Updated mobile source emission factors in Thailand

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Abstract:
In response to emission control strategies, the Royal Thai government by the Pollution Control Department (PCD) is obligated to estimate emissions from on-road vehicle fleets. Estimates of vehicle emissions are obtained by multiplying an estimate of the vehicle kilometer traveled (VKT) by a given class of vehicles by an appropriate emission factor (EF). The EF is defined as the estimated average emission rate for a given pollutant for a given class of vehicles. EFs are based on average speeds, ambient temperature, diurnal temperature range, altitude, fuel volatility and I/M programs; changes in these input assumptions alter the resulting emission factors. The different class of motor vehicles were conducted emission tests in the Automotive Emission Laboratory (AEL),Thailand and pollutants such as CO, HC, NOx, PM and Air Toxics were measured under different situations such as fuel type and its quality, engine technology and driving speed and patterns for example. The emission results will be developed appropriately to calculate as emission factors of each vehicle types in Thailand. There are 4 mainly motor vehicle emission factors developed for 4 class of motor vehicles which are motorcycle (MC),light duty gasoline vehicle (LG),light duty diesel vehicle (LD) and heavy duty diesel vehicle (HD). Those emission factors will be applied to estimate mobile source emission loading in study areas which will be investigated with traffic data yearly. The outcomes will be supported in further appropriated policy and measure to manage and control air pollution problem in Thailand particularly mobile sources.

Keywords: *fuel quality; engine technology; traffic fleet; emission factor; emission testing*

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1. Introduction

The Pollution Control Department (PCD), Ministry of Natural Resources and Environment, Thailand has been developed an emission inventories and mobile source emission factors using results of emission testing conducting in Automotive Emission Laboratory (AEL),Thailand since 2000. The appropriated emission testing results of different class motor vehicles have been calculated to be mobile source emission factors in Thailand. The basic emission estimation methodology involves multiplying an activity factor by the mobile source emission factors. The On-Road Mobile Source category represents emissions from roadway and highway vehicles, such as motorcycles, cars, trucks, and buses in different engine technology and fuel types. The outcomes will be supported in further appropriated policy and measure to manage and control air pollution problem in Thailand particularly mobile sources.

2. Material and methods

Variety of test vehicles have been selected according to the engine type and technology, used fuel and mileage of in-used vehicles which are motorcycles (MC), light duty gasoline vehicle (LG), light duty diesel vehicle (LD) and heavy duty diesel vehicle (HD). These selected vehicles represent the most common in their categories used in Thailand. Each vehicle was driven onto the dynamometer following Bangkok driving cycle which have been developed as the test standard consequently, properly secured, and the exhaust sampling system connected (Fig. 1). There are some differences between driving cycles of each type of vehicles such as speed, testing time and idle duration for example. Fig. 2 to Fig. 3 show the Bangkok driving cycles. For each vehicle, separate measurements of emission such as HC, CO, NOx, PM, air toxics and fuel consumption were measured. The QA&QC have been applied to verify the developed mobile source emission factors.

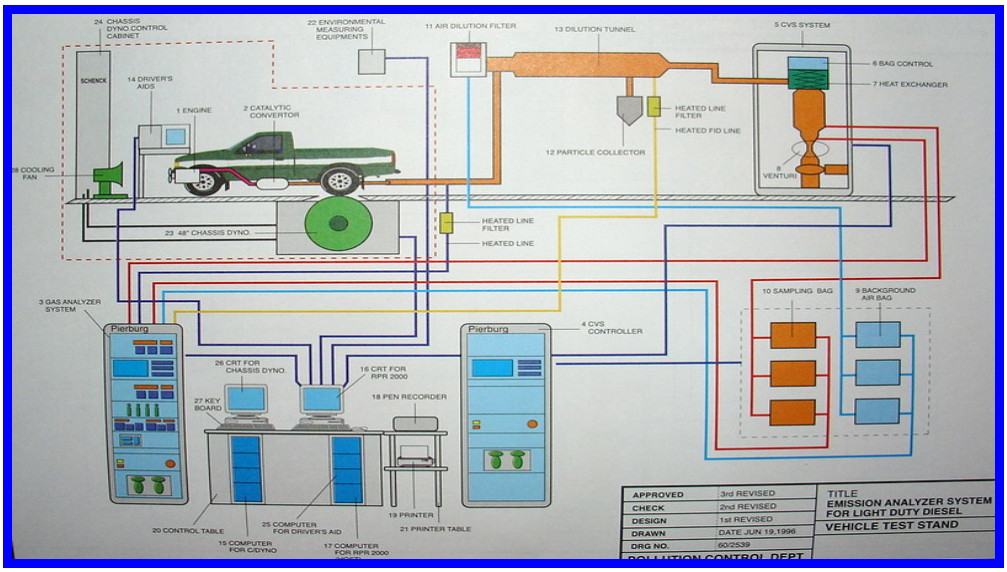

Fig. 1 Diagram of Emission Testing Laboratory.

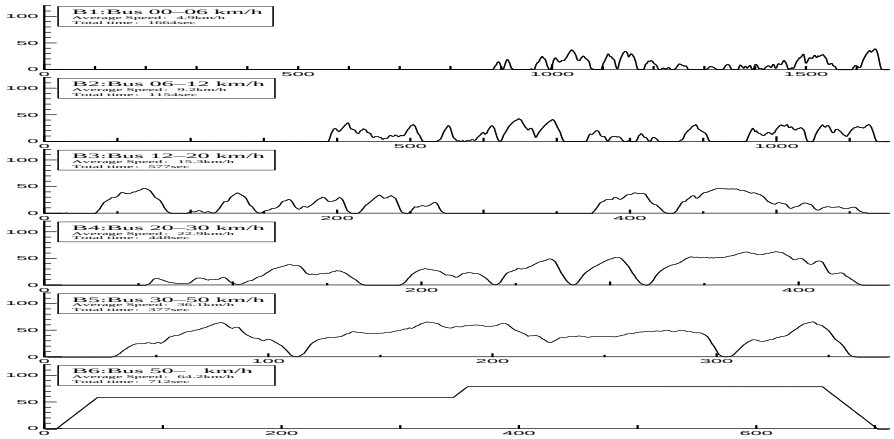

Fig. 2 Bangkok Driving cycle of Buses & Truck.

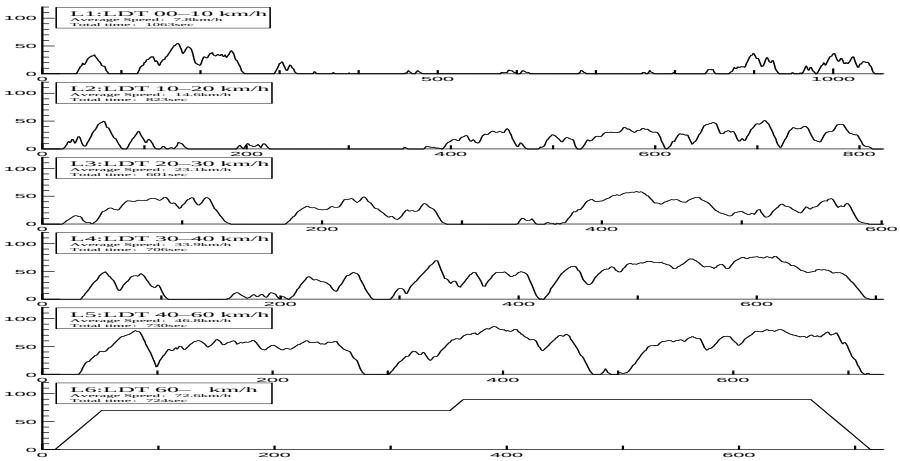

Fig. 3 Bangkok Driving cycle of Light duty diesel Vehicle.

3. Results

The updated mobile source emission factors developed by the PCD using the results of emission testing are shown in Table 1.

Table 1 Updated Mobile source emission factors in Thailand

Vehicle Type	Level/ Fuel Type	Pollutants	Speed (km/hr)								
			10	20	30	40	50	60	70	80	90
Bus	1998-2000 /Diesel	HC (g/km)	0.85	0.46	0.32	0.25	0.20	0.17	0.17	0.18	0.19
		CO (g/km)	18.2	15.4	13.9	13.1	12.4	11.9	11.9	12.4	13.3
		NOx (g/km)	19.7	12	8.98	7.31	6.24	5.48	5.48	5.8	6.13
		PM (g/km)	0.84	0.62	0.52	0.44	0.42	0.39	0.39	0.40	0.44
		CO2 (g/km)	1789	1155	834	745	647	577	577	606	646
	2001 & Later /Diesel	HC (g/km)	1.83	1.05	0.76	0.61	0.51	0.44	0.44	0.46	0.49
		CO (g/km)	6.36	3.72	2.72	2.18	1.83	1.59	1.59	1.67	1.78
		NOx (g/km)	13.5	9.47	7.70	6.65	5.93	5.40	5.40	5.67	6.05
		PM (g/km)	1.12	0.98	0.91	0.86	0.83	0.80	0.80	0.84	0.89
		CO2 (g/km)	1475	1038	846	731	653	595	595	625	667
	Pre-2000 /CNG	HC (g/km)	17.4	9.3	6.5	4.9	4.07	3.45	3.0	2.66	2.39
		CO (g/km)	52.6	16.4	8.3	5.13	3.53	2.60	2.0	1.60	1.31
		NOx (g/km)	53.8	40.6	34.5	30.7	28.0	26.0	24.5	23.2	22.1
		CO2 (g/km)	2125	1457	1169	999	885	801	737	685	643
	2001-2004 /CNG	HC (g/km)	8.91	5.65	4.33	3.58	3.09	2.74	2.48	2.27	2.10
		CO (g/km)	1.22	1.03	0.94	0.88	0.83	0.80	0.77	0.75	0.72
		NOx (g/km)	18.3	14.9	13.3	12.2	11.5	10.8	10.4	10.0	9.67
		CO2 (g/km)	2049	1447	1181	1023	914	835	772	722	681
Truck	1998-2000 /Diesel	HC (g/km)	1.83	1.22	0.97	0.82	0.72	0.65	0.65	0.68	0.72
		CO (g/km)	4.24	3.46	3.08	2.83	2.65	2.51	2.51	2.64	2.81
		NOx (g/km)	15.0	10.4	8.44	7.26	6.45	5.86	5.86	6.16	6.57
		PM (g/km)	1.2	0.93	0.77	0.67	0.60	0.55	0.55	0.54	0.53
		CO2 (g/km)	1401	1127	993	907	846	799	799	756	739
	2001 & Later /Diesel	HC (g/km)	0.83	0.55	0.43	0.36	0.32	0.29	0.29	0.29	0.28
		CO (g/km)	5.40	3.61	2.85	2.41	2.12	1.90	1.90	2.0	1.98
		NOx (g/km)	15.1	10.0	7.91	6.68	5.86	5.26	5.26	5.53	5.46
		PM (g/km)	0.45	0.41	0.39	0.37	0.36	0.35	0.35	0.33	0.31
		CO2 (g/km)	1438	1010	821	709	633	577	577	606	604
Pickup (Light duty diesel vehicle)	Pre-2000 /Diesel	HC (g/km)	0.68	0.38	0.27	0.21	0.18	0.15	0.13	0.12	0.11
		CO (g/km)	2.06	1.29	0.99	0.82	0.70	0.62	0.56	0.51	0.48
		NOx (g/km)	2.12	1.67	1.46	1.32	1.23	1.15	1.09	1.05	1.00
		PM (g/km)	0.16	0.12	0.10	0.09	0.08	0.08	0.07	0.07	0.07
		CO2 (g/km)	364	273	231	206	188	174	163	155	147
	2001-2004 /Diesel	HC (g/km)	0.11	0.07	0.05	0.04	0.04	0.03	0.03	0.03	0.02
		CO (g/km)	1.58	0.74	0.47	0.34	0.27	0.22	0.18	0.16	0.14
		NOx (g/km)	1.20	0.84	0.69	0.59	0.53	0.48	0.44	0.41	0.39
		PM (g/km)	0.22	0.18	0.15	0.14	0.13	0.12	0.12	0.11	0.11
		CO2 (g/km)	326	248	211	188	172	160	151	143	136
	2005-2011 /Diesel	HC (g/km)	0.17	0.13	0.11	0.09	0.08	0.08	0.07	0.07	0.06
		CO (g/km)	1.62	0.85	0.60	0.47	0.38	0.32	0.28	0.25	0.22
		NOx (g/km)	1.21	0.87	0.73	0.64	0.57	0.53	0.49	0.46	0.44
		PM (g/km)	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04
		CO2 (g/km	317	239	203	180	165	153	144	136	130
Passenger Car (Light duty gasoline vehicle)	2001-2004 /Gasoline 95	HC (g/km)	0.11	0.07	0.05	0.04	0.04	0.03	0.03	0.03	0.02
		CO (g/km)	0.48	0.52	0.55	0.56	0.58	0.59	0.60	0.61	0.62
		NOx (g/km)	0.48	0.31	0.24	0.20	0.17	0.15	0.13	0.12	0.12
		CO2 (g/km)	271	209	180	161	149	139	131	124	119
	2005-2011 /Gasohol 95 (E-10)	HC (g/km)	0.009	0.007	0.006	0.005	0.005	0.005	0.004	0.004	0.004
		CO (g/km)	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08
		NOx (g/km)	0.10	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01
		CO2 (g/km)	227	180	157	142	132	124	118	113	108
	2005-2011 / Gasohol 95 (E-20)	HC (g/km)	0.009	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.008
		CO (g/km)	0.062	0.063	0.063	0.064	0.064	0.064	0.064	0.065	0.065
		NOx (g/km)	0.041	0.029	0.024	0.021	0.019	0.017	0.016	0.015	0.014
		CO2 (g/km)	239	183	157	140	129	120	113	107	102
	2001-2004 /LPG	HC (g/km)	0.351	0.245	0.198	0.17	0.15	0.13	0.12	0.11	0.11
		CO (g/km)	3.74	1.32	0.72	0.47	0.33	0.25	0.20	0.16	0.14
		NOx (g/km)	2.98	3.07	3.12	3.16	3.19	3.21	3.23	3.25	3.26
		CO2 (g/km)	324	231	190	165	148	135	125	117	111
	2005-2011 /CNG	HC (g/km)	0.23	0.14	0.11	0.09	0.07	0.07	0.06	0.05	0.05
		CO (g/km)	0.13	0.08	0.06	0.05	0.04	0.04	0.03	0.03	0.03
		NOx (g/km)	0.23	0.28	0.30	0.32	0.34	0.36	0.37	0.38	0.39
		CO2 (g/km)	298	215	178	155	140	128	119	112	106
Taxi	2005-2011 /LPG	HC (g/km)	1.21	0.74	0.56	0.46	0.39	0.34	0.31	0.28	0.26
		CO (g/km)	0.74	0.47	0.35	0.29	0.25	0.22	0.20	0.18	0.17
		NOx (g/km)	3.29	2.87	2.65	2.50	2.40	2.31	2.24	2.18	2.13
		CO2 (g/km)	227	185	165	152	142	135	129	124	120
	2005-2011 /CNG	HC (g/km)	0.75	0.44	0.32	0.26	0.21	0.19	0.16	0.15	0.13
		CO (g/km)	1.05	0.79	0.66	0.59	0.53	0.49	0.46	0.44	0.41
		NOx (g/km)	0.42	0.26	0.20	0.16	0.14	0.13	0.11	0.10	0.09
		CO2 (g/km)	224	172	147	132	121	113	106	101	96
Motorcycle	2009-2011/ Gasoline 91	HC (g/km)	0.30	0.23	0.19	0.17	0.16	0.15	0.14	0.13	0.12
		CO (g/km)	2.37	2.59	2.74	2.84	2.92	2.99	3.05	3.10	3.15
		NOx (g/km)	0.09	0.11	0.13	0.14	0.15	0.16	0.17	0.17	0.18
		CO2 (g/km)	57.1	47.8	43.2	40.1	37.9	36.2	34.8	33.6	32.7
	2009-2011/ Gasohol 91	HC (g/km)	0.29	0.22	0.18	0.16	0.15	0.14	0.13	0.12	0.11
		CO (g/km)	2.96	2.92	2.89	2.88	2.86	2.85	2.84	2.84	2.83
		NOx (g/km)	0.11	0.14	0.16	0.18	0.19	0.21	0.22	0.23	0.22
		CO2 (g/km)	40.5	35.8	33.3	31.6	30.4	29.5	28.7	27.9	27.4
Tuk Tuk	LPG	HC (g/km)	12.3	4.64	2.62	1.75	1.28	0.99	0.79	0.66	0.56
		CO (g/km)	7.52	3.74	2.48	1.86	1.48	1.23	1.06	0.92	0.82
		NOx (g/km)	0.61	0.43	0.36	0.31	0.28	0.25	0.23	0.22	0.21
		CO2 (g/km)	136	98.1	81	70.7	63.7	58.4	54.3	50.9	48.2

4. Conclusion

In the case of traffic air pollution, such as an emission inventory must be compiled using activity statistics and emission factors for a wide range of vehicle types. Current trends are towards integrating urban traffic control systems and assessments of the environmental effects of motor vehicles. In this paper, a methodology for estimating emissions from mobile sources using emission testing data is described. This methodology is used to calculate emission loadings of selected pollutants such as NO_x, CO, HC, PM and air toxics. A mobile source emissions inventory is compiled by emission factors and activity data as VKT. The predicted emissions are employed in a dispersion model along with local meteorological conditions and site geometry. The resultant pollutant concentrations are compared to average ambient curbside conditions measured simultaneously with on-line air quality monitoring equipment for appropriated verifying. The outcomes of emission estimation and results of mathematic traffic model will support to a policy maker to establish and implement appropriated control strategies to manage and control automotive air pollution problem effectively.

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