupancy		High occupancy vehicle lanes, Parking priority to HOVs.	Congestion pricing, Tax incentives.
Restrain demand		Vehicle use limitation; parking policies	Road pricing, fuel tax etc.
Increased public transport share	Dedicated busways	Bus priorities; Public transport regulatory reform.	Subsidy to public transport.
REDUCING FUEL USED PER VEHICLE KILOMETER			
Improve fuel economy	Increase engine efficiency	Fuel economy standards.	Fuel taxation
Encourage NMT	Investment in NMT infrastructure	Protection of NMT in road use.	
Improve traffic management	Intelligent traffic system technology		
REDUCING EMISSIONS PER UNIT OF FUEL USED			
Improve fuel quality		Tighter diesel fuel standards, Bans on leaded gasoline.	Differential taxation
Improve vehicle maintenance		Age restriction on vehicles I/M programs	taxation and fines.
Improve conventional diesel technology	Four stoke; electrinic fuel injection; oxodation catalyst	Tighter emission standards for in-use vehicles, Diesel sulfur reduction to enable catalyst adoption	
Improve two-and three wheeler technology	Higher quality lubricant for two stroke engine, Four stroke engine.	Tighter two/three-wheeler emission standards	Differential taxation
Use alternative fuels	Investment in CNG or Biodiesel distribution	Much tighter PM standards, Mandate use of gas	vehicle taxation.
Switch to clean diesel technology	Ultra-low sulfur fuel and particulate trap	Much tighter PM standards	Higher tax on conventional diesel.

It is known that local air pollutions alleviating policies might get joint benefits or trade-offs while they are implemented as GHG reduction policies. For example, in Bangkok, enforcing a effective I/M program, which administers a loaded PM exhaust emissions test on all diesel fueled vehicles, will reduce mobile source emissions from the current fleets by up to 25%, or about 3,250 tons per year, while only a few percent of CO_2 emissions could be reduced; implementing the oxidations catalyst and bi-fuel retrofit programs will reduce PM10 emission by an additional 300 tons per year while it almost has no effecting on CO_2 emission reduction. Therefore, transport sector CDM projects must be inclusive measures in which multiple objectives relating to transportation needs, and global, regional and local externalities appear simultaneously.

4.2 Model Descriptions

The models for estimating emissions from road traffic CDM projects proposed in this study consist of two components of the modeling process, like, travel behavior and emission model. The output of the previous one can be an input to the next one corresponding to the project types. The model framework is shown in Figure 2.

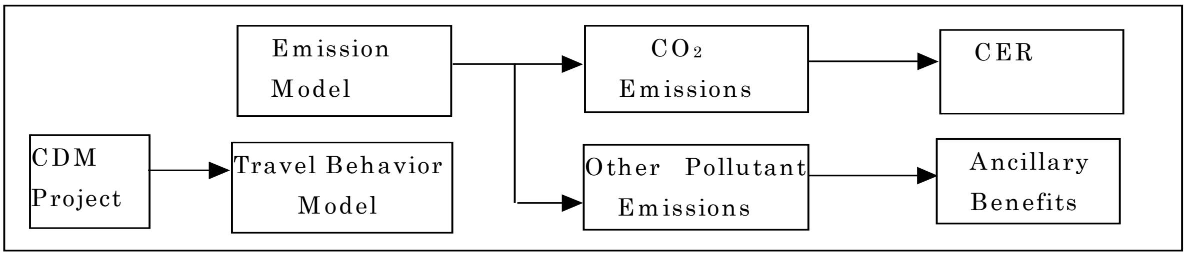

Figure 2. Model Frameworks

Travel behavior model mostly is affected by project boundary and project category (technological changing or behavioral changing). Since, a series of models supply information for travel behavior estimation. Well-known one is four-step approach and etc. Considering to existed flaws of four-step approach that is not likely to occur in practice. And also, regarding to the diversity of CDM actions in transport sector as mentioned above sections, combined equilibrium travel demand models are proposed for travel behavior estimation that can integrate traveler's characteristics, temporal variations, mode diversity and land use elements into the model corresponding to the specific CDM project. Some empirical models corresponded to specific projects are shown in Table 5.

Table 5. Some Empirical Models

Mitigation ways	Categories	Examples	Models
Technological Changing	Fuel Alternation	Biodiesel for Buses	Statistics data and technological developments combined.
	Engine Shifting	Compressed Natural Gas Buses	The same as above.
Behavior Changing	Transport Policies	Road Pricing or Area Pricing	Modal Split (MS) and Network Assignment (NA) combined model.
	Land Use & Infra-structures	Bus Rapid Transit	Trip Distribution (TD) Modal Split (MS) and Network Assignment (NA) combined model.
	City Logistics	Truck Terminal Distribution	Multi-mode, discrete time interval aggregated User-Equilibrium (UE) model.

For emission model, propose to have different attitude toward to GHG and other pollutants due to for specified fuel, the mass of GHG (mainly CO_2) emitted by vehicle can be assumed to be directly proportional to the fuel consumed by vehicle, on the other hand, the emissions of NO_x, PM and CO seem to not straightforward related to fuel consumption of vehicle. Therefore, the GHG emissions from CDM actions keen to be gained from fuel consumption of vehicles, while other pollutant emissions (mainly NO_x and PM10) try to be got by driving pattern of vehicles based on the previous model output.

4.3. Emission Model

Based on the output of previous Travel Behavior Model that number of vehicle, vehicle travel kilometer and vehicle speed by link, emissions from vehicles will be calculated by emission models. Mathematical expression of the models is given below.
Top-down calculation for GHG:

$$C_{gij} = FC_{ij} \times EF_i \tag{4.1}$$

Bottom-up calculation for other air pollutants:

$$C_{oij} = \sum_{n} VTK_{ij} \times Ef_{ij} \tag{4.2}$$

Here:

g : GHG, i : Fuel type, j : Vehicle type,
o : Other air pollutants,
C : Emission amount (Ton CO_2),
FC : Fuel consumption (Liters or MJ),
EF : Emission Factor (Ton CO_2/Liter or MJ),
VKT : Vehicle Travel Kilometers (km/vehicle/time),
Ef : Emission factor (gram/km), n : Number of vehicle.

4.4 Ancillary Benefit Estimation Model

Health benefits (morbidity and mortality) from reduction of NO_x and PM10 emissions are applied, as ancillary benefits for this paper, considering to the health benefits are the common benefits from the most transport sector GHG mitigation policies, in addition to health damages from roadside air pollution in developing countries higher than that of other sector. The fixed damage cost coefficient Model is used for health benefits estimation. Mathematical expression of the model is given below.

$$D_j = d_j^{NO_x} \times E_j^{NO_x} + d_j^{PM10} \times E_j^{PM10} \tag{4.3}$$

Here:

D_j : Total damage costs inflicted by region j (US$),
E_j^k : Total emissions of pollutnats $k (k = NO_x, PM10)$ in region j (Ton),
d_j^k : Damage cost coefficient of pollutants k in region j (US$/Ton).

5. CASE STUDY

5.1 Introduction

Bangkok, the capital city of Thailand with the number of vehicles totals 6 million, at least 50% of inhabitants use buses for their commuting to work everyday. In 2002, Bangkok Mass Transport Authority (BMTA) arranged 14,662 buses to provide the public service. Out of this number, 3,655 buses are operated by BMTA itself while the other 11,007, among them 3,010 are large buses, are operated by contracted private companies who normally purchase out-of-operation buses from BMTA, these privately-operated buses are not usually in the good condition. In addition, political considerations have held the bus fare to low fare; most private bus companies face the difficulty in maintaining theirs buses in a good and clean operating condition so that these buses became the main source of emissions.

Two assumption case study CDM projects will be done in Bangkok, Thailand. One is CNG bus operating project (engine change), called project (1); another is Biodiesel use for BMTA Buses (fuel alternative) project, called project (2). It is assumed that funds and technologies are provided by private entities of Japan to hold CER. The CNG and Biodiesel are accepted as clean fuels that assuring a decreasing of CO_2, NO_x and PM10 emissions from vehicle in the terms of both per kilometer travel and per unit fuel consumption. The projects description is shown in Table 6.

Table 6. Projects Descriptions

Project	Additionality	Boundary	Baseline	Notice
(1)	As a clean fuel reduce CO_2 and other pollutants. Investment barriers exist for private companies to implement the project.	Covers emissions from 250 buses and related pipelines. Targets CO_2, NO_x and PM10.	Static business-as-usual baseline that base year situation will extend within the project period.	Small-scale project, targets private companies air-conditioned buses. Credit period is 7 years (2005-2011).
(2)	New technology, both technological and financial barriers exist for the project. Laboratory tests showed that biodiesel could reduce CO_2 and other pollutants.	Covers emissions from 3,611diesel buses(1,674 regular buses and 1,937 air-conditioned buses) and emissions from fuel and materials transportation. Targets CO_2, NOx and PM10.	Static business-as-usual baseline that base year situation will extend within the project period.	Objects BMTA operated buses. Coconut Methyl Ester (CME) from coconut oil, blended with diesel by 20% to be used as biodiesel. Credit period is 10 years (2005-2014).

5.2 Data Collection and Calculation Methods

Data of fuel consumption, vehicle travel and number of buses come from BMTA Annual Reports and emission factors for GHG are from Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines while emission factors for NOx, PM10 are from Japan Transport Cooperation Association's Final Report on CDM in Thailand. The related data for the both projects are shown in Table 7 and Table 8.

Table 7. Related Data of the Project (1)

	Natural gas	Diesel
Fuel consumption	56,750.2 m^3/year/bus	50,748.6 liter/year/bus
Emission factor of CO_2	1427.6 gram/m^3	2,697.5 gram/liter
Emission factor of NO_x	5.7gram/km	16.36 gram/km
Emission factor of PM10	0.19 gram/km	2.2 gram/km
Emission factor of CH_4	1.1 gram/m^3	0.06 gram/km

GHG emissions are calculated by equation (4.1), other pollutants emissions like NO_x, PM10 are calculated by equation (4.2) based on the vehicle-driving pattern. Emissions from the Biodiesel Buses are calculated based on the carbon neutral nature of the CME and blend rate efficiency of biodiesel, emissions from material transportation are calculated by bottom-up method. Based on the result of Tokyo Environment Science Laboratory's study the 20% CME blended biodiesel have no differences in the term of fuel consumption compare to pure diesel while it may reduce CO_2 emissions by 6% (except carbon neutral affection), PM10 emissions by 40% and NO_x emissions by few percent.

Table 8. Related Data of the Project (2)

	Regular Buses	Air conditioned Buses
Fuel consumption	52,161,717 liter/year	98,570,807 liter/year
Emission factor of CO_2	2,697.5 gram/liter	2,697.5 gram/liter
Emission factor of NO_x	13.83 gram/km	13.34 gram/km
Emission factor of PM10	1.67 gram/km	1.07 gram/km
Average travel distances	131,979,852 km/year	184,489,422 km/year
Number of buses	1,674	1,937

5.3 Emissions Reduction Results

The emission differences between the baseline scenario and the project scenario are to be the result of emissions reduction. In the case of project (1), the baseline is a static historical baseline that 250 private companies operated diesel buses will keep the average historical condition of fuel efficiency (1.87 km/liter), travel distance (average 260 km/day) and average speed (10km/h)(from practical driving condition) within the project period. As a result, the baseline scenario will produce 34,253.4 CO_2e ton of GHG (CO_2 and CH_4), 388.14 ton of NO_x and 52.19 ton of PM10 emissions per year. On the other hand, the project scenario of operating 250 CNG retrofitted buses will yearly produce 20,581.1 CO_2e ton of GHG, 135.23 ton of NOx and 4.5 ton of PM10 emissions on the condition of 0.598 m^3/km fuel efficiency and 260 km/day vehicle travel kilometer.

In the case of project (2), baseline still is a static historical baseline, 3,611 (consist of 1,674 regular and 1,937 air conditioned buses) BMTA operated diesel buses will keep current trend within the project period that baseline scenario will yield yearly GHG (mainly CO_2), NO_x and PM10 emissions, by 406,600.98 CO_2e ton, 3880 ton and 299.11 ton respectively. The project scenario will develop by using 20% CME blended biodiesel for the same number of buses that keeping the same travel condition with the baseline. CO_2 emissions from CME producing are treated to be zero due to carbon neutral nature of coconuts and assumption of hydropower supplying for plants. The other air pollutant emissions from CEM producing process are neglected here; as a result, the project scenario will produce yearly emissions of CO_2, NO_x and PM10 from bus operating by 300884.72 CO_2e ton, 3763.6 ton and 179.45 ton respectively, also from material transportation, by 72.15 CO_2e ton, 0.94 ton and 0.11 ton respectively.

The results of comparing the CDM project scenarios emissions with the baseline scenarios emissions show that the project (1) will gain yearly reduction of GHG, NO_x and PM10 emissions by 13,772.30 ton CO_2e, 252.91 ton and 47.69 ton respectively while the project (2) will get yearly reduction of above three kinds of gases emissions by 105,644.10 CO_2e ton, 115.46 ton and 119.53 ton respectively. The emission estimations in the case studies are very conservative while both cases applied static method that has not considered vehicles deterioration or technical penetration during project period.

5.4 Financial Analysis

The optimistic price of 10.96 US$ per ton CO_2 (Natsource Japan 2004) is used for CER calculation. For a good understanding of how carbon credits affect financial viability of the project, it is very important to define cost and benefits term. Incremental cost term is used for this paper. It is defined as the additional costs economic agents incur when undertaking a climate mitigation project against a baseline. Incremental costs in this paper include invest cost, operating & maintenance cost and CDM administrative cost. Benefits include operating and carbon benefits. In this paper, ancillary benefits are also our concern. Cost and benefit items for the case studies are explained in Table 9.

Table 9. Cost and Benefit Explanation

		Project(1)	Notice	Project (2)	Notice
Invremental cost (MillionUS$)	Capital cost	10	259 buses, US$ 0.04 million for per CNG kit.	27.85	Cost for CME producing plant that has capacity of producing 120 ton CME per day.
	Administrative cost	0.2	Costs forfeasibility studies, baseline analysis, and monitoring and verification, roughly estimated based on the experiences from PCF.	0.5	Costs forfeasibility studies, baseline analysis, and monitoring and verification, roughly estimated based on the experiences from PCF.
	Operating and Maintenance cost	0.125/year	Maintenance gap between diesel buses and CNG, US$ 500 additional for per CNG bus.	5.7/year	Operating and maintenance cost for plant.
	Material cost			18.38/year	Cost for purchasing materials for CME producing..
Revenue (MillionUS$)	Operating benefit	1.66/year	Fuel cost differences, CNG bus can save US$0.07 per km than diesel buses.	9.66/year	Benefits from the selling of product.
	CER	0.15/year	With the price of US$ 10.96 for per CO_2	1.16/year	With the price of US$ 10.96 for per CO2e.

In the 12% social discount rate, financial analysis of projects show that in the project (1), the IRR is 2% without CER consideration, though the FIRR is increased to be 5% by CER, however, the CDM project would not make financial sense to invest. Have to point out here is that the project could still be attractive from a social perspective because of ancillary benefits.

In the case of project (2), though coconut industry is seen to stimulate local economy so that increase income levels of small-scale coconut growers. However, at present, the price of CME is more than twice higher than the price of diesel (0.93 US$/liter for CME and 0.37 US$/liter for diesel) that there is a market barrier. It implies that for use of 20% CME blended diesel, there is a need of US$ 16.88 million annual government subsidy for incremental fuel cost for 3,611 BMTA buses. Without the fuel subsidy, the project does not make any sense. Therefore, treating a whole project by dividing it two portions of ODA and CDM baseline projects is appropriate. In that case, CME producing and refining plants could be implemented by ODA with the 11% of FIRR, and CDM portion of the project could be the CER buying action accompanying with some technical transferring. In other words, entities from Japan can buy annually 13, 772.3 CO_2e ton of CRE that can be US$ 0.15 million with the price of US$ 10.96 per ton CO_2. Attention must be paid to the point that ancillary benefits from the whole project most likely be the motivation for host country to provide subsidy.

5.5 Cost Benefit Analysis

For assessing ancillary benefits mainly health benefits that include benefits of avoiding from respiratory illness and premature death in the exposed population, fixed damage cost coefficient Model is applied. The health benefits from NO_x and PM10 are estimated by equation (4.3). And damage cost coefficients are US$ 200,000 per ton of PM, 2,500 US$ per ton NO_x, these figure were derived by PAS/EPS (2001) using the rapid assessment methodology set out by Lvovsky et al (2000).

With the ancillary benefits of US$10.16 million per year, the project (1)'s B/C is 5.58 and IRR is over 100% while with the ancillary benefits of US$ 24.18 million per year, the project (2)'s B/C is 1.85 and IRR is 99%. However, the ancillary benefits mostly incur to the host country's side that has no really meaning to the investor side, as CDM is a business mechanism, even though it has an aim of SD stimulating in the host country.

Therefore, in order to activate transport sector CDM projects that have nature of generating more local benefits than global benefits, burden-sharing scheme could be one convincible option. From this point of view, for the project (1), even if, 10% amount of ancillary benefits is involved into project as government support for new technology that can reduce investor sides load as a benefit and make the project financially viable with 17% of FIRR. Host country also can get the aim of reducing adverse health effects cost effectively when US$ 1.02 million yearly cost will return with US$ 10.16 million yearly health benefits. For the project (2), it is obvious that fuel subsidy from the host country's government that is the precondition of whole project, is very reasonable while US$ 16.88 million yearly input can generate yearly benefit of US$ 24.18 million, moreover benefit from the selling of CER also can reduce the subsidy. Investor side also, can gain CER cost effectively by implementing financially viable ODA project.

6. CONCLUSIONS AND DISCUSSIONS

In transport sector, even technically sounded GHG mitigation projects may not be CDM projects due to lack of economical viability. The ancillary benefit consideration in CDM cost benefit cycle could be an optimum condition for feasibility of CDM projects this due to ancillary benefits can offset a significant fraction of the incremental project costs. In this case study, the fractions were 4.94 for project (1) and 0.87 for project (2). It implies that the case study CDM projects are not cost effective for Global climate change mitigation, but are cost effective for local environment improvement.

And, the ancillary benefits could be threshold for transport sector CDM projects evaluation in the view of sustainable development due to financially unsounded projects like in this paper are still cost-effective for most developing countries. However, ancillary benefit values lie in a wide range that leads variety of result. Here, the most important thing in transport sector is how to set a burden share scheme on which host and investor sides can reach to the point of getting globally and locally benefits simultaneously by sharing project costs based on the comprehensible local benefit (ancillary benefits) from the CDM project.

As an our initial research on CDM, both case studies in this paper are belong to the technologically changing scope, transport sector projects related to the behavior changing, especially for infra-structure projects, really need to benefited from CDM. Forecasting traffic situations from behavior changing projects is a main point for both carbon and ancillary benefits estimation. This is our further concern.

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