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The Third Joint Seminar of Japan and Indonesia
Environmental Sustainability and Disaster Prevention (3rd ESDP-2015)
Bandung Institut Teknologi, Indonesia November 25th, 2015

Environmental Sustainability and Disaster Prevention

PROGRAM BOOK

3rd ESDP2015

The Third Joint Seminar of Japan and Indonesia
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Seminar Time Schedule

No	Time	Title
	08.00 - 09.00	Registration
	09.00 - 09.15	Opening Ceremony: Welcoming Address by Prof Ade Sjafruddin (FCCE ITB) Prof Toshida Kitada (NIT Gifu College)
Part 1 Environmental Sustainability		
E1	09.15 - 09.30	**Modeling of Wet Deposition in Chemical Transport Simulation** Toshihiro Kitada
E2	09.30 – 09.45	**Emission Reduction from Implementation of Bus Rapid Transit Corridor 13th in Jakarta** Asep Sofyan, Lailatus Siami, and Russ Bona Frazila
E3	09.45- 10.00	**Estimation of Total Carbon Emission from Forest Fires: Case Study of Borneo Island** Arno Adi Kuntoro, Ade Wahyu, and Hendri
E4	10.00 - 10.15	**Photosensitivity of Graphitic Carbon Nitride Films Obtained by Evaporation** Hitoe Habuchi
E5	10.15 - 10.30	**Evaluation of Continuous and Filter-Based Methods for Measuring $PM_{2.5}$ Mass Concentration in Bandung Urban Area** Fatimah Dinan Qonitan, Puji Lestari, and Haryo S. Tomo
	10.30 – 10.45	**Break**

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EMISSION REDUCTION FROM IMPLEMENTATION OF BUS RAPID TRANSIT CORRIDOR 13th IN JAKARTA

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Abstracts: Green transport nowadays become important concern related to emission reduction. This is also become one of policy brief in Jakarta Macro Transportation (JTM) plan. Busway or so-called BRT as one of reliable mass tranportation in Jakarta has been developed for 12 corridor. 13th corridor is planned as elevated with length 14.6 km typed 2 lanes 2 way. Are this scenario will be significantly affect for emission reduction? This main question will be figured out in this research. Eventually, emission of transportation sector in Indonesia reached almost 200 Gg/year up to 2012. In the research, road networking model is used for representing actual condition of complex urban road in Jakarta. By the result of road assignment, will be estimated the traffic volume every road. Hence, Emission load calculated by bottom – up emission inventory and carried out from road segmentation. Afterwards, emission will be mapped out by spatial distribution resolution 1 km x 1 km that reveals emission reduction due to development of busway 13th is 9% of all emission, respectively. This sufficiently high rate of emission reduction due to fuel shift from fossil fuel to gas considered.

Keywords: Busway corridor 13th, Road networking model, Emission Inventory, Load Emission

INTRODUCTION

The transportation sector is contributes around 23% of GHG emissions overseas (Li et al., 2010). In fact, this sector is the largest source of pollution of the atmosphere contributing to global warming (Progiou and Ziomas, 2011). Road transport contributed to the increase in emissions of air pollutants and cause environmental and health problems depends on the type and concentration of pollutants (Souza et al., 2013).

Jakarta, the capital city of Indonesia, keep becomes the largest center of urbanization which means mobility level of people and goods would higher constantly. In addition, with urban sprawl of the city will enforce people in suburb (Bodetabek) to do activity in the heart of Jakarta and daily moving in and to Jakarta. Traffic congestion has become usual pattern.
Car-oriented development is still the prevalent paradigm of urban development in the developing countries that triggers from exponential growth of private cars in emerging economies. The most widely adopted strategy on mass transportation is BRT development. BRT is a public transport concept that allows high-capacity buses to operate at a rapid speed with some priorities through an integrated system including dedicated lanes, stations, and technologies and advanced branding (United Nations Centre for Regional Development, 2014).

In Jakarta itself, traffic management conduct by Jakarta Macro Transportation (JTM) plan since 1985. It comprised by three main policies in mass transportation development, traffic restriction, and road capacity development. In line with these, DKI Jakarta Act No.1 of 2012 about Spatial Plan 2030, Article 22 paragraph (2) states that efficient road transportation will be realized if the target of 60% of the population using public transport and increase the average speed - the road network average a minimum of 35 km/h.

Regarding with emissions reduction, the existing literature has investigated the individual impacts of bus service improvements mostly. Yet, only few studies assessed the combined effects of various strategies on transit bus emissions (Alam et al., 2014).

The main objective of this research is to know the effect busway 13th corridor in reduct the emission load in 2017. The study will covers CO, NOx, PM_{10} and VOC from car, motorcycle, bus, minibus and truck. The method used in this study is road network model and adapted Emission inventory from EMEP / European Environment Agency in 2013. The emissions inventory is the basis of air quality modeling and analysis and also to understand the shape and the transport of pollutants and the reference to pollution control (Fu, et al 2013). However, many factors that affect vehicle emissions and large amounts of data will be needed in the inventory of emissions from vehicles. So, it is arduous to develop an accurate inventory of emissions for major cities (Wang et al, 2008).

Description of the study corridor

DKI Jakarta is capital city of Indonesia lied on 6°12' south latitude and 106 °48' east longitude with the width 662.33 km^2 (BPS, 2012). The study location includes all public roads and toll (**Figure 1).** Type modes of transportation in Jakarta are divided into mass transit and private vehicles. For mass transport is dominated by minibus, bajaj and busway. While, private vehicles consisting of cars and motorcycles.

Nowadays, the number of busway is already in operation reached 12 corridors (**Figure 2**). And the number of passengers in 2012 reached 304,799 passengers/day or 111,251,869 passengers annualy. As for the plan of development with elevated busway are on 13, 14 and 15 corridors whereas the line 13th connecting Ciledug - Blok M. Corridors 14th connecting Kalimalang - Block M. And corridor 15th connecting Depok – Manggarai.

METHODOLOGY

Calculation

In this study, the calculation of vehicles number is use road network model. As for input are OD (Origin - Destination) matrix and road networking data (Arifin, 2012) of Jabodetabek in 2012 (SATURN, 2013). In the network model, the area is divided into several zones of travel. Each zone is represented by 1 zone center (centroid) connected to the road network through the centroid connector. Here, the road network in Jakarta road network is divided into some 42 zones (see **Table 2**).

Table 1. Number and Zone of Jakarta Road System

No	Zone	No	Zone
211	Gambir	**241**	Tebet
212	Sawah Besar	**242**	Setiabudi
213	Kemayoran	**243**	Mampang Prapatan
214	Senen	**244**	Pasar Minggu
215	Johar Baru	**245**	Kebayoran Baru
216	Menteng	**246**	Kebayoran Lama
217	Tanah Abang	**247**	Cilandak
218	Cempaka Putih	**248**	Pancoran
222	Penjaringan	**249**	Jagakarsa
223	Tanjung Priok	**251**	Matraman
224	Koja	**252**	Pulo Gadung
225	Cilincing	**253**	Jatinegara
226	Pademangan	**254**	Kramat Jati
227	Kelapa Gading	**255**	Pasar Rebo
231	Kalideres	**256**	Cakung
232	Grogol Petamburan	**257**	Duren Sawit
233	Tamansari	**258**	Makasar
234	Tambora	**259**	Ciracas
235	Kembangan	**261**	Cipayung
236	Cengkareng		
237	Palmerah		
238	Kebon Jeruk		

OD Matrix to be assigned in Jabodetabek road network data is as follows (see **Table 3**).

Table 2. In part OD Matrix 2012

Zone	211	212	….	510	511
211	0	405	….	2	14981
212	410	0	….	2	5464
……	……	…..	….	……	……
510	2	2	….	0	
511	16102	5778	….	235	379468

The vehicles number passing each segment of road in the city represent as vehicles volume in units pcu/h is converted into the number of vehicles with passenger car equivalence (Department of Public Works, 1997). Emissions inventory calculations performed road segments when the vehicle working and using the following equation (EMEP / European Environment Agency, 2013):

$$\mathbf{E_{i,k,T} = N_k \times L_{A,T} \times e_{i,k}} \quad \textbf{(1)}$$

$E_{i,k,T}$ is pollutant emission of i[g] at time T. N_k is vehicle typed k. $L_{a,T}$ is length road of a [km] at time T. And $e_{i,k}$ is emission factor [g/km] for pollutan i, for vehicle typed k, at time T. Emission factor showed by **Table 4** below.

Table 3. Summary of Emission Factor

No.	Pollutan	Vehicle Typed	Emission Factor (g/km)
1.	**CO**	Car	37.3
		Motorcycle	14.7
		Bus	5.71
		Minibus	2.71
		Truck	1.85
2.	**NOx**	Car	1.8336
		Motorcycle	0.0576
		Bus	15.84
		Minibus	8.989
		Truck	4.183
3.	**VOC**	Car	2.77
		Motorcycle	8.18
		Bus	1.99
		Minibus	0.706
		Truck	1.07
4.	**PM_{10}**	Car	0.0022
		Motorcycle	0.176
		Bus	0.909
		Minibus	0.479
		Truck	0.333

Source: EMEP- Corinair, 2013

Transportation demand was forecasted for 2017 using the main transportation network in place in 2012. The transport networks in BAU scenarios in 2012 and 2017 are assumed to be the same. The 2017 BAU scenario assumes that elevated busway 13th corridor would be implemented in 2017. The scenarios with the corresponding assumptions on transport network and enforced policies are summarized in **Table 5**.

Table 4. Summary of Emission Factor

Scenario	**Transport network and enforced policies**
Baseline	2012 Transportation demand + No action
BAU 2017	2017 Transportation demand + No action
Busway 2017	2017 Transportation demand + Elevated Busway 13th Corridor development

Figure 1. Study area of DKI Jakarta (PU Cipta Karya, 2012)

Policy scenario were developed based on the mass transportation typed *Bus Rapid Transit/Busway*, this is based on a comparison of the cost of the various types of mass transit (see **Table 1)**.

Table 5 Characteristics of Mass Transportation (Velocity,Construction Cost, Capacity)

No	Mode Type	Velocity	Cost	Capacity	Total Investment
		Km/h	Mill. USD/km	Passanger/ dir./h – Cor.	Km/ million US$
1	Bus Rapid Transit (Busway)	10 – 30	0,5 – 2,5	15.000 – 35.000	275/275
2	Light rail Transit (Monorail)	15 – 25	12 – 25	18.000 – 40.000	27,8/600
3	Mass rapid Transit (Subway)	30 – 35	30 – 105	20.000 – 70.000	14/900

Source: ITDP in transportation department in figures 2012, 2012

Mass transportation with the most efficient velocity, capacity passanger and total investment is bus rapid transit (BRT/busway). Some developing Asian cities consider BRT in their public transport planning because of its advantages of lower investment cost and flexible implementation over rail systems. Moreover, BRT is recommended that would shift private vehicle users to a transport sector which emits lower CO_2 (Satiennam et al, 2015).

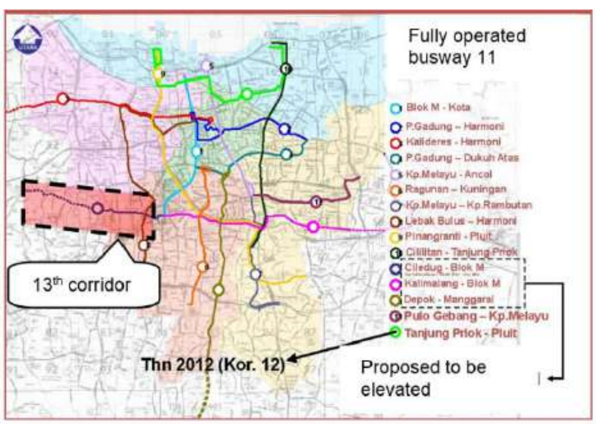


Figure 2. Busway corridor which has been operating in the city of Jakarta in 2012 (Transportation Department in figures, 2012)

On previous study (Ernst, 2006) showed that the possibility of shiftment from private transportation to buses by 14%. In the scenario, elevated busway to be implementated is corridor 13^{th}. The length of the corridor 13^{th} is 14.6 for a type of application 2x1 lanes (2 lanes 2 way).

RESULTS AND DISCUSSION

Traffic Volume

OD Matrix to be assigned to the Jabodetabek road network data for baseline is shown in

Table 6 below.

Table 6 In part Result of Baseline

Zone	211	212	….	510	511
211	0	405	….	2	14981
212	410	0	….	2	5464
……	……	…..	….	……	……
510	2	2	….	0	
511	16102	5778	….	235	379468

So the vehicles volume on the road traffic Jakarta as follows.

Table 7 In part Result of Baseline Vehicle Volume

Simulation/buffer		**Vehicle Volume (pcu/hr)**	
A node	B node	Total	Fixed
C 211	50091	29,205	0
50091	C 211	32,685	0
C 212	50090	10,674	0
50090	C 212	11,669	0
C 213	50045	13,760	0
……….	……….	……….	……….
……….	……….	……….	……….
90137	41448	6,280	0
90138	50160	4,541	0
90139	90130	2,323	0

Details proportion of passing vehicles on the main road and highway can be seen in **Figure 5**. The roads with the densest volumes are on the road Ciputat Raya. The number of cars, motorcycles, buses, minibuses, and trucks respectively - helped as many as 10,132; 49,076; 280; 407 and 650 units a day. The number of cars and trucks at most dominating motorway Gatot Subroto respectively - also 7823 and 4477 units per day.

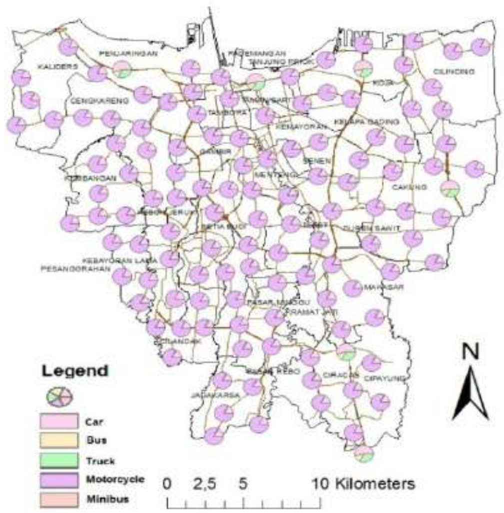


Figure 3. Mode Share based on typed in Jakarta by 2012

The proportion of vehicles that dominate the toll road in Jakarta is a car, whereas on a main road motorcycles dominate. This is the main cause of congestion (Ferdinansyah, 2009). The level of preference for private vehicles in Jakarta is quite high due to social status, security and comfort of the rider. Lacks of public transport services also trigger the use of private vehicles (Dissanayake and Morikawa, 2010).

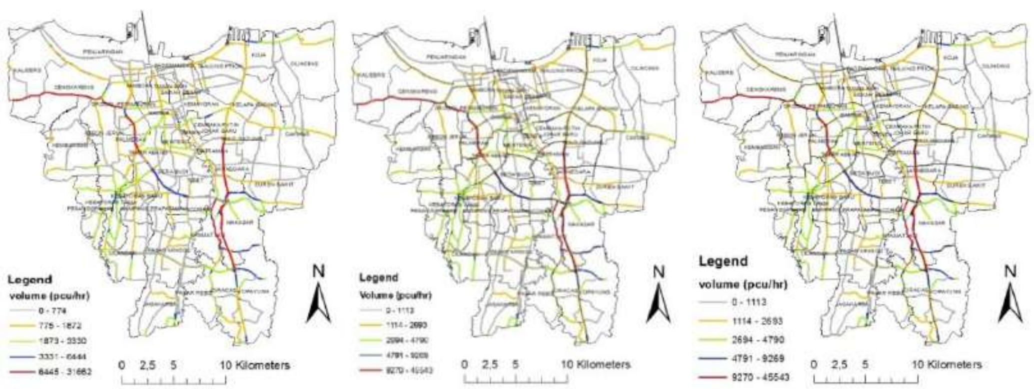
At baseline, where a scenario have not be applicable in 2012. The volume of vehicles on each road follows the path of a primary arterial road (**Figure 4**). In West Jakarta, the heavy volume of vehicles are in Cengkareng sub-district is on the road Daan amounted to 31,662 pcu/h (passenger car unit/hour). This is due to the high number of trips from the town Tangerang to Jakarta and vice versa (Sunggiardi, 2009). In addition, compared to other major roads in Jakarta, Daan Mogot road is one of the arterial roads at speeds below 10 km/h (Putranto, 2010). Activities dominant land use in the surrounding streets is in the form of services trade industry, and offices.

In South Jakarta, the heavy volume of vehicles are in Kebayoran Lama sub-district is on the road Ciputat Raya amounted to 23,992 pcu/h. The basic capacity of 4,950 pcu/h and per direction basis capacity of 5,560 pcu/h. Triggers number of vehicle volume is due to the use of the main road to the mobility of vehicle and to South Tangerang. In Ciputat there are also several small terminal, as in Jombang market, Bintaro market and Serpong market. Certainly, this will increase the number of vehicles passing on Ciputat Raya road. In East Jakarta, in Kramat Jati district heavy volume of vehicles crossing located on the May. Jend. Sutoyo street of 7,137 pcu/h. Several roads with heavy volumes estimated road network model are the road with high-frequency congestion. This is in line with the data traffic jam-prone areas in Jakarta.

Highway has a volume of most solid vehicles are toll roads Gatot Subroto in Central

Jakarta area Tanah Abang subdistrict with a volume of 16,470 pcu/h. Volume ratio and capacity on the road is around 0.91. This means that the road almost reached the degree of saturation. Toll road in East Jakarta with heavy volume is Jagorawi and the junction with the volume of vehicles Cawang 7,182 pcu/ h and 6,831 pcu/h. One treatment to reduce the density of vehicles in Jakarta is the modal shifts vehicle. Modal shifts of vehicles from cars and motorcycles allows changes to the ratio of VOC/NOx in the atmosphere (Nugroho, 2010).

The spread of the volume of vehicles on the scenario BAU 2017 did not undergo significant changes as well as Scenario of busway 2017. West Jakarta areas with high vehicle volume remained at Daan Mogot Street.



(a) (b) (c)

Figure 4. (a) Traffic Volume each segment in Jakarta by 2012**. (**b) Traffic Volume each segment in Jakarta by 2017. (c) Traffic Volume each segment in Jakarta based on busway 13th scenario by 2017

Load Emission

As a whole, baseline emission inventory on road segmentation in Jakarta by 2012 resulted 148,343 Gg/yr for NO_x; CO as 229,953 Gg/yr; PM_{10} as 2,089 Gg/yr. and VOC emission as 72.867 Gg/yr. CO plays the largest contribution as 50,73% of all pollutants and NOx as 32,73% as the second largest (**Figure 5a**). Meanwhile BAU scenario 2017 resulted emission load of NO_x as 29,687Gg/yr; CO as 330,748 Gg/yr; PM_{10} as 3,003 Gg/yr and VOC as 104,807 Gg/yr (**Figure 5b).** After Busway corridor 13th applied, NO_x as 29,651.47Gg/yr; PM_{10} as 2,991.55Gg/yr and VOC as 104,269.76 Gg/yr. CO still play as the largest emission for 329,377.52 Gg/yr and reached 72.48% of all pollutant typed (**Figure 5c).**

As we can see in **Figure 6 above**, the BAU Scenario resulted the largest emission load of NOx pollutant is laid on toll roads, toll roads i.e. IR. Wiyoto Wiyono with emissions amounting to 5,820.25 Gg/year. The highest NOx pollutants emissions on the main road, is located on the road of Ciputat Raya with emissions by 530.35 Gg/year. For NOx Emissions are highest on the motorway, although on a main road of vehicles is more varied.

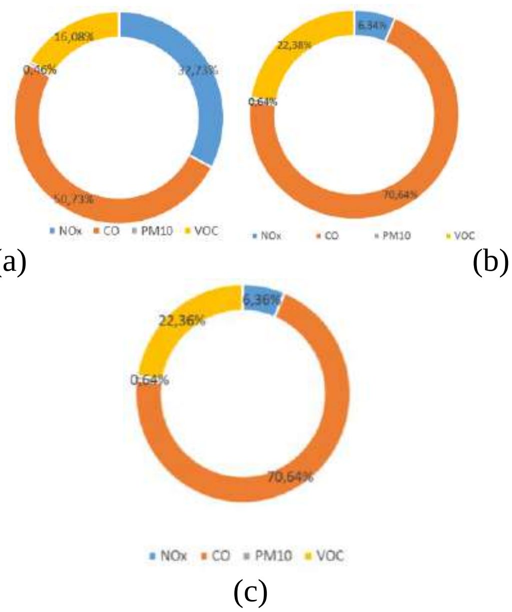


Figure 5. Emission Share of : (a) Baseline scenario in 2012. (b) BAU 2017 Scenario (c) Busway Corridor 13th in 2017

This is due to the number of vehicles of trucks that travel the highway more than the number of vehicles traveling on the main road. In addition, the length of the road on toll roads with the highest emission is longer than the main road. Emission load of CO highs along the Jakarta-Cikampek toll road of 1,695.94 Gg/year. On the main road, the largest emissions load of CO is on the road Ciputat Raya amounted to 1,279.58 Gg/year. Meanwhile, the highest CO emission load is on the highway, this is due to the number of cars and trucks more in that way. The largest PM_{10} emission load laid on toll roads, toll roads is located in IR. Wiyoto Wiyono with emissions amounted to 48.02 Gg/year. Emissions of the pollutants PM_{10} highest on the main road, is located on the road of Ciputat Raya with emissions by 10.82 Gg/year. On the highest emissions PM_{10} emissions are on the highway, although on a main road kind of vehicles is more varied. This is due to the number of vehicles of the same trucks that travel the highway more than the number of vehicles traveling on the main road. In addition, the length of the road on toll roads with the largest emission is longer than the main road. The highest VOC pollutants emissions load on the main street, namely in roads Ciputat Raya with emissions by 499.94 Gg/year. VOC emission load is in toll roads located in IR. Wiyoto Wiyono with emissions amounted to 430.28 Gg/year.

a) NO_x (b) CO (c) PM_{10} (d) VOC

Figure 6. Emission Load Based on Type of Pollutant: Baseline in 2012 (up). BAU Scenario in 2017 (middle). Busway Corridor 13th Scenario in 2017 (bottom).

In **Figure 6 Middle** can be seen, the emission load of each segment road in 2017 in DKI Jakarta. In General, the pattern of load emissions BAU scenario 2017 unchanged and only the values of the quantity of emissions are increasing at each toll road. When compared to scenarios Do – Nothing in 2012, pollutants NOx and VOC decline. While the pollutants CO and PM_{10}, the shares of load emissions are fixed.

In **Figure 6 below** can be seen, the emission load of each segment road in Jakarta. VOC pollutants Pattern is almost the same with NOx emissions burden, of which the highest are on the roads in and around Cawang Panjaitan. While the pattern of CO pollutant almost the same with those of PM_{10}, where the highest emission is around toll road Cawang and Letjen. S. Parman.

Table 8 Comparison of scenario result

cenario	Traffic Volume (smp/jam)	NO_x (Gg/yr)	CO (Gg/yr)	PM_{10} (Gg/yr)	VOC (Gg/yr)
BAU 2017	2,006	29	330	3	104.81
Scen. 3 Busway	2,002	25	326	2.43	103.06
Emission load reduction (%)		13%	1%	19%	2%

CONCLUSION

Emission inventory on road segmentation in Jakarta by 2012 resulted 148,343 Gg/yr for NO_x; CO as 229,953 Gg/yr; PM_{10} as 2,089 Gg/yr. and VOC as 72.867 Gg/yr. CO plays the largest contribution as 50.73% of all pollutants and NOx as 32.73% as the second largest. However the largest emission load located in other lane and it is resulted that emission load reduction from Busway 13th corridor operation is unsignificant with the rate 9%, repectively. In addition, the lane of this corridor is shorter compare than others. It is needs a further study to understand fully how much the exact emission load reduction of mode shitment to busway that illustrate CNG as fuel in combination with operational changes that lead to further improves emission reductions. To such degree emission reduction on busway depending on their operations, technology, age and passenger loading that eventually transit buses could be as polluting as private cars on a per passenger basis (Lau et al., 2012).

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