Spatial Distributed Emission Inventory of On-Road Transport in Thailand

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Abstract

On-road is the most commonly used mode to assure passenger and freight transport in Thailand, which makes this sector the second largest sector in energy consumption and the second largest national emitter of carbon dioxide (CO_2) just after power production. In addition, its air pollutant emissions are function of the number of vehicles, type of vehicles, type of fuel, fuel consumption, and especially the vehicle kilometer travelled. In this study, we developed a spatial distributed emission inventory of on-road transport in Thailand in 2010. This aims at evaluating the impacts of emissions from on-road transport on the regional air quality inside the country. The pollutants of interest include NO_X, SO_2, CO_2, CO, NMVOC, NH_3, CH_4, N_2O, PM_{10}, $PM_{2.5}$ and BC. The number and type of vehicle data were collected from national record of registered vehicles. The type of fuel and fuel consumption data were from national energy reports. The vehicle kilometer travelled data were from the national statistics and random-sampling survey. For all pollutants, the emission estimation was calculated using "The Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) – model". The overall results showed a significant difference between regions in emissions from on-road transport. In order to assess the influence of emission factor and control technology in use on the total emissions, we also collected country-specific emission factors for CO, CO_2, NO_X, PM_{10}, and Total Hydrocarbon (THC). A comparison of our results with regional inventory, i.e. REAS and GAINS-Asia is presented and discussed.

Methodology

In "the Greenhouse Gas and Air Pollution Interactions and Synergy (GAINS)-model, emission is estimated from the production between the activity data , the emission factor, and the control strategy. [1]

$$E_{its} = \sum_{m} [A_{its} \times ef_{ism} \times Appl_{itsm}]$$

$$ef_{ism} = ef_{is}^{NOC} \times (1 - remeff_{sm})$$

$$\sum_m Appl_{its} = 1$$

Where, A_{its} is the activity

ef_{ism} is the emission factor for the fraction of the activity subject to control by technology m

$Appl_{itsm}$ is the application rate of technology m to activity s

ef_{is}^{noc} is the no control emission factor for activity

$remeff_{sm}$ is the removal efficiency of technology m when applied to activity s

Activity Data

Table 1 Activity data, available data, and source of data

Activity Data	Available data	Source
Number and type of vehicle	- Vehicle kilometer classified by vehicle type, area and year	Travelled vehicle km on highway, Annual report, Department of Highway (DOH)
	- Total travelled distance classified by area and year	Travelled vehicle km on highway, Annual report, Department of Highway (DOH)
	- Number of registered vehicle classified by vehicle type, fuel type, area and year	Department of Land Transport (DLT)
Type of fuel and fuel consumption	- Fuel consumption in transportation sector classified by fuel type, area, and year	Annual report oil and Thailand 2010, Department of Energy Development and Efficiency (DEDE)
	- Fuel Consumption rate classified by vehicle type	Somchai Janchaona, KMUTT
Vehicle kilometer travelled	- Vehicle kilometer classified by vehicle type, area and year	Travelled vehicle km on highway, Annual report, Department of Highway (DOH)
	- Total travelled distance classified by area	Travelled vehicle km on highway, Annual report, Department of Highway (DOH)

Control Technology

Thailand launched 4 engine standards including Euro I, Euro II, Euro III, and Euro IV, which define the applied emission control technology. This study took into account the age of vehicle and the year when the standard enter into force to assess the share of a given control technology in the total fleet.

Result

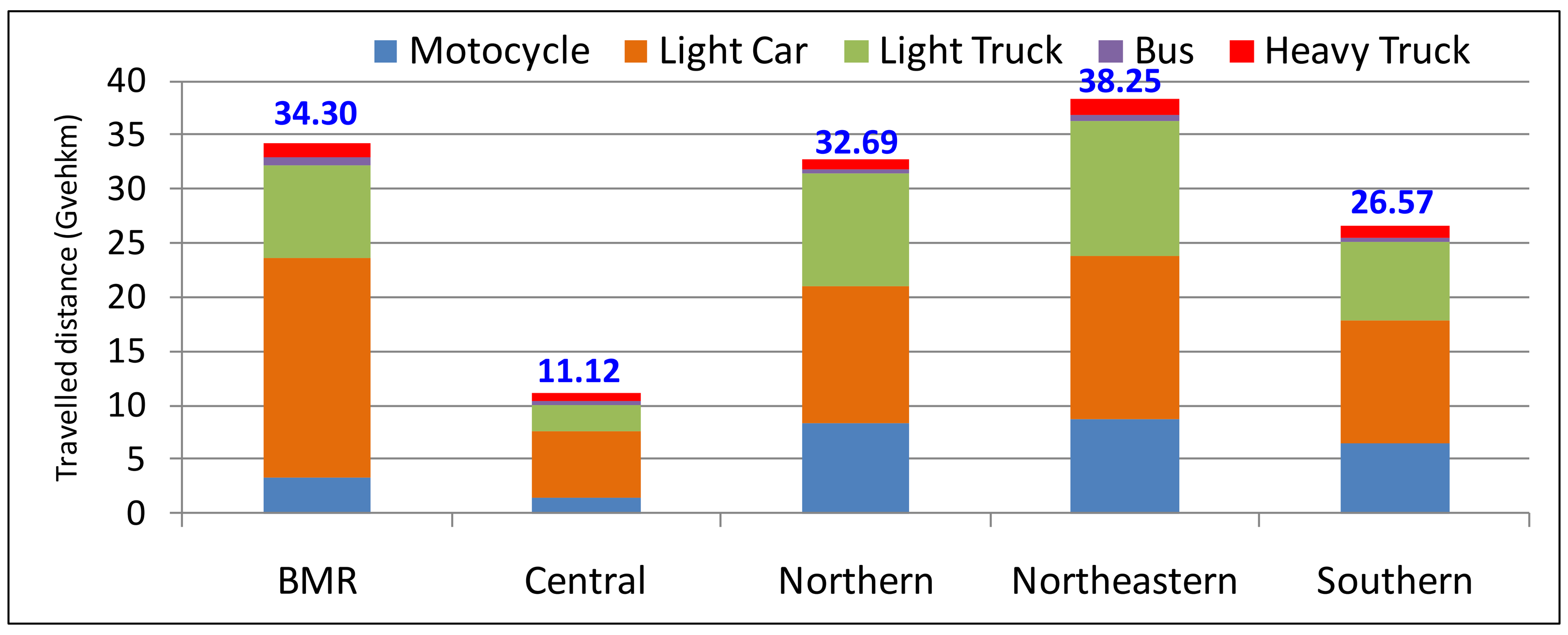

Figure 1 Travelled distance on highway road by mode and region

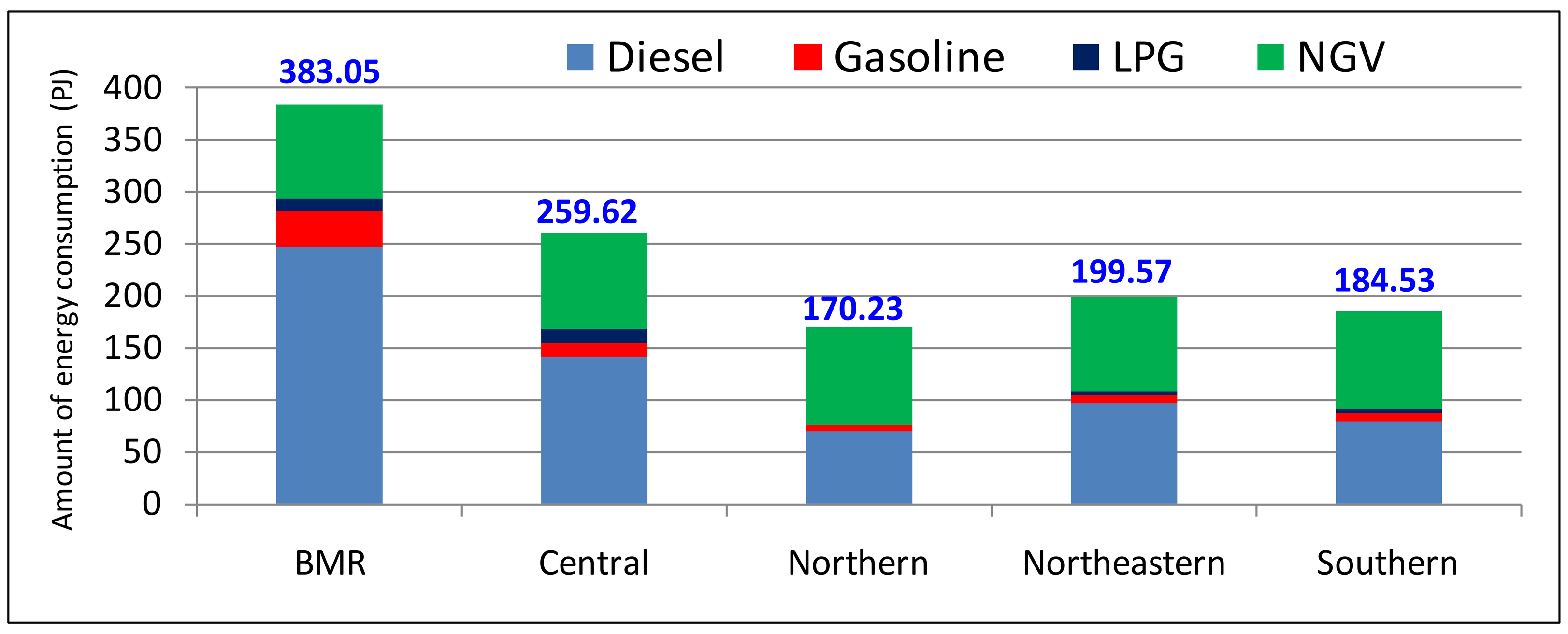

Figure 2 Fuel consumption of on-road transport by fuel type and region

In 2010, the total travelled distance on highway road was 142.9 Gveh.km, which consumed 1,197 PJ of fuel. Bangkok and Metropolitan Region (BMR) represented the second largest travelled distance, mainly from light duty car consuming the largest amount of fuel (Figure 1 and 2).

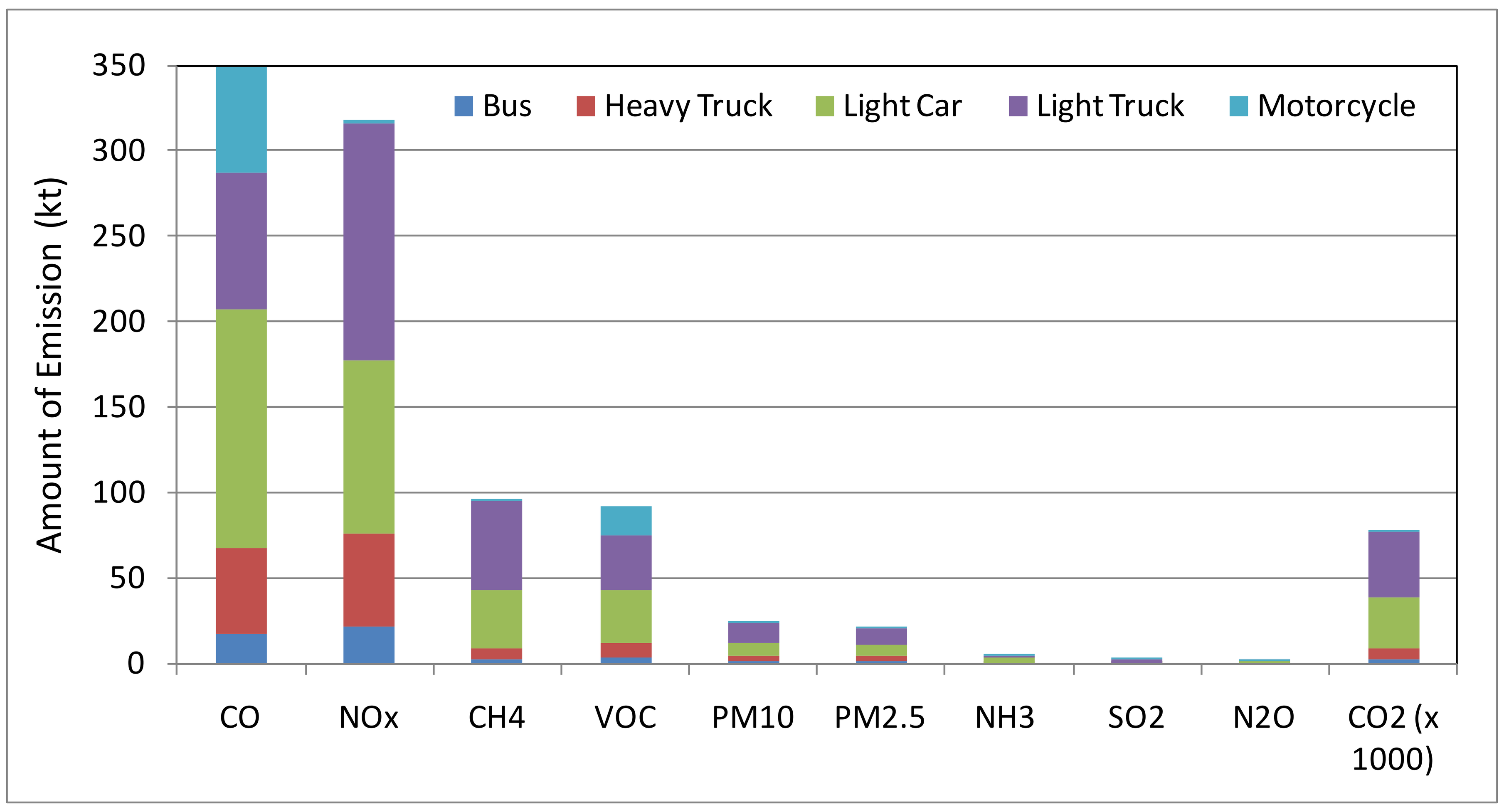

Figure 3 Emission of on-road transportation in Thailand, 2010

Figure 3 shows the estimated on-road emission inventory by region. The amount of emission of CO_2, CO, NO_X, CH_4, VOC, PM_{10}, $PM_{2.5}$, NH_3, SO_2, and N_2O was about 78,300 kt, 349.4 kt, 318.0 kt, 96.3 kt, 91.6 kt, 23.4 kt , 20.9 kt, 4.6 kt, 3.2 kt, and 1.5 kt respectively.

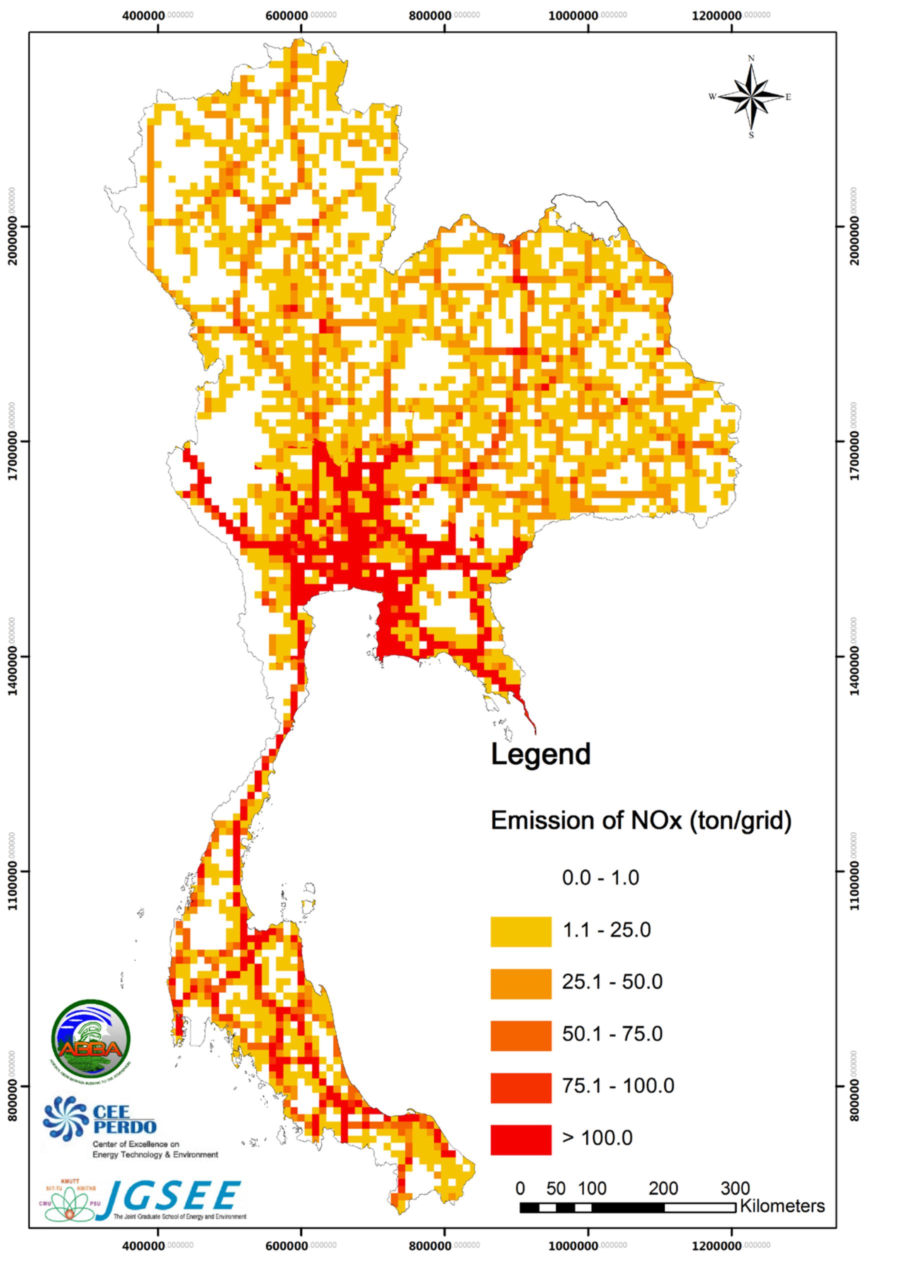

Figure 4 Spatial distribution of NO_x emission of on-road transportation in Thailand, 2010

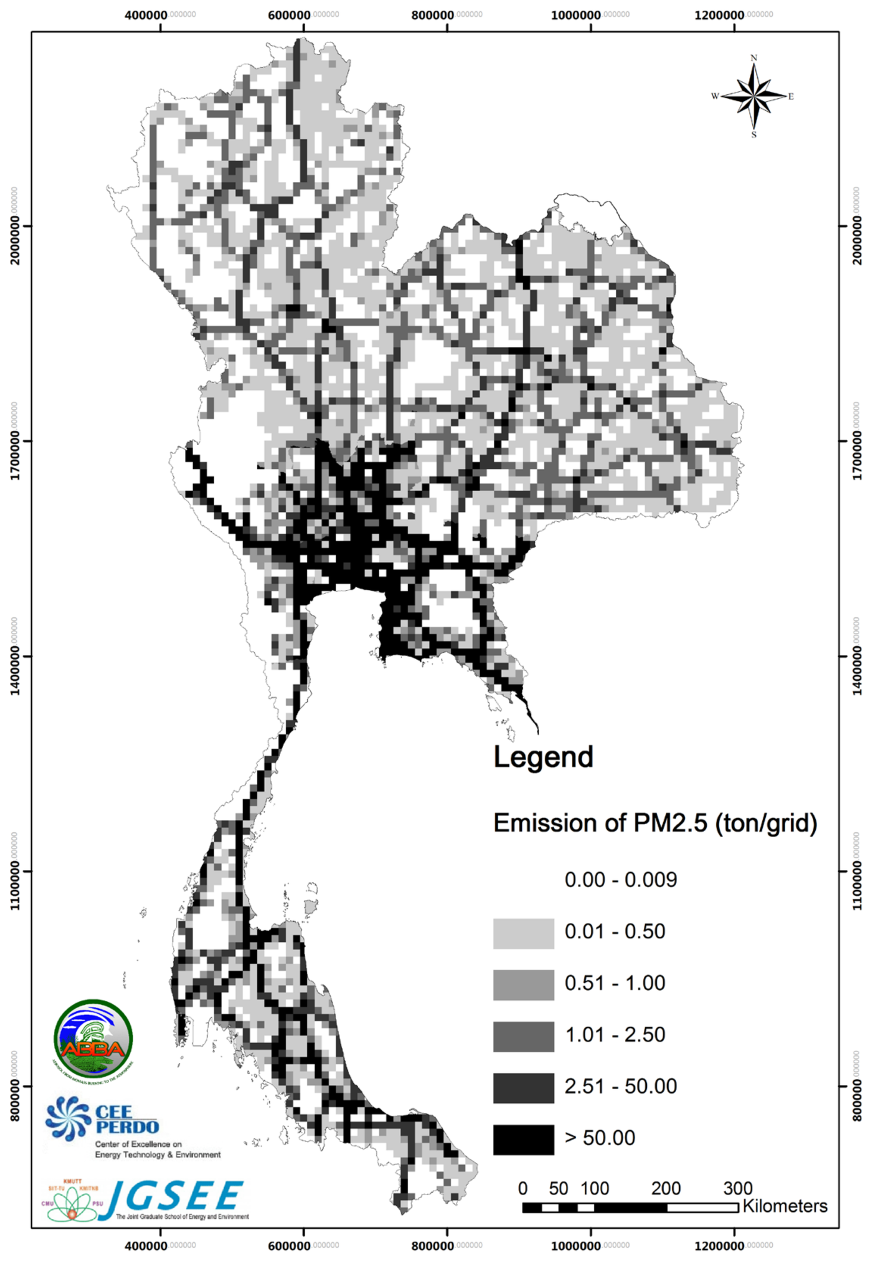

Figure 5 Spatial distribution of $PM_{2.5}$ emission of on-road transportation in Thailand, 2010

Figures 4 and 5 show the spatial distribution of emission density of NO_x and $PM_{2.5}$ on the road network in Thailand in 10 km x 10 km. The highest emission density was on the motorway connecting BMR to other regions. The low emission density was found on local roads (i.e. route between provinces) and collector roads (route between districts).

Table 3 Comparison of the road-transport emissions derived from IIASA and REAs with result from this study

	Amount of Emission (Gg)			Ratio		
	This study	IIASA	REAS	This study/IIASA	This study/REAS	IIASA/REAS
CO_2 (x 1000)	78.3	52.32	47.16	**1.50**	**1.66**	1.11
CO	349.43	1,279.20	2,593.08	**0.27**	**0.13**	0.49
NO_x	318.05	469.29	340.78	**0.68**	**0.93**	1.38
VOC	79.65	330.29	N/A	**0.24**	**-**	-
CH_4	96.29	20.6	8.75	**4.67**	**11.00**	2.35
PM_{10}	23.44	30.39	31.78	**0.77**	**0.74**	0.96
NH_3	4.63	4.07	2.34	**1.14**	**1.98**	1.74
SO_2	3.21	6.21	12.3	**0.52**	**0.26**	0.50
N_2O	1.49	1.97	2.39	**0.76**	**0.62**	0.82

Remark: IIASA = GAINS model with IIASA information REAs = Regional emission inventory in ASEAN region (2008)

A comparison of our emission estimates with those obtained from GAINS-IIASA and REAS (Table 3) showed:

- **All emissions except CH_4 and NH_3 from our estimate were much lower than those obtained in the two other databases ➔ Control technology in use in Thailand (especially in medium duty truck, heavy duty truck, semi-trailer, and trailer modes) is of higher efficiency and in higher share than what was assumed in the regional databases.**
- **CH_4 and NH_3 (This study) is much higher ➔ This study was able to account LPG and NGV consumption using country-specific data on energy consumption and type of fuel used, which were not included in the regional databases.**

Conclusions & Recommendations

This study constitutes the first spatial distributed emission inventory of on-road transport in Thailand. The use of bottom-up approach enabled to improve the accuracy of the estimates by 15 to 70% relatively to those compiled by regional databases, depending on the pollutants. For further study, it is recommended to include higher tier of country-specific control technology, fuel type, and especially emission factors obtained from national measurements and monitoring.

References

[1] IIASA-International Institute for Applied Systems Analysis Schlossplatz, The GAINS model, p.2.

[2] J. Kurokawa, et al (2013), Emission of air pollutants and greenhouse gases over Asian regions during 2000-2008: Regional emission inventory in Asia (REAS) version 2, *Atmos. Chems. Phys.* **13**, pp.11019-11058.

Acknowledgement

This work was supported by Joint Graduate School of Energy and Environment, Center of Excellence on Energy and Environment (CEE) – S&T Post-Graduate Education and Research Development Office (PERDO), Thailand; Toyota Cooperation, Japan; and International Institute for Applied System Analysis (IIASA).

The 16th GEIA Conference on Bridging Emissions Science and Policy, Boulder, Colorado, USA
10-11 June, 2014

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