A Study of CO_2 and PM_{10} Emissions from Public Transportation Projects in Khon Kaen University

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Abstract

This research paper estimates the emissions from existing and proposing public transportation projects in Khon Kaen University. The project is estimated by following principle of Clean Development Mechanism (CDM). The proposed transportation project includes 3 scenarios. The first scenario is the substitution of diesel usage of Song Thaew (pickup truck) with Compressed Natural Gas (CNG). The second and third scenarios are the shuttle bus project using CNG with an average passenger of 6.9% and 15% of total mode share, respectively. The objectives of this research are to calculate the emission reductions of Carbon Dioxide (CO_2), and Particulate Matter (PM_{10}), when each scenario is compared with the condition without project (the baseline scenario). The results show that first second and third scenarios can reduce CO_2 emission about 220 Ton (0.67%), 1,816 Ton (5.51%) and 5,812 Ton (17.63%) respectively. The PM_{10} emission reductions are about 0.16 Ton (3.76%), 0.27 Ton (6.48%) and 0.74 Ton (17.79%) respectively.

Keywords: Emission, CO_2, PM_{10}, Public Transport, CDM

1. Introduction

Khon Kaen University (KKU) is high growth rate of population and development and population, especially number of students which are mostly traveling by private vehicles (especially motorcycle). Moreover traveling of population emits CO_2 which is cause Global Warming problem. Nowadays the KKU have public transport includes a modified pickup truck called "Song Thaew" in Thai (managed by the private company) and shuttle bus (managed by KKU). Each public transport project can reduce using private vehicle and also reduce emission form vehicle too.

Consequently, authors would like to show the benefits from public transportation projects in KKU.

2. Literature review

Gojash O. (2005) [1] evaluated the replacement of existing fuel with alternative fuels of the bus service companies in Bangkok (Bangkok Mass Transit Authority (BMTA) and Private Company) by following principle of CDM. This research considered the two case studies. The former study has evaluated the operation of private company with 250 air-conditioned buses using natural compression gas (CNG) The later study has evaluated the operation of BMTA with 3,661 using

Bio-diesel (B20, Diesel 80% and Coconut Oil 20%). The evaluation result shows that both case studies could reduce the amount of GHG emission and achieve the cost effectiveness.

Tippichai A. (2007) [2] proposed the alternative fuel for buses of Bangkok Mass Transit Authority. There are totally 3,636 buses with 2,029 air-conditioned buses and 1,594 non-air-conditioned buses. The emission of buses was calculated based on the principle of CDM. This research compared the emission of two alternative fuels (Bio-diesel (B10) and natural compression gas (CNG)) with condition without project (Baseline Case). The emission was calculated by the CDM methods, Top-Down and Bottom-Up1 methods. The results show that replacement of existing fuel with B10 has decreased efficiently CO_2 emission rather than CNG.

Daniel M. (2004) [3] studied about an evaluation of transportation policies implementing in Manila, Philippines. There are 8 single policies and 3 combined policies for implementation. The implementing scenarios consist of Motor Vehicle Inspection, Transportation Demand Management, Replacement of 2-Stroke with 4-Stroke Motorcycles for Tricycles, Construction of Bikeways, Expansion of the Metropolitan Railway Network, Diesel Particulate Trap (DPT) for Buses and Jeepneys, Compressed Natural Gas (CNG) for Buses, Coco-methyl ester (CME) for Jeepneys, Combination of all scenarios except railways and switching of two stroke to four stroke tricycles, Combination of all scenarios except railways and Combination of all scenarios. This study applied the 4-step urban transportation planning model to analyze and estimate the exiting and future traffic volume by using JICA STRADA program. The evaluation result reveals that the proposing policies could save about 19% of health medical cost of population. The high effective policies are the motor vehicle Inspection, replacement of 2-stroke with 4-stroke motorcycles for tricycles and expansion of the metropolitan railway network.

SIRDC. (2008) [4] studied about feasibility study of traffic and transportation project in Khon Kaen University (KKU). This project is respond travel demand inside KKU in future. This project proposed KKU Shuttle Bus project for using about adjust traffic problems. This study applied the 4-step urban transportation planning model to analyze and estimate the existing and future traffic volume by using CUBE program. Results of traffic volume validated with real traffic volume. Traffic volume by modal are different real traffic volume about 2 % of total traffic volume in validation point and each validation point are not over different 15% which that value are in acceptable error. Results of this study reveals if have KKU shuttle bus project, can reduce total travel distance about 15.2%, can reduce total travel time about 21.8%, can reduce average travel speed about 8.4% and can reduce traffic volume per capacity of road (V/C) about 22.7%.

3. Methodology

3.1 Proposed Transportation Projects

This study proposes public transportation projects to reduce CO_2 emission and PM_{10} emission in the KKU. These emission reduction of each proposed project is estimated by comparing with existing condition without project (Baseline Case) in present year (in year 2007) and 7 years later (in year 2014) following the principle of CDM. The three scenarios are established as follows.

Baseline Scenario: Do Nothing

Scenario 1: Implementing the project of substitution of fuel usage of Song Thaew operating inside KKU from Diesel to Compressed Natural Gas (CNG) as shown in Figure 1.

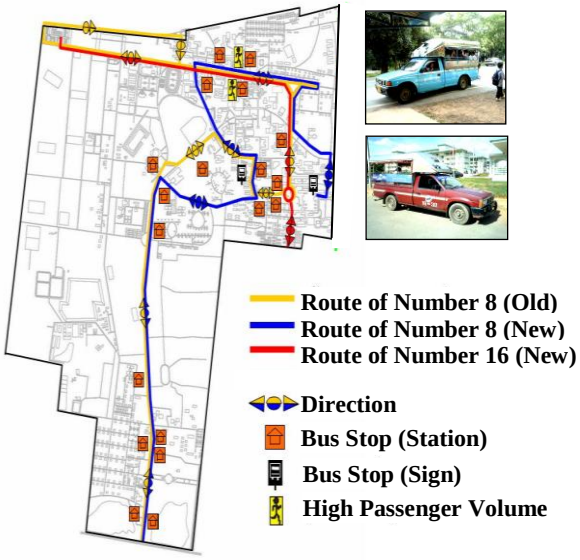

Fig 1. Song Thaew Routes in Khon Kaen University

Scenario 2 and Scenario 3: Implementing the project of replacement of existing Song Thaew by a campus shuttle bus using CNG as shown in Figure 2 and each scenario has an average passenger of 6.9% and 15% of total mode share, respectively.

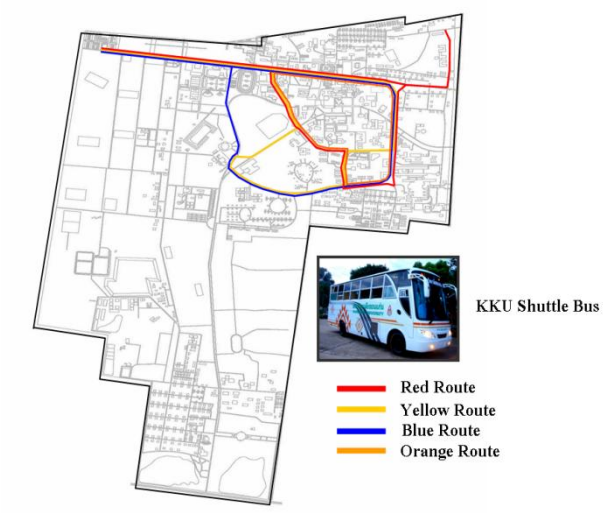

Fig 2. KKU Shuttle Bus Routes

4.1 Calculating CO_2 and PM_{10} Emission

The authors summarize all steps to calculate CO_2 and PM_{10} emission in flow chart for comprehensive understand as shown in Figure 3. This flow chart consists of the first step of data collection, including collecting primary and secondary data. The next step is estimation of traffic volume by 4-step urban transportation planning model using JICA STRADA program, then validating the results. The last steps are calculating CO_2 and PM_{10} emission by link and by whole network. The same sequence will be repeat calculated for CO_2 and PM_{10} emission in future years.

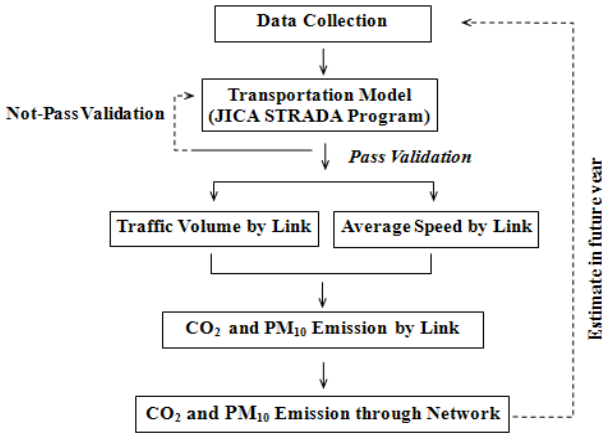

Fig 3. Flow Chart of Calculating CO_2 and PM_{10} Emission

Data Collection: These researches have surveyed the service attributes of existing Song Thaew operating and KKU Shuttle Bus in KKU. The surveyed data in service route, route, frequency, volume, average speed by link, weight of vehicle, average number of passengers per day, and etc. Moreover this research has been given data from several sources. The general data (such as number of population and employment), road network and transportation demand volumes of KKU are given by SIRDC (2008) [4]. It surveyed the existing traffic volume on main road by mid block counting. The existing and future travel behaviors (mode choice) of KKU population were surveyed by questionnaire interview. And, the emission data of various speed which is show example of emission by passenger car in figure 4 and figure 5. These emission data are given by MLIT-Japan (2004) [5].

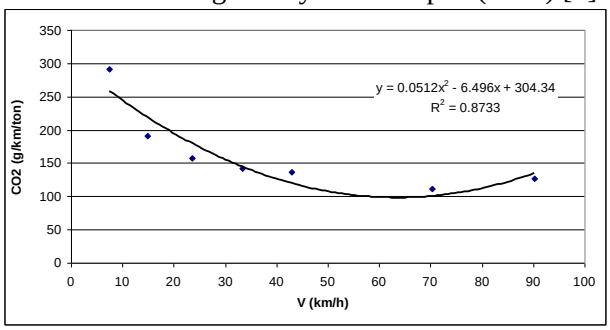

Fig 4. CO_2 emission of passenger car
Source: MLIT-Japan (2004) [5]

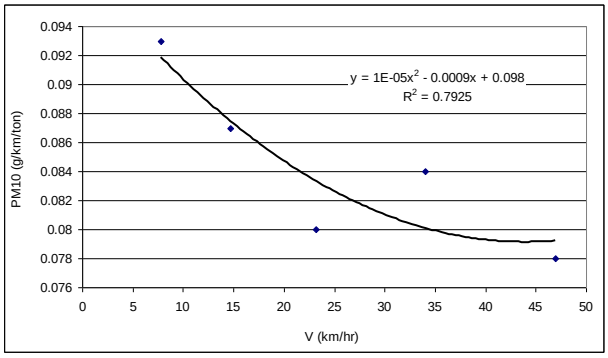

Fig 5. PM_{10} emission of passenger light duty truck
Source: MLIT-Japan (2004) [5]

Calculation of Traffic Volumes along Road Network: This research applied the 4-step urban transportation planning model through using JICA STRADA program to estimate exiting traffic volume (year 2007) and future traffic volume (year 2014) along KKU road network. In part of modal split is use result of research form literature review [4]. These result show in figure 6 and figure 7.

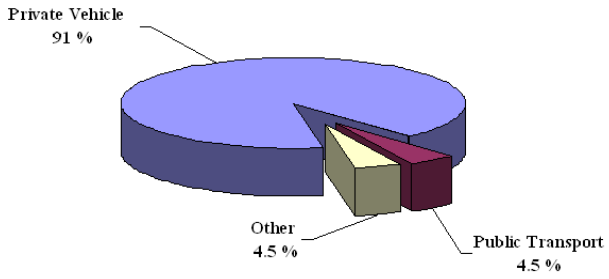

Fig 6. Mode Choice of KKU Population in 2007
Source: SIRDC (2008) [4]

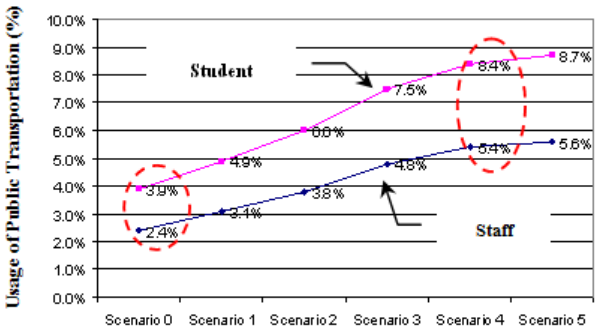

Fig 7. Usage of Public Transportation in future
Source: SIRDC (2008) [4]

Red cycles are mean average value for using in this research (3.15% in scenario 1 and 6.90% in scenario 2).

4.2 Validation Traffic Volume

After completing a running of a demand model, the traffic volume on each road link resulted from a model has been compared with the real traffic volume by specific link to validate the reliability of the model as shown in figure 8.

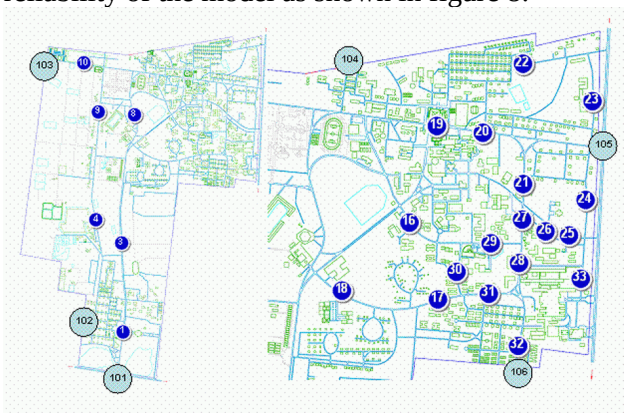

Fig 8. Surveyed points for validation
Source: SIRDC (2008) [4]

4.4 Estimation of CO_2 and PM_{10} emission

After the estimated traffic volumes by link were accepted. There results from traffic assignments model, including traffic volume and average speed by link, would be further applied to estimate CO_2 and PM_{10} emission by link by applying the equation 1 from OTP (2007) [6]. The Emission factors in the equation are given by the project of MLIT-Japan (2004) [5]. This project researched the emission rates of each vehicle type in Bangkok that is similar to the vehicle type used in KKU.

$$\text{Emission of Link} = \sum_k \sum_i D_k \times T_{ki} \times Ef_{ki} \times WT_i \quad (1)$$

Where

k = Link number

i = Vehicle type (Car, Light Duty Truck, Motorcycle, Truck and Bus)

D_k = Link length (km)

$T_{k,i}$ = Traffic volume in link k of vehicle type i (Vehicle)

Ef_{ki} = Amount of CO_2 and PM_{10} Emission on link k of vehicle type i (g/km/Ton)

WT_i = Weight of vehicle type i (Ton)

5. Results and Discussions

5.1 Results of Traffic Volume in Network

Result of estimation by JICA STRADA program can show in table 1.

Table 1 Traffic Volume in 2014

Scenario NO.	Traffic Volume in 2014 (PCU / hour)
Do nothing	788
1	788
2	759
3	681

It can explain that if KKU have operating Scenario 2 and Scenario 3, will be reduce usage of private vehicle but Scenario 1 has not change operation which change usage fuel only , So then traffic volume be the similar do nothing scenario.

5.2 Results of CO_2 and PM_{10} emission

Result of estimation with CO_2 and PM_{10} emission in 2014 by use equation 1 as show in table 2 and reduction of CO_2 and PM_{10} emission as show in table 3.

Table 2 Quantity of CO_2 and PM_{10} emission

Scenario NO.	CO_2 (Ton)	PM_{10} (Ton)
Do nothing	32,979	4.18
1	32,759	4.02
2	31,163	3.91
3	27,166	3.44

Table 3 Reduction of CO_2 and PM_{10} emission

Scenario NO.	CO_2 emission reduction (Ton)	PM_{10} emission reduction (Ton)
1	220	0.16
2	1,816	0.27
3	5,812	0.74

It can explain that both CO_2 and PM_{10} emission reduction from Scenario 1 causes from CNG emitting CO_2 and PM_{10} less than Diesel although the proportion selecting Song Thaew for traveling inside KKU is unchanged. On the other hand, both CO_2 and PM_{10} emission reduction from Scenario 2 and Scenario 3 causes from replacing Song Thaew using Diesel with the shuttle bus using CNG and also switching of some private vehicle users to shuttle bus. It results in decreasing of some CO_2 and PM_{10} emitted by private vehicle.

6. Conclusion

All public transportation projects provide the benefits for Khon Kaen University and can reduce CO_2 and PM_{10} emission especially, the project of shuttle bus. Hence, the more private mode users switching to use shuttle bus the more CO_2 and PM_{10} emission reduction. The proposed projects would be possibly considered to be implemented for CDM in Khon Kaen University.

As the recommendation for future study, the estimation of CO_2 emission should consider carefully on the load of emitting vehicle because it will achieve more accurate result. The additional policies, such as cover way construction, vehicle ban zone, campaign, and etc., should be considered in order to promote the implementation of shuttle bus project.

7. Acknowledgment

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