PROGRESS OF CDM PROJECT IN TRANSPORT SECTOR: Lessons learned from bus replacement project, Yogyakarta, Indonesia

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ABSTRACT: Transport sector, particularly urban transport sector has long been recognized as the main contributor of Green House Gases Emissions. CDM or Clean Development Mechanism as one of the mechanism within the Kyoto Protocol has provided an opportunity to finance urban public transport project using the principle of a carbon trading. Yogyakarta Public Transport Alliance aims to implement CDM project by introducing alternative technology to reduce GHG and thus providing financing opportunity for the project. After two years of preparation and project proposal development, several lessons have been drawn from the exercise. Transport sector project should treat revenue coming from CDM project as the co-benefit instead of the main source of revenue. Additionality of CDM lies in its ability to restructure bus industry to be an efficient, and is oriented toward service quality. Participation from bus crew and transport operator is the key for a successful implementation of the project.

RÉSUMÉ : Le secteur du transport, surtout le secteur du transport urbain, a longtemps été reconnu comme le principal responsable d'émissions de gaz à effet de serre. Le MDP ou Mécanisme de Développement Propre comme un des mécanismes du Protocole de Kyoto a fourni l'opportunité de financer un projet de transport public urbain en utilisant le principe du « pollueur–payeur ». L'alliance de transport public Yogyakarta aspire à mettre en oeuvre le projet de MDP en introduisant une technologie alternative pour réduire les gaz à effet de serre et fournissant ainsi une opportunité de financement pour le projet. Après deux ans de préparation et de développement de la proposition du projet, plusieurs leçons ont été tirées de l'exercice. Le projet du secteur de transport doit traiter le revenu provenant du projet de MDP comme le co-profit plutôt que la source principale de revenu. L'atout supplémentaire du MDP se trouve dans sa capacité à restructurer l'industrie des autobus pour la rendre efficace et orientée vers la qualité de service. La participation des chauffeurs d'autobus et de l'opérateur de transport est la clef d'une mise en oeuvre couronnée de succès du projet.

1 INTRODUCTION

1.1 CDM Project in Transport Sector: the Rationale

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was formally adopted by the third session of the Conference of the Parties (COP 3) on 11 December 1997 in Kyoto, Japan. The Protocol establishes a legally binding obligation on Annex I countries (subject to entry into force) to reduce emissions for six greenhouse gases (GHGs) in total by about 5.0% below 1990 levels by the years 2008-2012. Six greenhouse gases are covered, not only carbon dioxide which accounts for the vast majority of emissions, but also methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride.

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An important element of the Protocol lies in the adoption of a five-year commitment period, rather than a target set for a single year. In the Article 10 of Kyoto Protocol, it was stated that "All Parties, taking into account their common but differentiated responsibilities, shall formulate, implement, publish and update programmes including measures to mitigate, and adapt to, climate change, covering energy, industry and transport sectors. Parties should also develop and promote modalities for the transfer of environmentally sound technologies."

In the Article 12 of the protocol a measure called Clean Development Mechanism is available for non Annex I countries which include Indonesia. In the article it was stated that "A Clean Development mechanism is established to assist non-Annex I Parties in achieving sustainable development. Certified emission reductions achieved through individual projects which reduce GHG emissions beyond what would have occurred in the absence of that project, can be used by Annex I Parties to help meet part of their commitments in Article 3. Certified emission reductions achieved between 2000 and 2008 can be credited against commitments under the first commitment period (2008-2012). A share of the proceeds from certified project activities is to be used to assist developing countries vulnerable to the adverse effects of climate change to meet the costs of adaptation."

The Clean Development Mechanism is the sole mechanism to allow countries not included in the Annex I, which is industrialized countries to participate in the global effort in reducing GHG emissions. The developing countries will now have the opportunity to attract investment in projects where potential reduction in GHG exists. This opportunity occurs because locations of projects are indifference in contributing the GHG emissions reduction while their abatement costs may differ substantially. Costs of reducing similar amount of carbon in a developed country will be relatively higher than in developing countries.

The term "creditable emissions" is therefore defined as the difference of GHG emissions between the implementation of the project and the baseline condition where the project is not implemented or is otherwise implemented with "dirtier" technology.

Transport sector is regarded as the primary sources of GHG emissions. Previous study from the Indonesian Government has identified that nationwide, transport sector is responsible for 24.1% GHG emission in 2000 and grows at the highest rate reaching 25% in 2025.

Table 1. Projection of total CO2 emissions from the energy demand sectors in Indonesia to 2025

Sector	Total CO2 emission (million t)				Growth Rate (% year)
	2000	2010	2020	2025	
Industry	58	73	109	141	2.4
House-holds	21	23	22	25	0.4
Transport	55	76	128	168	3.4
Power plants	54	90	220	275	5.1
Energy Industry	40	35	48	63	1.9
TOTAL	228	298	526	672	3.3

Source: National Strategy Study on CDM, 2001, SME-GTZ, pp. xxii

1.2 Principles and Assumptions

Project eligible for CDM investment funding has several principles and assumptions. These principles and assumptions are critical since they reflect the appropriateness and compliance of the project. It ensures sustainability aspects of the development.

The followings are principles and assumptions to be considered when developing CDM project.

Baseline methodology

For the CDM project, it is essential to determine the baseline. Baseline is defined as a level upon which the intended output of investment is measured against. In a common appraisal term, baseline is also a "do-nothing" or "do-minimum" scenario. In the baseline, emissions are estimated using a certain method.

The project chooses fixed dynamic baseline methodology to estimate the baseline emission. Fixed dynamic baseline can be defined as one that is planned from the beginning to change at a certain rate over time (Salon, 2001). This is due to the change in engine performance that would cause increase of emission over the years. The other reason is that in transport sector, a slight change in technology and behavior may influence the emission significantly. Therefore it makes more sense to use the fixed dynamic baseline in this project.

Project category

Based on Appendix B of the simplified modalities and procedures for small-scale CDM project activities, the project activity conforms to project type III.C Emission reductions by low-greenhouse gas emitting vehicles or according to the Appendix B of Annex II of the simplified modalities and procedures for small-scale CDM project activities, the project activity conforms to project type iii (other project activities) and project category L (emissions reductions in the transport sector).

Additionality and incremental costs

This principle implies that the CDM project will have to demonstrate that without CDM the investment will not take place. In other word, if the urban buses should be replaced after 7 years, there is no need for CDM project to cause the replacement because it is already mandatory for every bus operator to comply with such regulation. CDM project will be eligible if it adds value to the project by introducing "cleaner" technology or system without which such introduction will not occur.

CDM project viability will be measured against the incremental costs of the presence of the new technology.

Project boundary and leakage

For every CDM project, it is essential to make sure that the owner identify project boundary, which is loosely defined as the boundary within which its impacts on emission can be measured and monitored.

Project leakage is defined as “Potential sources if increased green house gases emissions outside project boundary that are significant and reasonably attributable to project activity” (Para. 89 (c) FCCC/CP/2000/ CRP.2/Add as quoted in SME, 2001).

Contribution to sustainable development

CDM project protocol ensures that developing countries are benefiting from the investment sustainable development indicators should be devised to guarantee that technology that is commonly imported and used in the country is economically justifiable, socially and environmentally acceptable and technologically adaptable. This principle avoids developing countries of being abused by investment from developed and industrialized countries. This principle also ensures that the project is within the country’s sustainable development objectives.

1.3 CDM Procedure and project cycle

For a project to be successfully executed as a CDM project, it has to go through a series of steps.

a. Project development stage. The project proponent should develop a Project Design Document containing a brief description of the project, how the baseline and emission reduction is calculated, stakeholder processes as well as determining the monitoring methodology
b. Approval by a Designated National Authority. CDM protocol requires that the project should be endorsed by a national organization specifically assigned for CDM project.
c. Validation by an Operating Entity. Once the project has been endorsed by DNA, the project emission should be validated by a registered independent firm. The task of this firm is analogous with an accounting firm in assuring that proposed emission reduction can be made possible during implementation.
d. Registration of CDM Project to the Executive Board. In order to be legally recognized as a commodity, the emission reduction should be registered and approved as a CDM project by an international body established by the UN.
e. Monitoring by an independent emission reduction monitoring organization.
f. Verification and issuance of CER. Once it is verified, than the CER (creditable emission reduction) can be traded or investment can be invited.

2 URBAN BUSES REPLACEMENT PROJECT FOR YOGYAKARTA CITY

2.1 The needs for bus replacement in the absence of CDM project

The city of Yogyakarta is situated in Java Island Indonesia. The city of Yogyakarta is a middle-size city in Indonesia with around 475,000 inhabitants. It has developed into an urban area with a population of around 1,000,000 people, living in places beyond the city’s administrative boundaries.

With 32.50 km2 of area, its population density ranges from 7,327 persons/km^2 to 27,373 persons/km2, creating a densely populated city and thus ideal for public transport operation. In the suburban area, the density remains low with around 5,000 persons/km^2. The city also has 238,249 km of road network covering approximately 5% of the city area. It means that the road is relatively narrow with low capacity. It should be pointed out that the attempt to widen the roads is unlikely to happen due to high building density along the roads. The urban area of Yogyakarta is an agglomeration of the city of Yogyakarta and two nearby regencies, Bantul and Sleman. The city is known as the cultural capital of Java attracting a number of foreign and domestic tourists. Over the years, the number of domestic as well as foreign tourists showed a promising future of tourism expected during the economic-turn-political crisis. Despite such condition, it is estimated that the number of domestic and foreign tourists will reach 1,225,000 and 300,000 in 2003 respectively. Yogyakarta is also an education city with around 50 universities and colleges having 69,744 students, where they hold a high percentage (15%) of the city population. It also attracts foreign students to stay for educational purposes. This creates a demand for public transportation.

The sublet system of the bus revenue between the owners and the crews (driver and conductor) makes it more complicated undertake a bus renewal program. The owners receive a fixed amount of money everyday from the bus crews, regardless how much money they earn on that day. The crews are also responsible for fueling, maintenance and any other expenses. The bus owners receive only 27.7% from the total revenue and 67.7% of the total net income. The crews have more direct control on the cash flow while the owners have limited power to try to increase their share of revenue. The local government is the one who sets up the bus fare and there is strong resistance if the bus operators would try to affect the tariff regulation, therefore it is hardly possible for them to get increase of revenue from the bus fare. This system is preferable to the crews, although they have to bear the maintenance costs, but the more passengers they get, the more money they may earn each day.

One important issue that should be taken into account is the Local Regulation of Yogyakarta Special Province No. 10/2001, which regulates age limitation for buses to a maximum of 15 years. To comply with this regulation, the operators are required to replace their fleets, which are older than 15 years.

At the moment, eighty percents from the 200 buses are older than 15 years. The owners still operate them since they still gain revenue from the investment that they did 15-20 years ago. An investment on new buses is worth more than six times annual revenue of the bus owners. The bus owners would not be able to afford an investment on new buses without supports from local government, state-owned oil and gas company (as the supplier of LPG) and financial service company (e.g. bank), which will be attracted by the status as future CDM project.

After the issuance of the Local Regulation of Yogyakarta Special Province No. 10/2001 in 2002, there was strong resistance from the bus entrepreneurs for they regarded the regulation as one sided and too early to be enforced. The Yogyakarta Local Transportation Department has agreed to put off the enforcement of this regulation until the end of 2006. The entrepreneurs are expected to replace their fleets in 2007.

2.2 Project description

The project will focus on the replacement of the existing buses with new buses fuelled by LPG. LPG is a by-product of oil refineries. LPG contains mainly propane with smaller amounts of propylene, butane and other light hydrocarbons. In atmospheric condition LPG is in gas phase, but usually it is stored under pressure as liquid in cylindrical tanks. Fuel tanks of LPG are typically manufactured of carbon steel and are similar in construction to compressed air tanks. Working pressure for vehicular tanks is typically about 1700 kPa (17 atm), and the tanks are equipped with pressure relief devices typically set in the vicinity of 2600 kPa (26 atm). Tanks are manufactured in a wide variety of sizes to suit different applications. Large LPG tanks used for fuelling facilities are typically manufactured from steel and should be qualified under standard pressure vessel codes. LPG is heavier than air. The leaked gas will accumulate in the maintenance pit or any low point in the maintenance facility. Any electrical equipment placed in the maintenance pit should be spark free. The maintenance facility should be equipped with hydrocarbon detectors located at low points that are likely to be accumulation points of the possible leaked gas.

LPG is common for fuelling smaller vehicles, but so far it is rarely found in transit buses. Engine technology for LPG vehicles is very similar to that of natural gas vehicles, with the exception that LPG is seldom used in dual-fuelled applications, due to its poorer knock resistance. One of the advantages of using LPG as fuel is that it requires easier maintenance. LPG vehicles suffer less internal carbon build up than gasoline vehicles. This means the spark plugs often last longer and the oil changes are less frequent. Using LPG vehicles will also lead to the CO reduction. Previous study showed that the CO reduction up to 60% is possible (YUPTA, 2003). The particulate emission was lower than gasoline vehicles and much lower than diesel vehicles. Other advantages of using LPG are: better mixing of fuel and air, higher octane number, better combustion process, lower service and reparation frequency and longer lifetime of lubricants.

Using LPG as fuel requires changes in fuel mixing system of the engine. This is due to the different phase LPG, which is gaseous in atmospheric condition, unlike diesel or gasoline that is liquid. Engine using LPG requires a converter or vaporizer to change the stored liquid LPG to gaseous phase.

Carburetor for engine of vehicles using LPG has to be specially designed. One of the most vital parts of the LPG carburetor is the automatic valve. This part can be in the form of electrical solenoid with vacuum lock-off system, which prevents flow of fuel despite of starting. This valve is placed at the minimum distance to regulator to minimize the volume. LPG carburetor consists of two major components, vaporizer regulator and updraft-type gas-air mixer. The steam fuel pipe has to work at working pressure of 5 psig (34.5 kPa gauge) or lower, made of material that resists the LPG gas. The low-pressure fuel pipe is placed between vaporizer (converter) and carburetor.

One drawback from LPG engine is that it has lower engine efficiency than that of diesel motor. Diesel motor uses Compression Ignition Engine (CIE) that has high compression ratio, hence higher efficiency, while vehicles using petroleum uses Spark Ignition Engine that has lower compression ratio. In common practice, LPG fuelled vehicles use SIE or dual fuel system, which also has lower efficiency. Diesel motor that uses LPG as fuel is still in research stage.

2.3 Estimating GHG emission reduction

The project calculates the emission of CO_2, N_2O and CH_4 in unit of tones CO_2 equivalent (to CO_2e). Other exhaust gases are neglected due to their insignificant amount.

$$E_{use}\left({GJ}/{day} \right) = \frac{FC \times CV}{10^3} \qquad (1)$$

where:
E_{use} : energy use per unit of service (GJ/day)
FC : daily fuel consumption (kg LPG)
CV : lower heating value of fuel (45.4 MJ/kg LPG)

$$\sum E\left({tonnesCO_2e}/{year} \right) = \frac{E_{use} \times US \times n \times \sum EF}{10^3} \qquad (2)$$

where:
E : GHGs emission (to CO_2e)
US : unit of service: operating days per year (days)
n : number of fleets
$\sum$EF : GHGs emission factor for LPG (62.952 kg CO_2 /GJ, 0.1448 kg e CO_2N_2O/GJ and 0.0639 e CO_2CH_4, lower heating value basis; reference: IPCC Default Data)

Energy use (E_{use}) of vehicles using LPG is derived from the estimation based on the energy use of current practice (old buses fuelled with diesel). The energy use of vehicles using diesel is calculated based on the survey data of fuel consumption. Diesel engine has different characteristics from LPG engine. Due to its higher compression ratio it has relatively higher combustion efficiency, hence lower fuel consumption. The project assumes LPG engine will have an estimate of 20% lower efficiency than that of diesel engine. After calculating the energy use in the first year of operation of diesel bus, this value will be multiplied with 1.2 to get the energy use of LPG engine in the first year.

First, the energy use of diesel in the average age of 20 years (in 2002) is calculated using Equation 1. Assuming that there has been a decline of engine efficiency of 20% during its 20 years of operation, then the energy use in the first year is equal to 80% from the value that is obtained in the first step. Since the Euse per day of diesel bus in the first year of operation = 970.496 MJ, the Euse of project is 120% from 970.496 MJ or equal to 1,164.59 MJ. This number is used to determine the average fuel consumption by dividing it by lower heating value of LPG. Using Equation 1, the LPG consumption for the same average distance (197.28 km) would be 25.65 kg/day.

The financial analysis conducted for this project has recommended to increase the average operating days from 24 to 27 days a month. This should be done in order to make the project more economical, in this case increasing the net present value (NPV) of the project. The reason why the operators are running their buses in only 24 days per month is due to the high breakdown rate of engine and consequently it requires frequent reparation. With the project activity, it might be possible to operate the buses in 27 days average per month.

Using Equation 2, the calculated GHGs emission of the project in the first year of operation, E1 is = 4,766.47 to CO_2e

Taking into account the fact that engine performance will deteriorate over time and it therefore affects the fuel economy, the project assumes the declining rate of 4% over 7 years of project crediting period. This phenomenon will affect in about equal magnitude on fuel economy as well as on the GHGs emission. Since the fuel economy would decrease in the rate of 4%, the estimated GHGs emission would increase by 5%. To simplify the calculation, the annual rate of decline is assumed to be equal.

The GHGs emission of the project in the seventh year of crediting period or eighth year of operation is:

E7 = 1.05 x E1 = 1.05 x 4,766.47

= 5,004.794 to CO2e

The difference between E7 and E1 is 238.32 to CO_2e. Having that number divided by 7 give results in the emission increase of 39.72 to CO_2e annually. GHGs emission each year will then be determined by simply adding previous year's emission with 39.72. The total GHGs emission in to CO_2e for n=7 years is calculated using the following formulae:

$$\sum_{n=7} E = E_1 + E_2 + \ldots + E_n \qquad (3)$$

Whereas the En is calculated using the following formulae:

$$E_n = E_1 + \left[(n-1)\Delta E \right] \qquad (4)$$

Applying those formulas, the total GHGs emission would be: $\sum$1-7 E = 34,199 to CO_2e

The project activity: bus replacement with vehicles using LPG reduces anthropogenic emissions by sources and directly emits less than 15,000 tons of CO_2e annually. The business as usual scenario (20-year old average buses with diesel for the first 2 years and 10-years old used buses for the next 5 years) would emit 37,167 tones e CO_2 while the project scenario would generate 34,199 tones of e CO_2

emission or annually between 4,766 to 5,004 tones e CO_2. Total emission reduction for 7 years of life of the project is 2,967 tones CO_2.

Without the CDM project activity, the fleets will still use diesel fuel, which will produce an estimate of tones e CO_2, but the proposed CDM project activity will use new engines running by LPG that will emit CO_2 34,199 tones e CO_2. Replacing engines with fuel switching from diesel to LPG will result in total GHGs emission reduction of tones CO_2 or 8% (in seven years).

2.4 *Methods for monitoring emission reduction*

Based on the above estimation, the monitoring methodology to measure the amount of emission reduction during project activity is by measuring the exact amount of LPG, which is consumed by the engine of 200 buses in 7 years. Considering the absence of odometer to measure the remaining LPG, to avoid running out of fuel during the operation, each bus will have two gas tanks on the mount with capacity of each tank is 40 kg. This allows the driver to switch to other tank when the first tank is empty and he can stop at specific locations to replace the empty tank. With average distance of 197.28 km, one bus will require about 26 kg of LPG per day.

At each LPG filling station, a balance is provided to measure the weight of the full tank and the empty tank. The difference between is the fuel consumption/bus/day. With this data the project can calculate the LPG consumption for 200 buses in 7 years as well as the emissions in tonnes CO_2.

3 LESSONS LEARNED FROM CDM IN TRANSPORT PROJECTS

3.1 *Main or co-benefits: Reliability of CDM funding for securing project feasibility*

The main feature of the bus replacement project in Yogyakarta is the use of LPG as the energy source for the buses. While it is preferable to use CNG for diesel fuel substitute, the option is not yet possible due to the unavailability of CNG filling station.

The project has learned that by switching the fuel to LPG, it will reduce its emission only by 8%, which is not too significant in regard with a total energy consumed by the system. The ability for CDM project to finance a larger part of expected benefit is also questionable. With current emission reduction of nearly 3,000 ton CO_2e in 7 years time, the value of emission reduction is only a fraction of costs for replacing the vehicle. The bulk of vehicle replacement costs are still to be recovered by fare-box revenue.

Verification and transaction costs for small-scale projects are also very high in comparison with the possible benefit from the investment.

It is therefore important to recognize the role of CDM project in transport sector as a facilitator of change. This feature perhaps distinguishes transport sector project with other commonly proposed CDM project in power generation sector.

3.2 *Compliance with CDM protocol: Paradox in reducing GHG in urban bus renewal project*

In complying with CDM protocol, transport project faces many serious challenges. While it is recognized that the major environmental benefits are attributable to soft measures such as deregulation, industry restructuring, demand management and promoting modal split, such measures are not eligible for CDM project. Current CDM project mostly involves the intervention of technology. Current study in India (Mohan, 2003) demonstrates that in India, the benefit for introducing an expensive scheme of CNG buses can easily wiped out if only 10% of its passengers change to private vehicles.

The trade off should be made when introducing new buses. Old buses tend to operate less hours or days than new buses. What was seen as financial and operational advantages of newer buses are now becoming a factor hampering the benefit from emission reduction. The benefit of operating longer working days catering more passengers is now becoming a reduction in total emission.

3.3 *Domestic regulatory framework*

For various purposes, many governments have not ratified Kyoto Protocol. Indonesian government has also not yet ratified it although the ratification of the protocol is the only way to initiate the establishment of a Designated National Authority. The understanding on CDM and its benefits to the country and private sectors creates a hurdle in the decision making process.

This situation hinders the prospect to further process the registration of CDM project to the Executive Board. At the moment, some CDM projects have been registered and verified for its CER, but this uncertainty increase project risks substantially. In the case of the bus renewal project, the private sector is reluctant to proceed with the next step because of the slow process in establishing domestic regulatory framework.

3.4 *Vulnerability of CDM project from international market price*

With the slow process in the ratification of Kyoto Protocol in both developing and developed countries, international market price can not really be predicted, and thus increase project owners' risk in estimating its project feasibility. Current US pull-out from the Kyoto Protocol alone has caused a sudden drop of the market price of carbon from an estimate of 15 USD/ton to the rock-bottom 3 – 5 USD/ton – even with the artificially mark-up price of many developed countries and international financial institution such as the World Bank.

3.5 Maturity of CDM market

Carbon market through CDM exercise is not yet a mature market. It is still at infancy. New players, buyers and sellers of future carbon emission are still seeking its ways to operate in an uncertain condition. For small-scale CDM projects, this situation is less likely to attract investor. Investors and risk takers are willing to risk their projects for larger, more secure projects such as power generation project and other energy sector.

The future of the CDM project will obviously depend on the maturity of the market and the way all player can recognize the opportunities and risks in order to exploit and mitigate them.

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