Appendix 11

Appendix 11 Emission Factor

11.1 Methodology Overview

The quantity of air pollutant emission while a motor vehicle runs 1km of distance is called emission factor. Emission factors of current and future motor vehicles were established on the same way as JICA study, 'AIR QUALITY MANAGEMENT STUDY FOR KELANG VALLEY REGION' AUG.1993, except for regulations and it's applied year.

Current and future mean the years of 1997 and 2000, and the year of 2020, respectively.

11.2 Exhaust Gas Emission Controls

The Malaysia government implemented Regulation ECE15.04 (Table A 11.1) for petrol vehicles and Regulation No.49 (Table A 11.2) for diesel vehicles. Also Regulation 91/441/EEC (Table A 11.3) will be enforced on petrol vehicles and Regulation EURO.01 (Table A 11.4) on diesel vehicles. These regulations were taken into consideration in formulating emission factors. The regulations have limits for both type approval and checks on production conformity, these regulations were assumed to be in effect as shown in Table A 11.5.

The conditions of 2020 was supposed like the following way that Taiwan Stage 2 (Table A 11.6) was introduced for motorcycle, regulation 94/12/EC (Table A 11.7) for passenger cars and commercial vehicles were converted to natural gas vehicles.

Table A 11.1 Regulation No.15.04

Reference Weight(kg)	CO (g/test)	HC + NOx (g/test)
RW≦1020	58	19
1020< RW≦1250	67	20.5
1250< RW≦1470	76	22
1470< RW≦1700	84	23.5
1700< RW≦1930	93	25
1930< RW≦2150	101	26.5
2150< RW	110	28

Note: Engine : Gasoline & Diesel
GVW : Under 3,500 kg
Test Mode: ECE mode (Average Speed:18.7 km/h) 4.0521 km/test
Source: Standards and Application Details, ECE15/04

Table A 11.2 Regulation No.49

Pollutant	Limit Value (g/kWh)
HC	3.5
CO	14
NOx	18

Table A 11.3 Regulation 91/441/EEC

Pollutant	(g/km)
CO	2.72
HC + NOx	0.97

Table A 11.4 Regulation EURO.01

Pollutant	Limit Value (g/kWh)
HC	1.1
CO	4.5
NOx	8.9

Table A 11.5 Regulation by Vehicle Type Considered in Setting Emission Factors

Fuel type	Vehicle type	-92	93-94	95-96	97	98	99	2000-
petrol	Motor Car	-	R.1504	R.1504	R.1504	R.1504	91/441/EEC	91/441/EEC
	Taxi	-	R.1504	R.1504	R.1504	R.1504	93/59/EEC	93/59/EEC
	Small Van	-	R.1504	R.1504	R.1504	R.1504	93/59/EEC	93/59/EEC
	Small Lorry	-	R.1504	R.1504	R.1504	R.1504	93/59/EEC	93/59/EEC
diesel	Public Large Bus	-	R.49	R.49	R.49	R.49	EURO.01	EURO.01
	Private Large Bus	-	R.49	R.49	R.49	R.49	EURO.01	EURO.01
	Mini Bus	-	R.49	R.49	R.49	R.49	R.49	R.49
	Medium Lorry/	-	R.49	R.49	R.49	EURO.01	EURO.01	EURO.01
	Large Lorry/Trailer	-	R.49	R.49	R.49	EURO.01	EURO.01	EURO.01

Note: New registered vehicles is assumed no new engine type model.

Table A 11.6 Regulation Taiwan Stage 2 for Motorcycle

Pollutant	(g/km)
CO	4.5
HC + NOx	3.0

Table A 11.7 Regulation 94/12EC for Passenger Cars

Pollutant	(g/km)
CO	2.2
HC + NOx	0.5

Table A 11.8 Compression Natural Gas Vehicles

		Limit Value	
		Bus	Lorry
Pollutant	HC (g/kWh)	1.1	0.5
	CO (g/kWh)	2.0	2.7
	NOx (g/kWh)	1.3	0.18
	Fuel Consumption (m^3N/km)	0.60	0.184

Source: 'Enhancement of CNG Vehicle', 1998, Japan Gas Association

11.3 Number of Different Types of Vehicles Registered in Each Year

Vehicle emission factors depend on the year when the vehicle was registered initially. Therefore, the number of vehicles registered initially at each year must be estimated to calculate average emission factors in the future. In Table A 11.9 the number of vehicles initially registered from 1972 to 2000 are given.

Table A 11.9 Number of Newly Registered Vehicles by Type(1972-2000)

Year	Motorcycle	Motor Car	Bus	Goods Vehicle Petrol	Goods Vehicle Diesel	Total
1972	-	21,592	311	2,546	1,506	4,052
1973	-	21,592	311	2,546	1,506	4,052
1974	-	21,592	311	2,546	1,506	4,052
1975	-	21,592	311	2,546	1,506	4,052
1976	-	21,592	311	2,546	1,507	4,053
1977	-	22,168	319	2,614	1,547	4,161
1978	46,460	27,056	389	3,190	1,888	5,078
1979	48,249	28,098	404	3,313	1,960	5,273
1980	67,493	39,305	566	4,634	2,742	7,376
1981	68,463	39,870	574	4,701	2,782	7,483
1982	68,661	39,985	575	4,714	2,790	7,504
1983	73,597	42,860	617	5,053	2,990	8,043
1984	71,166	41,444	596	4,886	2,891	7,777
1985	58,821	34,255	493	4,039	2,390	6,429
1986	23,924	24,585	396	4,549	2,438	6,987
1987	13,342	20,222	325	1,217	1,574	2,791
1988	16,606	28,919	278	1,339	2,303	3,642
1989	32,283	44,745	371	2,230	4,579	6,809
1990	46,824	60,470	454	3,436	7,486	10,922
1991	53,147	69,230	636	3,473	9,709	13,182
1992	64,651	67,232	536	5,918	4,444	10,362
1993	62,035	66,095	841	6,005	4,509	10,514
1994	71,967	79,344	661	7,076	5,314	12,390
1995	82,567	112,268	882	9,923	7,451	17,374
1996	88,703	148,381	1,016	13,172	9,892	23,064
1997	101,094	170,264	1,554	12,412	9,320	21,732
1998	91,631	98,134	705	9,507	7,255	16,762
1999	79,818	103,440	728	10,009	7,649	17,658
2000	45,467	119,168	899	11,732	8,773	20,504

Source: 'AIR QUALITY MANAGEMENT STUDY FOR KELANG VALLEY REGION final report Vol.3 AUG.1993' from 1972 to 1992.
'New Registered Motor Vehicles by Type and State', from 1993 to 1996
Estimated by this study from 1997 to 2000, as mentioned in Section 0.

11.4 Cumulative Mileage and Emission Factors

Cars tend to emit more pollutants with longer driving mileage. The deterioration rates in Malaysia were established as shown in Table A 11.10

Table A 11.10 Deterioration Rate of Emission Factor with Increase of Cumulative Mileage

Engine Type	Vehicle type	Pollutant Deterioration Rate per 10000km			Note (Applied Year)
		HC	CO	NOx	
Petrol	Motorcycle	0.054	0.045	0.186	Current(1977-2000)
	Motor Car Van	0.003	0.037	0.0	Chassis Dynamometer Test. 1972-1974 (1972-1994)
	Taxi	0.025	0.025	0.025	91/441/EEC(1995-2000)
	Small Lorry	0.031	0.037	0.0	(1972-1994)
		0.025	0.025	0.025	91/441/EEC(1995-2000)
Diesel	Van	0.038	0.030	0.017	Pre-1975(1972-1992)
	Taxi Mini Bus	0.038	0.022	0.014	US.EPA(1993-2000)
	Medium Lorry	0.058	0.032	0.027	Pre-1978(1972-1992)
		0.058	0.019	0.013	US.EPA(1993-2000)
	Medium Bus	0.009	0.009	0.0	1972-1974(1972-1992)
	Large Bus Large Lorry Trailer	0.010	0.009	0.0	US.EPA(1993-2000)

Source : 'AIR QUALITY MANAGEMENT STUDY FOR KELANG VALLEY REGION' final report Vol.3 AUG.1993

11.5 Annual Mileage and Cumulative Mileage

Because of differences in emission factors by model years, it is necessary to establish models of annual mileage (travel fractions) in order to calculate average emission factors. For each types of vehicle, the travel fractions can be calculated from the vehicle compositions by registration years and annual mileage.

In Table A 11.11, the average life and annual mileage covered by different types vehicles are depicted.

Table A 11.11 Average Life and Annual Mileage by Various Types of Vehicles

Vehicle type	Average Life (year)	Annual Mileage (1000km/year)
Motorcycle	7	11.27
Private Car	10	19.32
Taxi	5	96.6
Bus	10	104.65
Van & Lorry	10	48.30

Source : AIR QUALITY MANAGEMENT STUDY FOR KELANG VALLEY REGION' final report Vol.3 AUG.1993

11.6 Establishment of Basic Emission Factors

Basic Emission factors for different types of vehicles and engines (Table A 11.12) were obtained using the emission factors for new vehicles (at 0 mileage) in Table A 11.12, and cumulative mileage of different types of vehicles.

The following is the equation to calculate the basic emission factors.

$$Bef = Ef * (1 + r * Cm)$$

Where;

Bef :	Basic emission factors
Ef :	Emission factor at 0 mileage
r :	Deterioration rate
Cm :	Cumulative mileage

Table A 11.12 (1) Emission Factor and Fuel Consumption Rates for Year 1997 at 0 Mileage and Deterioration Rate

Petrol Vehicles

Vehicle Type	Model Years	Item	Emission Factor	Base Speed	Travel Fraction	Average Cumulative Mileage (1000km/unit)	Emission Factor at 0 mileage	Deterioration Rate (per 10000km)
Motorcycle	1982-97	HC	13.54	31.5	1.000	68	9.9	0.054
		CO	22.20	31.5	1.000	68	17	0.045
		NOx	0.17	31.5	1.000	68	0.075	0.186
		FC	0.040	31.5	1.000	68	0.04	0
Motor Car	1977-85	HC	2.85	18.7	0.318	298	2.62	0.003
		CO	41.67	18.7	0.318	298	19.82	0.037
		NOx	1.23	18.7	0.318	298	1.23	0
		FC	0.091	18.7	0.318	298	0.091	0
	1986-91	HC	2.75	18.7	0.259	150	-	0.003
		CO	20.15	18.7	0.259	150	-	0.037
		NOx	2.05	18.7	0.259	150	-	0
		FC	0.092	18.7	0.259	150	-	0
	1992	HC	2.71	18.7	0.070	97	-	0.003
		CO	16.98	18.7	0.070	97	-	0.037
		NOx	2.1	18.7	0.070	97	-	0
		FC	0.092	18.7	0.070	97	-	0
	1993-97	HC	2.37	18.7	0.209	35	2.35	0.003
	Proton	CO	5.60	18.7	0.209	35	4.96	0.037
		NOx	2.19	18.7	0.209	35	2.19	0
		FC	0.099	18.7	0.209	35	0.099	0
	1993-97	HC	2.65	18.7	0.143	35	2.62	0.003
	Others	CO	22.39	18.7	0.143	35	19.82	0.037
		NOx	1.23	18.7	0.143	35	1.23	0
		FC	0.091	18.7	0.143	35	0.091	0
Van	1977-97	HC	2.31	18.7	1.000	385	2.07	0.003
		CO	47.84	18.7	1.000	385	19.73	0.037
		NOx	3.06	18.7	1.000	385	3.06	0
		FC	0.130	18.7	1.000	385	0.13	0
Taxi	1987-92	HC	3.21	18.7	0.600	725	2.64	0.003
		CO	27.58	18.7	0.600	725	7.49	0.037
		NOx	2.70	18.7	0.600	725	2.7	0
		FC	0.093	18.7	0.600	725	0.093	0
	1993-97	HC	2.49	18.7	0.400	193	2.35	0.003
		CO	8.50	18.7	0.400	193	4.96	0.037
		NOx	2.19	18.7	0.400	193	2.19	0
		FC	0.099	18.7	0.400	193	0.099	0
Small Lorry	1977-97	HC	4.54	18.7	1.000	385	2.07	0.031
		CO	47.84	18.7	1.000	385	19.73	0.037
		NOx	3.06	18.7	1.000	385	3.06	0
		FC	0.130	18.7	1.000	385	0.13	0

Notes : FC : Fuel Consumption Rate
Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.12 (2) Emission Factor and Fuel Consumption Rates for Year 1997 at 0 Mileage and Deterioration Rate

Diesel Vehicles

Vehicle Type	Model Years	Item	Emission Factor	Base Speed	Travel Fraction	Average Cumulative Mileage (1000km/unit)	Emission Factor at 0 mileage	Deterioration Rate (per 10000km)
Van	1977-92	HC	2.36	31.5	0.71	504	0.81	0.038
		CO	4.22	31.5	0.71	504	1.68	0.030
		NOx	1.69	31.5	0.71	504	0.91	0.017
		FC	0.100	31.5	0.71	504	0.1	0.000
	1993-97	HC	0.24	31.5	0.29	91	0.18	0.038
		CO	0.85	31.5	0.29	91	0.71	0.022
		NOx	0.91	31.5	0.29	91	0.81	0.014
		FC	0.100	31.5	0.29	91	0.1	0.000
Mini Bus	1977-92	HC	4.58	31.5	0.747	1282	0.78	0.038
		CO	7.46	31.5	0.747	1282	1.54	0.030
		NOx	4.42	31.5	0.747	1282	1.39	0.017
		FC	0.230	31.5	0.747	1282	0.23	0.000
	1993-97	HC	0.48	31.5	0.253	209	0.27	0.038
		CO	1.21	31.5	0.253	209	0.83	0.022
		NOx	1.19	31.5	0.253	209	0.92	0.014
		FC	0.230	31.5	0.253	209	0.23	0.000
Medium Bus Large Bus	1977-92	HC	5.66	31.3	0.747	1282	2.63	0.009
		CO	16.41	31.3	0.747	1282	7.62	0.009
		NOx	15.87	31.3	0.747	1282	15.87	0.000
		FC	0.50	29.0	0.747	1282	0.5	0.000
	1993-97	HC	2.44	31.3	0.253	209	2.02	0.010
		CO	6.46	31.3	0.253	209	5.44	0.009
		NOx	11.73	31.3	0.253	209	11.73	0.000
		FC	0.50	29.0	0.253	209	0.5	0.000
Medium Lorry	1977-92	HC	3.06	31.5	0.809	504	0.78	0.058
		CO	4.02	31.5	0.809	504	1.54	0.032
		NOx	3.28	31.5	0.809	504	1.39	0.027
		FC	0.230	29.0	0.809	504	0.23	0.000
	1993-97	HC	0.41	31.5	0.191	91	0.27	0.058
		CO	0.97	31.5	0.191	91	0.83	0.019
		NOx	1.03	31.5	0.191	91	0.92	0.013
		FC	0.230	29.0	0.191	91	0.23	0.000
Large Lorry	1977-92	HC	3.82	31.3	0.809	504	2.63	0.009
		CO	11.08	31.3	0.809	504	7.62	0.009
		NOx	15.87	31.3	0.809	504	15.87	0.000
		FC	0.500	29.0	0.809	504	0.5	0.000
	1993-97	HC	2.20	31.3	0.191	91	2.02	0.010
		CO	5.89	31.3	0.191	91	5.44	0.009
		NOx	11.73	31.3	0.191	91	11.73	0.000
		FC	0.500	29.0	0.191	91	0.5	0.000

Notes : FC : Fuel Consumption Rate
Unit : g/km for HC, CO and NOx, and l/km for FC

11.7 Number of Different Types of Vehicles Registered in Each Years

Vehicle emission factors depend on the year when the vehicle was initially registered. Therefore the number of vehicles registered at each year must be estimated to calculate average emission factors in the future. If motorcycles, age over 14 years and other type of vehicles (exclusive of taxi), age over 20 years were assumed to be extinguished, then, the registered number of vehicles in year t could be calculated from the following equation. The total number of vehicles registered from 1986 to 2000 according to their types and the year first registered were estimated as shown in Table A 11.13.

$$Nv(t) = Tv(t-1) * r(t) + Nv(t-Vl)$$

Where;

t :	Year
Nv :	Number of registered vehicles
Tv :	Total number of registered vehicles
r :	Annual growth rate of number of vehicles
Vl :	Vehicle life

Table A 11.13 (1) Travel Weighting Fraction Calculation and Cumulative Mileage

Motorcycle, 2000

Model Year	Fleet Regis-tration		Ann ual Mile age		Travel Fraction	Average Age	Cumu-lative Mileage (1000km)	
	a	b =a/ sum(a)	c	d =b * c	e =d/ sum(d)	f	g =f * g of 1993	h =e * g
1986	23924	0.0274	0.5	0.013686	0.014251	13.75	154.96	2.2
1987	13342	0.0153	1	0.015264	0.015895	13	146.51	2.3
1988	16606	0.0190	1	0.018999	0.019784	12	135.24	2.7
1989	32283	0.0369	1	0.036935	0.038461	11	123.97	4.8
1990	46824	0.0536	1	0.053571	0.055785	10	112.70	6.3
1991	53147	0.0608	1	0.060805	0.063318	9	101.43	6.4
1992	64651	0.0740	1	0.073966	0.077024	8	90.16	6.9
1993	62035	0.0710	1	0.070973	0.073907	7	78.89	5.8
1994	71967	0.0823	1	0.082336	0.08574	6	67.62	5.8
1995	82567	0.0945	1	0.094464	0.098368	5	56.35	5.5
1996	88703	0.1015	1	0.101484	0.105679	4	45.08	4.8
1997	101094	0.1157	1	0.11566	0.120441	3	33.81	4.1
1998	91631	0.1048	1	0.104834	0.109168	2	22.54	2.5
1999	79818	0.0913	1	0.091319	0.095094	1	11.27	1.1
2000	45467	0.0520	0.5	0.026009	0.027084	0.25	2.82	0.1
(Sum)	874060	1.0000		0.960305	1			61.3

Table A 11.13 (2) Travel Weighting Fraction Calculation and Cumulative Mileage

Motor Car, 2000

Model Year	Fleet Regis-tration a	b =a/ sum(a)	Annual Mileage c	d =b * c	Travel Fraction e =d/ sum(d)	Average Age f	Cumu-lative Mileage (1000km) g =f * g of 1993	h =e * g	Sub Total of Travel Fraction i	Average Cumu-lative Mileage
1980	39305	0.0271	0.5	0.0136	0.0143	19.75	381.57	5.5		
1981	39870	0.0275	1	0.0275	0.0291	19	367.08	10.7		
1982	39985	0.0276	1	0.0276	0.0292	18	347.76	10.1		
1983	42860	0.0296	1	0.0296	0.0313	17	328.44	10.3		
1984	41444	0.0286	1	0.0286	0.0302	16	309.12	9.3		
1985	34255	0.0236	1	0.0236	0.0250	15	289.8	7.2	0.1591	334.1
1986	24585	0.0170	1	0.0170	0.0179	14	270.48	4.9		
1987	20222	0.0139	1	0.0139	0.0148	13	251.16	3.7		
1988	28919	0.0199	1	0.0199	0.0211	12	231.84	4.9		
1989	44745	0.0309	1	0.0309	0.0326	11	212.52	6.9		
1990	60470	0.0417	1	0.0417	0.0441	10	193.2	8.5		
1991	69230	0.0477	1	0.0477	0.0505	9	173.88	8.8	0.1810	208.2
1992	67232	0.0464	1	0.0464	0.0490	8	154.56	7.6	0.0490	154.6
1993	66095	0.0456	1	0.0456	0.0482	7	135.24	6.5		
1994	79344	0.0547	1	0.0547	0.0579	6	115.92	6.7		
1995	112268	0.0774	1	0.0774	0.0819	5	96.6	7.9		
1996	148381	0.1023	1	0.1023	0.1082	4	77.28	8.4		
1997	170264	0.1174	1	0.1174	0.1242	3	57.96	7.2		
1998	98134	0.0677	1	0.0677	0.0716	2	38.64	2.8	0.4920	80.2
1999	103440	0.0713	1	0.0713	0.0754	1	19.32	1.5		
2000	119168	0.0822	0.5	0.0411	0.0435	0.25	4.83	0.2	0.1189	14.0
(Sum)	1450216	1.0000		0.9454	1.0000			139.5	1.0000	139.5

Table A 11.13 (3) Travel Weighting Fraction Calculation and Cumulative Mileage

Mini Bus, Medium and Large Bus, 2000

									for Mini Bus		for Medium and Large Bus	
Model Year	Fleet Regis-tration		Ann ual Mile age		Travel Fraction	Average Age	Cumu-lative Mileage (1000km)		Sub Total of Travel Fraction	Average Cumu-lative Mileage	Sub Total of Travel Fraction	Average Cumu-lative Mileage
	a	b =a/ sum(a)	c	d =b * c	e =d/ sum(d)	f	g =f * g of 1993	h =e * g	i		i	
1980	566	0.0413	0.5	0.0207	0.0218	19.75	2066.84	45.1				
1981	574	0.0419	1	0.0419	0.0443	19	1988.35	88.0				
1982	575	0.0420	1	0.0420	0.0443	18	1883.70	83.5				
1983	617	0.0450	1	0.0450	0.0476	17	1779.05	84.6				
1984	596	0.0435	1	0.0435	0.0459	16	1674.40	76.9				
1985	493	0.0360	1	0.0360	0.0380	15	1569.75	59.7				
1986	396	0.0289	1	0.0289	0.0305	14	1465.10	44.7				
1987	325	0.0237	1	0.0237	0.0251	13	1360.45	34.1				
1988	278	0.0203	1	0.0203	0.0214	12	1255.80	26.9				
1989	371	0.0271	1	0.0271	0.0286	11	1151.15	32.9				
1990	454	0.0331	1	0.0331	0.0350	10	1046.50	36.6				
1991	636	0.0464	1	0.0464	0.0490	9	941.85	46.2				
1992	536	0.0391	1	0.0391	0.0413	8	837.20	34.6	0.4729	1467.3	0.4729	1467.3
1993	841	0.0614	1	0.0614	0.0648	7	732.55	47.5				
1994	661	0.0482	1	0.0482	0.0510	6	627.90	32.0				
1995	882	0.0644	1	0.0644	0.0680	5	523.25	35.6				
1996	1016	0.0741	1	0.0741	0.0783	4	418.60	32.8				
1997	1554	0.1134	1	0.1134	0.1198	3	313.95	37.6				
1998	705	0.0515	1	0.0515	0.0544	2	209.30	11.4			0.4363	451.2
1999	728	0.0532	1	0.0532	0.0562	1	104.65	5.9				
2000	899	0.0656	0.5	0.0328	0.0347	0.25	26.16	0.9	0.5271	386.3	0.0908	74.7
(Sum)	13703.	1.0000		0.9465	1.0000			897.5	1.0000	897.5	1.0000	897.5

Table A 11.13 (4) Travel Weighting Fraction Calculation and Cumulative Mileage

Petrol Small Van and Small Lorry, 2000

Model Year	Fleet Regis-tration a	b =a/ sum(a)	Ann ual Mile age c	d =b * c	Travel Fraction e =d/ sum(d)	Average Age f	Cumu-lative Mileage (1000km) g =f * g of 1993	h =e * g	Sub Total of Travel Fraction i	Average Cumu-lative Mileage
1980	4634	0.0356	0.5	0.0178	0.0190	19.75	953.93	18.1		
1981	4701	0.0362	1	0.0362	0.0386	19	917.70	35.4		
1982	4714	0.0363	1	0.0363	0.0387	18	869.40	33.6		
1983	5053	0.0389	1	0.0389	0.0415	17	821.10	34.1		
1984	4886	0.0376	1	0.0376	0.0401	16	772.80	31.0		
1985	4039	0.0311	1	0.0311	0.0331	15	724.50	24.0		
1986	4549	0.0350	1	0.0350	0.0373	14	676.20	25.2		
1987	1217	0.0094	1	0.0094	0.0100	13	627.90	6.3		
1988	1339	0.0103	1	0.0103	0.0110	12	579.60	6.4		
1989	2230	0.0172	1	0.0172	0.0183	11	531.30	9.7		
1990	3436	0.0264	1	0.0264	0.0282	10	483.00	13.6		
1991	3473	0.0267	1	0.0267	0.0285	9	434.70	12.4		
1992	5918	0.0455	1	0.0455	0.0486	8	386.40	18.8		
1993	6005	0.0462	1	0.0462	0.0493	7	338.10	16.7		
1994	7076	0.0544	1	0.0544	0.0581	6	289.80	16.8		
1995	9923	0.0763	1	0.0763	0.0814	5	241.50	19.7		
1996	13172	0.1013	1	0.1013	0.1081	4	193.20	20.9		
1997	12412	0.0955	1	0.0955	0.1019	3	144.90	14.8		
1998	9507	0.0731	1	0.0731	0.0780	2	96.60	7.5	0.8697	419.7
1999	10009	0.0770	1	0.0770	0.0821	1	48.30	4.0		
2000	11732	0.0902	0.5	0.0451	0.0481	0.25	12.08	0.6	0.1303	34.9
(Sum)	130024	1.0000		0.9371	1.0000			369.5	1.0000	369.5

Table A 11.13 (5) Travel Weighting Fraction Calculation and Cumulative Mileage

Diesel Van, and Medium and Large Truck, Lorry and Trailer, 2000

Model Year	Fleet Registration a	b =a/ sum(a)	Annual Mileage c	d =b * c	Travel Fraction e =d/ sum(d)	Average Age f	Cumulative Mileage (1000km) g =f * g of 1993	h =e * g	Sub Total of Travel Fraction i	Average Cumulative Mileage
1980	2,742	0.0251	0.5	0.0125	0.0132	19.75	953.93	12.6		
1981	2,782	0.0255	1	0.0255	0.0269	19	917.70	24.7		
1982	2,790	0.0255	1	0.0255	0.0270	18	869.40	23.4		
1983	2,990	0.0274	1	0.0274	0.0289	17	821.10	23.7		
1984	2,891	0.0265	1	0.0265	0.0279	16	772.80	21.6		
1985	2,390	0.0219	1	0.0219	0.0231	15	724.50	16.7		
1986	2,438	0.0223	1	0.0223	0.0236	14	676.20	15.9		
1987	1,574	0.0144	1	0.0144	0.0152	13	627.90	9.5		
1988	2,303	0.0211	1	0.0211	0.0222	12	579.60	12.9		
1989	4,579	0.0419	1	0.0419	0.0442	11	531.30	23.5		
1990	7,486	0.0685	1	0.0685	0.0723	10	483.00	34.9		
1991	9,709	0.0888	1	0.0888	0.0938	9	434.70	40.8		
1992	4,444	0.0407	1	0.0407	0.0429	8	386.40	16.6	0.4612	600.4
1993	4,509	0.0413	1	0.0413	0.0436	7	338.10	14.7		
1994	5,314	0.0486	1	0.0486	0.0513	6	289.80	14.9		
1995	7,451	0.0682	1	0.0682	0.0720	5	241.50	17.4		
1996	9,892	0.0905	1	0.0905	0.0955	4	193.20	18.5		
1997	9,320	0.0853	1	0.0853	0.0900	3	144.90	13.0	0.3524	222.7
1998	7,255	0.0664	1	0.0664	0.0701	2	96.60	6.8		
1999	7,649	0.0700	1	0.0700	0.0739	1	48.30	3.6		
2000	8,773	0.0803	0.5	0.0401	0.0424	0.25	12.08	0.5	0.1863	58.2
	109281	1.0000		0.9473	1.0000			366.2	1	366.2

Table A 11.13 (6) Travel Weighting Fraction Calculation and Cumulative Mileage

Taxi, 2000

Model Year	Fleet Registration a	b =a/ sum(a)	Annual Mileage c	d =b * c	Travel Fraction e =d/ sum(d)	Average Age f	Cumulative Mileage (1000km) g =f * g of 1993
1990-1992					0.3000	8.90	859.74
1993-1998					0.6000	4.50	434.70
1999-2000					0.1000	0.60	57.96

Note : Travel Fraction is assumed by JICA, 1993, because no actual data was available.

11.8 Separation of HC and NOx Limit Value in Regulation

In the Regulation 91/441/EEC (Table A 11.3), Taiwan Stage2 (Table A 11.6) and 94/12/EC (Table A 11.7), HC and NOx are summed together, the given values must be separated. From the results of Japanese ten mode (average speed 17.8 km/h) tests, the ratio of HC and NOx is around 1:3 (HC=0.08 & NOx=0.24 g/km). Since, for example the average speed of Regulation 91/441/EEC test is 33.6 km/h, the Japanese values were extrapolated using equations (Table A 11.16). The relations of HC and NOx emissions with speeds are listed in Table A 11.14.

Table A 11.14 Change of Emission Rates of HC and NOx with Speed

		Average speed (km/h)	
		17.8	33.6
Pollutant (g/km)	HC	1.49	0.95
	NOx	1.15	0.98

Now, HC emission at the average speed of 33.6 km/h is given by the following equation..

$$\frac{\frac{1.49}{0.95}\cdot x}{\frac{1.15}{0.98}\cdot(1.13-x)} = \frac{1}{3}$$

Hence, HC emission X is 0.23 and NOx is 0.90 g/km (at 0 mileage in Table A 11.15(1)).

11.9 Basic Emission Factors

Basic emission factors and travel fractions for the year 1997 and 2000, as shown in Table A 11.15, were obtained from the emission factors for new vehicles (at 0 mileage), the cumulative mileage of various types of vehicles, the deterioration rates of emission factors. No deterioration with increase of mileage was assumed on fuel consumption rate. In the same way, basic emission factors and travel fractions for the year 2020 are shown in Table A 11.16.

Table A 11.15 (1) Emission Factor and Fuel Consumption Rates for Year 2000 at 0 Mileage and Deterioration Rate

Petrol Vehicles (1)

Vehicle Type	Model Years	Item	Emission Factor	Base Speed	Travel Fraction	Average Cumulative Mileage (1000km/unit)	Emission Factor at 0 mileage	Deterioration Rate (per 10000km)
Motorcycle	1986 -2000	HC	13.16	31.5	1.000	61	9.9	0.054
		CO	21.67	31.5	1.000	61	17	0.045
		NOx	0.16	31.5	1.000	61	0.075	0.186
		FC	0.040	31.5	1.000	61	0.04	0
Motor Car	1980-85	HC	2.88	18.7	0.159	334	2.62	0.003
		CO	44.32	18.7	0.159	334	19.82	0.037
		NOx	1.23	18.7	0.159	334	1.23	0
		FC	0.091	18.7	0.159	334	0.091	0
	1986-91 Proton	HC	2.80	18.7	0.101	208	2.64	0.003
		CO	13.26	18.7	0.101	208	7.49	0.037
		NOx	2.70	18.7	0.101	208	2.7	0
		FC	0.09	18.7	0.101	208	0.093	0
	1986-91 Others	HC	2.78	18.7	0.080	208	2.62	0.003
		CO	35.09	18.7	0.080	208	19.82	0.037
		NOx	1.23	18.7	0.080	208	1.23	0
		FC	0.09	18.7	0.080	208	0.091	0
	1992 Proton	HC	2.76	18.7	0.029	155	2.64	0.003
		CO	11.77	18.7	0.029	155	7.49	0.037
		NOx	2.70	18.7	0.029	155	2.7	0
		FC	0.09	18.7	0.029	155	0.093	0
	1992 Others	HC	2.74	18.7	0.020	155	2.62	0.003
		CO	31.15	18.7	0.020	155	19.82	0.037
		NOx	1.23	18.7	0.020	155	1.23	0
		FC	0.09	18.7	0.020	155	0.091	0
	1993-98 Proton	HC	2.41	18.7	0.292	80	2.35	0.003
		CO	6.43	18.7	0.292	80	4.96	0.037
		NOx	2.19	18.7	0.292	80	2.19	0
		FC	0.10	18.7	0.292	80	0.099	0
	1993-98 Others	HC	2.68	18.7	0.200	80	2.62	0.003
		CO	25.69	18.7	0.200	80	19.82	0.037
		NOx	1.23	18.7	0.200	80	1.23	0
		FC	0.091	18.7	0.200	80	0.091	0
	1999-00	HC	0.24	33.6	0.119	14	0.23	0.025
		CO	3.27	33.6	0.119	14	3.16	0.025
		NOx	0.93	33.6	0.119	14	0.9	0.025
		FC	0.10	18.7	0.119	14	0.099	0

Notes: FC : Fuel Consumption Rate
Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.15 (2) Emission Factor and Fuel Consumption Rates for Year 2000 at 0 Mileage and Deterioration Rate

Petrol Vehicles (2)

Vehicle Type	Model Years	Item	Emission Factor	Base Speed	Travel Fraction	Average Cumulative Mileage (1000km/unit)	Emission Factor at 0 mileage	Deterioration Rate (per 10000km)
Van	1980-98	HC	2.33	18.7	0.870	420	2.07	0.003
		CO	50.39	18.7	0.870	420	19.73	0.037
		NOx	3.06	18.7	0.870	420	3.06	0
		FC	0.130	18.7	0.870	420	0.13	0
	1999 -2000	HC	0.25	33.6	0.130	35	0.23	0.025
		CO	3.43	33.6	0.130	35	3.16	0.025
		NOx	0.98	33.6	0.130	35	0.9	0.025
		FC	0.130	18.7	0.130	35	0.13	0
Taxi	1990-92 Proton	HC	3.32	18.7	0.300	860	2.64	0.003
		CO	31.32	18.7	0.300	860	7.49	0.037
		NOx	2.70	18.7	0.300	860	2.7	0
		FC	0.093	18.7	0.300	860	0.093	0
	1993-98 Proton	HC	2.66	18.7	0.600	435	2.35	0.003
		CO	12.94	18.7	0.600	435	4.96	0.037
		NOx	2.19	18.7	0.600	435	2.19	0
		FC	0.099	18.7	0.600	435	0.099	0
	1999 -2000	HC	0.26	33.6	0.100	58	0.23	0.025
		CO	3.62	33.6	0.100	58	3.16	0.025
		NOx	1.03	33.6	0.100	58	0.9	0.025
		FC	0.099	33.6	0.100	58	0.099	0
Small Lorry	1980-98	HC	4.77	18.7	0.870	420	2.07	0.031
		CO	50.39	18.7	0.870	420	19.73	0.037
		NOx	3.06	18.7	0.870	420	3.06	0
		FC	0.130	18.7	0.870	420	0.13	0
	1999 -2000	HC	0.25	33.6	0.130	35	0.23	0.025
		CO	3.44	33.6	0.130	35	3.16	0.025
		NOx	0.98	33.6	0.130	35	0.9	0.025
		FC	0.130	18.7	0.130	35	0.13	0

Notes: FC : Fuel Consumption Rate
Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.15 (3) Emission Factor and Fuel Consumption Rates for Year 2000 at 0 Mileage and Deterioration Rate

Diesel Vehicles (1)

Vehicle Type	Model Years	Item	Emission Factor	Base Speed	Travel Fraction	Average Cumulative Mileage (1000km/unit)	Emission Factor at 0 mileage	Deterioration Rate (per 10000km)
Van	1980-92	HC	2.66	31.5	0.461	600.0	0.81	0.038
		CO	4.70	31.5	0.461	600.0	1.68	0.030
		NOx	1.84	31.5	0.461	600.0	0.91	0.017
		FC	0.100	31.5	0.461	600.0	0.1	0.000
	1993-97	HC	0.33	31.5	0.352	223.0	0.18	0.038
		CO	1.06	31.5	0.352	223.0	0.71	0.022
		NOx	1.06	31.5	0.352	223.0	0.81	0.014
		FC	0.100	31.5	0.352	223.0	0.1	0.000
	1998 -2000	HC	0.07	31.5	0.186	58.0	0.057	0.038
		CO	0.26	31.5	0.186	58.0	0.228	0.022
		NOx	0.43	31.5	0.186	58.0	0.401	0.014
		FC	0.100	31.5	0.186	58.0	0.1	0.000
Mini Bus	1980-92	HC	5.13	31.5	0.473	1467.3	0.78	0.038
		CO	8.32	31.5	0.473	1467.3	1.54	0.030
		NOx	4.86	31.5	0.473	1467.3	1.39	0.017
		FC	0.230	31.5	0.473	1467.3	0.23	0.000
	1993 -2000	HC	0.67	31.5	0.527	386.0	0.27	0.038
		CO	1.53	31.5	0.527	386.0	0.83	0.022
		NOx	1.42	31.5	0.527	386.0	0.92	0.014
		FC	0.230	31.5	0.527	386.0	0.23	0.000
Medium Bus Large Bus	1980-92	HC	6.10	31.3	0.473	1467.0	2.63	0.009
		CO	17.68	31.3	0.473	1467.0	7.62	0.009
		NOx	15.87	31.3	0.473	1467.0	15.87	0.000
		FC	0.50	29.0	0.473	1467.0	0.5	0.000
	1993-98	HC	2.93	31.3	0.436	451.0	2.02	0.010
		CO	7.65	31.3	0.436	451.0	5.44	0.009
		NOx	11.73	31.3	0.436	451.0	11.73	0.000
		FC	0.50	29.0	0.436	451.0	0.5	0.000
	1999 -2000	HC	0.68	31.3	0.091	75.0	0.635	0.010
		CO	1.87	31.3	0.091	75.0	1.749	0.009
		NOx	5.80	31.3	0.091	75.0	5.800	0.000
		FC	0.50	29.0	0.091	75.0	0.5	0.000
Medium Lorry	1980-92	HC	3.49	31.5	0.461	600.0	0.78	0.058
		CO	4.50	31.5	0.461	600.0	1.54	0.032
		NOx	3.64	31.5	0.461	600.0	1.39	0.027
		FC	0.230	29.0	0.461	600.0	0.23	0.000
	1993-97	HC	0.62	31.5	0.352	223.0	0.27	0.058
		CO	1.18	31.5	0.352	223.0	0.83	0.019
		NOx	1.19	31.5	0.352	223.0	0.92	0.013
		FC	0.230	29.0	0.352	223.0	0.23	0.000
	98-2000	HC	0.11	31.5	0.186	58.0	0.085	0.058
		CO	0.30	31.5	0.186	58.0	0.267	0.019
		NOx	0.49	31.5	0.186	58.0	0.455	0.013
		FC	0.230	29.0	0.186	58.0	0.230	0.000

Notes: FC : Fuel Consumption Rate
Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.15 (3) Emission Factor and Fuel Consumption Rates for Year 2000 at 0 Mileage and Deterioration Rate

Diesel Vehicles (2)

Vehicle Type	Model Years	Item	Emission Factor	Base Speed	Travel Fraction	Average Cumulative Mileage (1000km/unit)	Emission Factor at 0 mileage	Deterioration Rate (per 10000km)
Large Lorry Trailer	1980-92	HC	4.05	31.3	0.461	600.0	2.63	0.009
		CO	11.73	31.3	0.461	600.0	7.62	0.009
		NOx	15.87	31.3	0.461	600.0	15.87	0.000
		FC	0.500	29.0	0.461	600.0	0.5	0.000
	1993-97	HC	2.47	31.3	0.352	223.0	2.02	0.010
		CO	6.53	31.3	0.352	223.0	5.44	0.009
		NOx	11.73	31.3	0.352	223.0	11.73	0.000
		FC	0.500	29.0	0.352	223.0	0.5	0.000
	1998 -2000	HC	0.67	31.3	0.186	58.0	0.635	0.010
		CO	1.84	31.3	0.186	58.0	1.749	0.009
		NOx	5.80	31.3	0.186	58.0	5.800	0.000
		FC	0.500	29.0	0.186	58.0	0.5	0.000

Notes: FC : Fuel Consumption Rate
Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.16 (1) Emission Factor and Fuel Consumption Rates for Year 2020 at 0 Mileage and Deterioration Rate

Petrol Vehicles

Vehicle Type	Model Years	Item	Emission Factor	Base Speed	Travel Fraction	Average Cumulative Mileage (1000km/unit)	Emission Factor at 0 mileage	Deterioration Rate (per 10000km)
Motorcycle	2006-20	HC	4.94	31.5	1.000	79	3.46	0.054
		CO	7.08	31.5	1.000	79	5.22	0.045
		NOx	0.07	31.5	1.000	79	0.03	0.186
		FCp	0.028	31.5	1.000	79	0.028	0
Motor Car	2001-20	HC	0.19	33.6	1.000	194	0.13	0.025
		CO	3.80	33.6	1.000	194	2.56	0.025
		NOx	0.68	33.6	1.000	194	0.46	0.025
		FCp	0.069	18.7	1.000	194	0.0693	0
Van	2001-20	HC	0.13	22.7	1.000	483	0.06	0.025
		CO	0.29	22.7	1.000	483	0.13	0.025
		NOx	0.15	22.7	1.000	483	0.07	0.025
		FCg	0.069	22.7	1.000	483	0.069	0
Taxi	2010-20	HC	0.13	22.7	1.000	483	0.06	0.025
		CO	0.29	22.7	1.000	483	0.13	0.025
		NOx	0.15	22.7	1.000	483	0.07	0.025
		FCg	0.069	22.7	1.000	483	0.069	0
Small Lorry	2001-20	HC	0.13	22.7	1.000	483	0.06	0.025
		CO	0.29	22.7	1.000	483	0.13	0.025
		NOx	0.15	22.7	1.000	483	0.07	0.025
		FCg	0.069	22.7	1.000	483	0.069	0

Table A 11.16 (2) Emission Factor and Fuel Consumption Rates for Year 2020 at 0 Mileage and Deterioration Rate

Natural Gas Vehicles

Vehicle Type	Model Years	Item	Emission Factor	Base Speed	Travel Fraction	Average Cumulative Mileage (1000km/unit)	Emission Factor at 0 mileage	Deterioration Rate (per 10000km)
Van	2001-20	HC	0.13	22.7	1.000	483	0.06	0.025
		CO	0.29	22.7	1.000	483	0.13	0.025
		NOx	0.15	22.7	1.000	483	0.07	0.025
		FCg	0.069	22.7	1.000	483	0.069	0
Mini Bus	2005-20	HC	0.15	31.5	1.000	785	0.038	0.038
		CO	0.54	31.5	1.000	785	0.16	0.03
		NOx	0.03	31.5	1.000	785	0.014	0.014
		FCg	0.184	31.5	1.000	785	0.184	0
Medium Bus Large Bus	2005-20	HC	1.13	31.3	1.000	785	0.635	0.01
		CO	1.33	31.3	1.000	785	0.777	0.009
		NOx	0.85	31.3	1.000	785	0.847	0
		FCg	0.60	31.3	1.000	785	0.60	0
Medium Lorry	2005-20	HC	0.14	31.5	1.000	483	0.038	0.058
		CO	0.31	31.5	1.000	483	0.16	0.019
		NOx	0.02	31.5	1.000	483	0.014	0.013
		FCg	0.184	31.5	1.000	483	0.184	0
Large Lorry Trailer	2005-20	HC	0.94	31.3	1.000	483	0.635	0.01
		CO	1.11	31.3	1.000	483	0.777	0.009
		NOx	0.85	31.3	1.000	483	0.847	0
		FCg	0.60	31.3	1.000	483	0.60	0

Notes: FCp : Petrol Fuel Consumption Rate
FCg : Compressed Natural Gas Consumption Rate
Unit : g/km for HC, CO and NOx, l/km for FCp, and m^3N/km for FCg

11.10 Average Speed and Emission Factors

Emission rate from a car changes with its speed. The change can be calculated by using equations given in Table A 11.17. Equations with separate correction factor coefficients according to vehicles type and engine type were derived using published data in the USA and Japan.

Table A 11.17 (1) Speed Correction Equation and its Factor Coefficients

HC,CO and NOx (1995-) : $SF(s)=\exp(a + b * s + c * s^2 + d * s^3 + e * s^4 + f * s^5)$

NOx (-1994) : $SF(s)=a + b * s + c * s^2 + d * s^3 + e * s^4 + f * s^5$

FC : $SF(s)=a / s + b$

Where;

s : Average speed (mph for HC, CO and NOx, km/h for FC)

Petrol Vehicles

Vehicle Type	Item	a	b	c	d	e	f
Motorcycle	HC	2.31026E+00	-2.89572E-01	1.52990E-02	-4.46689E-04	6.48183E-06	-3.63456E-08
1983-2000	CO	2.33989E+00	-2.96978E-01	1.60071E-02	-4.77396E-04	7.06752E-06	-4.03978E-08
	NOx	1.68635E+00	-1.18303E-01	6.54975E-03	-1.37139E-04	1.00849E-06	0.00000E+00
	FC	6.20800E-01	4.39100E-02				
Motor Car	HC	2.68382E+00	-3.44633E-01	1.95417E-02	-6.25720E-04	9.78442E-06	-5.83369E-08
1977-1997	CO	2.83929E+00	-3.68756E-01	2.10782E-02	-6.76438E-04	1.06267E-05	-6.36405E-08
	NOx	7.83838E-01	3.28549E-04	1.06029E-03	-3.19350E-05	2.90389E-07	0.00000E+00
	FC	7.25200E-01	6.15200E-02				
1998-2000	HC	9.84090E-01	-5.67319E-02	3.32320E-04			
	CO	8.58419E-01	-4.37969E-02				
	NOx	3.86041E-01	-2.62961E-02	3.36740E-04			
	FC	7.25200E-01	6.15200E-02				
Van	HC	2.68382E+00	-3.44633E-01	1.95417E-02	-6.25720E-04	9.78442E-06	-5.83369E-08
1977-1998	CO	2.83929E+00	-3.68756E-01	2.10782E-02	-6.76438E-04	1.06267E-05	-6.36405E-08
	NOx	7.83838E-01	3.28549E-04	1.06029E-03	-3.19350E-05	2.90389E-07	0.00000E+00
	FC	7.25200E-01	6.15200E-02				
1999-2000	HC	9.84090E-01	-5.67319E-02	3.32320E-04			
	CO	8.58419E-01	-4.37969E-02				
	NOx	3.86041E-01	-2.62961E-02	3.36740E-04			
	FC	7.25200E-01	6.15200E-02				
Taxi	HC	9.84090E-01	-5.67319E-02	3.32320E-04			
1987-1998	CO	8.58419E-01	-4.37969E-02				
	NOx	3.86041E-01	-2.62961E-02	3.36740E-04			
	FC	7.25200E-01	6.15200E-02				
1999-2000	HC	9.84090E-01	-5.67319E-02	3.32320E-04			
	CO	8.58419E-01	-4.37969E-02				
	NOx	3.86041E-01	-2.62961E-02	3.36740E-04			
	FC	7.25200E-01	6.15200E-02				
Small Lorry	HC	2.39540E+00	-3.35781E-01	2.11609E-02	-7.31550E-04	1.20715E-05	-7.48566E-08
1977-1994	CO	2.48747E+00	-3.91562E-01	2.70721E-02	-9.76178E-04	1.65270E-05	-1.04317E-07
	NOx	9.42131E-01	-4.23240E-02	3.86253E-03	-9.39853E-05	7.53883E-07	
	FC	7.69500E-01	7.61500E-02				
1995-2000	HC	9.84090E-01	-5.67319E-02	3.32320E-04			
	CO	8.58419E-01	-4.37969E-02				
	NOx	3.86041E-01	-2.62961E-02	3.36740E-04			
	FC	7.25200E-01	6.15200E-02				

Source : U.S.EPA for HC,CO and NOx, Japanese Environment Agency for FC

Table A 11.17 (2) Future Speed Correction Equation and its Factor Coefficients

HC,CO and NOx : $SF(s)=\exp (a + b * s + c * s^2)$

FC : $SF(s)=a / s + b$

Where;

s : Average speed (mph for HC, CO and NOx, km/h for FC)

Diesel Vehicles

Vehicle Type	Item	a	b	c
Van	HC	0.90900	-0.05500	0.00044
	CO	1.37520	-0.08800	0.00091
	NOx	0.66800	-0.04800	0.00071
	FC	1.35500	0.08848	
Taxi	HC	0.90900	-0.05500	0.00044
	CO	1.37520	-0.08800	0.00091
	NOx	0.66800	-0.04800	0.00071
	FC	1.35500	0.08848	
Mini Bus	HC	0.90900	-0.05500	0.00044
	CO	1.37520	-0.08800	0.00091
	NOx	0.66800	-0.04800	0.00071
	FC	1.35500	0.08848	
Medium Bus Large Bus	HC	0.92400	-0.05500	0.00044
	CO	1.39600	-0.08800	0.00091
	NOx	0.67600	-0.04800	0.00071
	FC	1.28000	0.18280	
Medium Lorry	HC	0.90900	-0.05500	0.00044
	CO	1.37520	-0.08800	0.00091
	NOx	0.66800	-0.04800	0.00071
	FC	1.35500	0.08848	
Large Lorry	HC	0.92400	-0.05500	0.00044
	CO	1.39600	-0.08800	0.00091
	NOx	0.67600	-0.04800	0.00071
	FC	1.28000	0.18280	

Source : U.S.EPA for HC,CO and NOx, Japanese Environment Agency for FC

11.11 Average Speed and Emission Factors

Speed correction equations and coefficient, according to vehicle type and engine type, were set as shown in Table A 11.17.

Emission factors for petrol and diesel vehicles, according to various speeds, shown in Table A 11.18, Table A 11.19, and Table A 11.20, were obtained using emission factors and travel fractions and speed correction equations.

Table A 11.18 (1) Emission Factor for Year 1997

Petrol Vehicles

		Average Travel Speed (km/h)											
Vehicle	Item	10	15	20	25	30	35	40	45	50	55	60	65
Motor cycle	HC	36.91	25.27	19.41	16.1	14.02	12.58	11.46	10.54	9.75	9.07	8.51	8.07
	CO	60.78	41.49	31.84	26.41	23	20.6	18.73	17.17	15.83	14.69	13.76	13.04
	NOx	0.2	0.18	0.17	0.17	0.17	0.17	0.18	0.19	0.2	0.2	0.21	0.21
	FC	0.067	0.054	0.047	0.043	0.041	0.039	0.037	0.036	0.035	0.035	0.034	0.034
Motor Car	HC	5.14	3.35	2.49	2	1.69	1.46	1.27	1.11	0.98	0.87	0.78	0.71
	CO	45.03	28.62	20.92	16.7	14.02	12.08	10.52	9.22	8.12	7.22	6.52	6.01
	NOx	1.59	1.66	1.74	1.83	1.91	2	2.07	2.14	2.19	2.24	2.28	2.32
	FC	0.125	0.102	0.091	0.084	0.08	0.077	0.074	0.072	0.071	0.07	0.069	0.068
Van	HC	4.46	2.91	2.16	1.74	1.47	1.27	1.1	0.97	0.85	0.75	0.68	0.62
	CO	95.89	60.94	44.56	35.57	29.86	25.72	22.4	19.63	17.29	15.38	13.88	12.8
	NOx	2.83	2.95	3.1	3.25	3.41	3.55	3.69	3.8	3.9	3.99	4.06	4.13
	FC	0.174	0.142	0.127	0.117	0.111	0.107	0.103	0.101	0.099	0.097	0.095	0.094
Taxi	HC	3.85	3.28	2.81	2.42	2.11	1.84	1.62	1.43	1.28	1.15	1.03	0.94
	CO	25.28	22.06	19.25	16.8	14.67	12.8	11.17	9.75	8.51	7.43	6.48	5.66
	NOx	2.79	2.61	2.46	2.33	2.23	2.14	2.07	2.02	1.98	1.95	1.94	1.94
	FC	0.127	0.104	0.093	0.086	0.082	0.078	0.076	0.074	0.072	0.071	0.07	0.069
Small Lorry	HC	7.95	5.49	4.3	3.61	3.14	2.77	2.44	2.15	1.89	1.68	1.52	1.4
	CO	82.8	57.05	45.58	39.4	35.18	31.56	28.1	24.81	21.87	19.47	17.73	16.67
	NOx	2.95	2.97	3.1	3.32	3.57	3.84	4.09	4.33	4.53	4.69	4.82	4.92
	FC	0.17	0.141	0.127	0.119	0.113	0.109	0.106	0.103	0.101	0.1	0.099	0.098

Notes : Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.18 (2) Emission Factor for Year 1997

Diesel Vehicles

Vehicle	Item	Average Travel Speed (km/h)											
		10	15	20	25	30	35	40	45	50	55	60	65
Van	HC	2.82	2.42	2.11	1.84	1.63	1.45	1.3	1.18	1.08	0.99	0.92	0.87
	CO	7.03	5.58	4.52	3.72	3.12	2.66	2.31	2.04	1.83	1.68	1.56	1.48
	NOx	2.08	1.86	1.68	1.54	1.43	1.34	1.28	1.24	1.22	1.21	1.22	1.25
	FC	0.17	0.136	0.119	0.109	0.102	0.097	0.093	0.09	0.088	0.086	0.084	0.083
Mini Bus	HC	5.55	4.78	4.15	3.63	3.21	2.86	2.57	2.33	2.13	1.96	1.82	1.71
	CO	12.31	9.79	7.92	6.52	5.46	4.66	4.04	3.57	3.21	2.94	2.73	2.59
	NOx	4.83	4.31	3.89	3.57	3.31	3.12	2.98	2.88	2.83	2.82	2.84	2.9
	FC	0.392	0.313	0.273	0.25	0.234	0.222	0.214	0.207	0.202	0.198	0.194	0.191
Medium Bus Large Bus	HC	8.02	6.9	5.99	5.25	4.64	4.13	3.71	3.36	3.07	2.83	2.63	2.47
	CO	30.14	23.96	19.38	15.96	13.37	11.4	9.9	8.74	7.86	7.19	6.7	6.35
	NOx	21.31	19	17.17	15.74	14.62	13.77	13.14	12.72	12.48	12.42	12.52	12.81
	FC	0.685	0.591	0.544	0.516	0.497	0.483	0.473	0.465	0.459	0.454	0.45	0.446
Medium Lorry	HC	3.72	3.2	2.78	2.43	2.15	1.91	1.72	1.56	1.42	1.31	1.22	1.14
	CO	6.83	5.43	4.39	3.62	3.03	2.59	2.24	1.98	1.78	1.63	1.52	1.44
	NOx	3.63	3.24	2.93	2.68	2.49	2.35	2.24	2.17	2.13	2.12	2.13	2.18
	FC	0.381	0.304	0.266	0.243	0.227	0.216	0.208	0.202	0.197	0.192	0.189	0.186
Large Lorry	HC	5.74	4.94	4.29	3.76	3.32	2.96	2.66	2.41	2.2	2.03	1.88	1.77
	CO	21.53	17.11	13.85	11.4	9.55	8.15	7.07	6.25	5.61	5.14	4.78	4.53
	NOx	21.25	18.95	17.12	15.69	14.57	13.73	13.1	12.68	12.45	12.38	12.49	12.77
	FC	0.685	0.591	0.544	0.516	0.497	0.483	0.473	0.465	0.459	0.454	0.45	0.446

Notes : Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.19 (1) Emission Factor for Year 2000

Petrol Vehicles

		Average Travel Speed (km/h)											
Vehicle	Item	10	15	20	25	30	35	40	45	50	55	60	65
Motor	HC	35.87	24.56	18.86	15.64	13.63	12.22	11.14	10.24	9.47	8.82	8.27	7.84
cycle	CO	59.33	40.5	31.08	25.78	22.45	20.11	18.28	16.76	15.46	14.34	13.43	12.73
	NOx	0.19	0.17	0.16	0.16	0.16	0.16	0.17	0.18	0.19	0.19	0.2	0.2
	FC	0.067	0.054	0.047	0.043	0.041	0.039	0.037	0.036	0.035	0.035	0.034	0.034
Motor	HC	4.57	2.99	2.23	1.79	1.51	1.31	1.14	1	0.88	0.78	0.7	0.64
Car	CO	39.17	25.07	18.42	14.75	12.4	10.68	9.31	8.15	7.18	6.38	5.75	5.29
	NOx	1.58	1.63	1.7	1.77	1.85	1.92	1.98	2.04	2.09	2.13	2.16	2.2
	FC	0.126	0.104	0.092	0.085	0.081	0.078	0.075	0.073	0.072	0.07	0.069	0.069
Van	HC	3.98	2.61	1.94	1.57	1.32	1.14	1	0.87	0.77	0.68	0.61	0.56
	CO	88.72	56.58	41.47	33.16	27.85	24	20.91	18.31	16.13	14.34	12.94	11.92
	NOx	2.63	2.72	2.84	2.97	3.1	3.22	3.33	3.43	3.51	3.59	3.65	3.71
	FC	0.174	0.142	0.127	0.117	0.111	0.107	0.103	0.101	0.099	0.097	0.095	0.094
Taxi	HC	3.46	2.95	2.53	2.18	1.9	1.66	1.46	1.29	1.15	1.03	0.93	0.85
	CO	22.43	19.58	17.09	14.91	13.02	11.36	9.91	8.65	7.55	6.59	5.75	5.02
	NOx	2.5	2.34	2.21	2.1	2	1.93	1.86	1.81	1.78	1.75	1.74	1.74
	FC	0.133	0.109	0.097	0.09	0.085	0.081	0.079	0.077	0.075	0.074	0.073	0.072
Small	HC	7.33	5.08	3.98	3.34	2.91	2.56	2.26	1.99	1.75	1.55	1.4	1.3
Lorry	CO	76.73	53.02	42.41	36.67	32.73	29.35	26.13	23.06	20.33	18.1	16.47	15.46
	NOx	2.73	2.74	2.85	3.02	3.24	3.46	3.68	3.88	4.05	4.19	4.3	4.39
	FC	0.17	0.141	0.127	0.118	0.113	0.108	0.105	0.103	0.101	0.1	0.098	0.097

Notes : Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.19 (2) Emission Factor for Year 2000

Diesel Vehicles

Vehicle	Item	Average Travel Speed (km/h)											
		10	15	20	25	30	35	40	45	50	55	60	65
Van	HC	2.43	2.1	1.82	1.59	1.41	1.25	1.13	1.02	0.93	0.86	0.8	0.75
	CO	6.14	4.88	3.95	3.25	2.72	2.32	2.02	1.78	1.6	1.47	1.36	1.29
	NOx	1.94	1.73	1.56	1.43	1.33	1.25	1.19	1.16	1.13	1.13	1.14	1.16
	FC	0.17	0.136	0.119	0.109	0.102	0.097	0.093	0.09	0.088	0.086	0.084	0.083
Mini Bus	HC	4.98	4.29	3.72	3.26	2.88	2.57	2.3	2.09	1.91	1.76	1.63	1.53
	CO	11.23	8.93	7.22	5.95	4.98	4.25	3.69	3.26	2.93	2.68	2.5	2.36
	NOx	4.53	4.04	3.65	3.34	3.11	2.93	2.79	2.7	2.65	2.64	2.66	2.72
	FC	0.392	0.313	0.273	0.25	0.234	0.222	0.214	0.207	0.202	0.198	0.194	0.191
Medium Bus Large Bus	HC	7.53	6.49	5.63	4.93	4.36	3.88	3.49	3.16	2.89	2.66	2.47	2.32
	CO	27.93	22.2	17.96	14.79	12.39	10.57	9.17	8.1	7.28	6.66	6.2	5.88
	NOx	19.5	17.38	15.71	14.4	13.37	12.59	12.02	11.64	11.42	11.36	11.46	11.72
	FC	0.685	0.591	0.544	0.516	0.497	0.483	0.473	0.465	0.459	0.454	0.45	0.446
Medium Lorry	HC	3.32	2.86	2.48	2.17	1.92	1.71	1.53	1.39	1.27	1.17	1.09	1.02
	CO	6.04	4.8	3.88	3.2	2.68	2.29	1.98	1.75	1.58	1.44	1.34	1.27
	NOx	3.26	2.91	2.63	2.41	2.23	2.1	2.01	1.94	1.91	1.9	1.91	1.96
	FC	0.381	0.304	0.266	0.243	0.227	0.216	0.208	0.202	0.197	0.192	0.189	0.186
Large Lorry	HC	5.11	4.4	3.82	3.35	2.96	2.63	2.36	2.14	1.96	1.8	1.68	1.57
	CO	18.97	15.08	12.2	10.04	8.41	7.18	6.23	5.5	4.95	4.53	4.21	3.99
	NOx	18.6	16.58	14.98	13.73	12.75	12.01	11.47	11.1	10.89	10.84	10.93	11.17
	FC	0.685	0.591	0.544	0.516	0.497	0.483	0.473	0.465	0.459	0.454	0.45	0.446

Notes : Unit : g/km for HC, CO and NOx, and l/km for FC

Table A 11.20 (1) Emission Factor for Year 2020

Petrol and CNG Vehicles

		Average Travel Speed (km/h)											
Vehicle	Item	10	15	20	25	30	35	40	45	50	55	60	65
Motor	HC	13.47	9.22	7.08	5.87	5.12	4.59	4.18	3.85	3.56	3.31	3.1	2.94
cycle	CO	19.38	13.23	10.15	8.42	7.33	6.57	5.97	5.48	5.05	4.69	4.39	4.16
	NOx	0.08	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09
	FC	0.047	0.038	0.033	0.03	0.028	0.027	0.026	0.025	0.025	0.024	0.024	0.024
Motor	HC	0.64	0.42	0.31	0.25	0.21	0.18	0.16	0.14	0.12	0.11	0.1	0.09
Car	CO	13.61	8.65	6.32	5.05	4.24	3.65	3.18	2.79	2.45	2.18	1.97	1.82
	NOx	0.55	0.57	0.6	0.63	0.66	0.69	0.71	0.74	0.76	0.77	0.79	0.8
	FC	0.092	0.076	0.067	0.062	0.059	0.057	0.055	0.053	0.052	0.051	0.051	0.05
Van	HC	0.19	0.16	0.14	0.12	0.11	0.1	0.09	0.08	0.07	0.07	0.06	0.06
	CO	0.5	0.4	0.32	0.27	0.22	0.19	0.16	0.15	0.13	0.12	0.11	0.11
	NOx	0.2	0.17	0.16	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.11	0.12
	FCg	0.104	0.083	0.073	0.066	0.062	0.059	0.057	0.055	0.054	0.053	0.052	0.051
Taxi	HC	0.19	0.16	0.14	0.12	0.11	0.1	0.09	0.08	0.07	0.07	0.06	0.06
	CO	0.5	0.4	0.32	0.27	0.22	0.19	0.16	0.15	0.13	0.12	0.11	0.11
	NOx	0.2	0.17	0.16	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.11	0.12
	FCg	0.104	0.083	0.073	0.066	0.062	0.059	0.057	0.055	0.054	0.053	0.052	0.051
Small	HC	0.19	0.16	0.14	0.12	0.11	0.1	0.09	0.08	0.07	0.07	0.06	0.06
Lorry	CO	0.5	0.4	0.32	0.27	0.22	0.19	0.16	0.15	0.13	0.12	0.11	0.11
	NOx	0.2	0.17	0.16	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.11	0.12
	FCg	0.104	0.083	0.073	0.066	0.062	0.059	0.057	0.055	0.054	0.053	0.052	0.051

Notes : Unit : g/km for HC, CO and NOx, l/km for FC, and m^3N/km for FCg

Table A 11.20 (2) Emission Factor for Year 2020

CNG Vehicles

Vehicle	Item	Average Travel Speed (km/h)											
		10	15	20	25	30	35	40	45	50	55	60	65
Van	HC	0.19	0.16	0.14	0.12	0.11	0.1	0.09	0.08	0.07	0.07	0.06	0.06
	CO	0.5	0.4	0.32	0.27	0.22	0.19	0.16	0.15	0.13	0.12	0.11	0.11
	NOx	0.2	0.17	0.16	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.11	0.12
	FCg	0.104	0.083	0.073	0.066	0.062	0.059	0.057	0.055	0.054	0.053	0.052	0.051
Mini Bus	HC	0.27	0.23	0.2	0.18	0.16	0.14	0.12	0.11	0.1	0.09	0.09	0.08
	CO	1.28	1.02	0.82	0.68	0.57	0.48	0.42	0.37	0.33	0.31	0.28	0.27
	NOx	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	FCg	0.313	0.25	0.219	0.2	0.187	0.178	0.171	0.166	0.162	0.158	0.155	0.153
Medium Bus	HC	2.02	1.74	1.51	1.32	1.17	1.04	0.93	0.84	0.77	0.71	0.66	0.62
	CO	3.13	2.49	2.01	1.66	1.39	1.18	1.03	0.91	0.82	0.75	0.7	0.66
Large Bus	NOx	1.26	1.12	1.02	0.93	0.86	0.81	0.78	0.75	0.74	0.73	0.74	0.76
	FCg	0.834	0.719	0.662	0.628	0.605	0.588	0.576	0.567	0.559	0.553	0.548	0.543
Medium Lorry	HC	0.25	0.22	0.19	0.16	0.15	0.13	0.12	0.11	0.1	0.09	0.08	0.08
	CO	0.73	0.58	0.47	0.39	0.33	0.28	0.24	0.21	0.19	0.18	0.16	0.15
	NOx	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	FCg	0.313	0.25	0.219	0.2	0.187	0.178	0.171	0.166	0.162	0.158	0.155	0.153
Large Lorry	HC	1.68	1.44	1.25	1.1	0.97	0.86	0.78	0.7	0.64	0.59	0.55	0.52
	CO	2.61	2.08	1.68	1.38	1.16	0.99	0.86	0.76	0.68	0.62	0.58	0.55
	NOx	1.26	1.12	1.02	0.93	0.86	0.81	0.78	0.75	0.74	0.73	0.74	0.76
	FCg	0.834	0.719	0.662	0.628	0.605	0.588	0.576	0.567	0.559	0.553	0.548	0.543

Notes : Unit : g/km for HC, CO and NOx and m^3N/km for FCg

11.12 Emission Factor for the Study

The data of traffic volume and speed of SMURT-KL, which were established by the transport planning group of the study team, were processed for pollutants estimation from four types of vehicle.

Emission factors for 4 vehicle types, shown in 4 tables from Table A 11.22 to Table A 11.25, were obtained using emission factors and vehicle fractions in Table A 11.21.

Table A 11.21 Correspondent Table Between Different Vehicle Types And Fractions To Be Generated 4 Vehicle Types' Emission Factor

4 Vehicle Type	10 Vehicle type		Ratio		Emission Factor Vehicle Type
			Morning Peak	All Day Average	
Motorcycle	1	Motorcycle	100.0	100.0	Motorcycle
		Sub Total	100.0	100.0	-
Car	2	Car	85.9	77.5	Motor Car
	3	Taxi	5.5	10.4	Taxi
	4	Small Van	6.7	8.8	Petrol Van
	8	Small Lorry Light 2 Ax.	1.8	3.3	Petrol Small Lorry
		Sub Total	100.0	100.0	-
Public Bus	5	Public Large Bus	64.8	58.6	Medium Bus and Large Bus
	7	Medium Bus	35.2	41.4	Mini Bus
		Sub Total	100.0	100.0	-
Heavy Vehicle	6	Private Large Bus	68.6	43.8	Medium Bus and Large Bus
	9	Large Lorry Van Heavy 2 Ax.	28.6	34.3	Medium Lorry
	10	Lorry Trailer Over 3 Ax.	2.9	21.9	Large Lorry
		Sub Total	100.0	100.0	-

Note : Ratio of Morning Peak is for CPA Study, and All Day Average for Study Area.

Table A 11.22 Emission Factor for Year 1997, Morning Peak for CPA

Vehicle	Item	Average Travel Speed (km/h)											
		10	15	20	25	30	35	40	45	50	55	60	65
Motor cycle	HC	36.91	25.27	19.41	16.1	14.02	12.58	11.46	10.54	9.75	9.07	8.51	8.07
	CO	60.78	41.49	31.84	26.41	23	20.6	18.73	17.17	15.83	14.69	13.76	13.04
	NOx	0.2	0.18	0.17	0.17	0.17	0.17	0.18	0.19	0.2	0.2	0.21	0.21
	FCp	0.067	0.054	0.047	0.043	0.041	0.039	0.037	0.036	0.035	0.035	0.034	0.034
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Car	HC	5.07	3.35	2.51	2.03	1.72	1.49	1.3	1.14	1	0.89	0.8	0.73
	CO	47.98	30.9	22.84	18.36	15.48	13.37	11.66	10.21	8.99	7.99	7.21	6.63
	NOx	1.76	1.82	1.89	1.98	2.06	2.14	2.21	2.28	2.34	2.38	2.43	2.46
	FCp	0.129	0.106	0.094	0.087	0.083	0.079	0.077	0.075	0.073	0.072	0.071	0.07
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Public Bus	HC	7.15	6.15	5.34	4.68	4.13	3.68	3.31	3	2.74	2.52	2.35	2.2
	CO	23.86	18.97	15.35	12.64	10.59	9.03	7.84	6.92	6.22	5.69	5.3	5.02
	NOx	15.51	13.83	12.5	11.45	10.64	10.02	9.57	9.26	9.08	9.04	9.12	9.32
	FCp	0	0	0	0	0	0	0	0	0	0	0	0
	FCd	0.582	0.493	0.449	0.422	0.404	0.392	0.382	0.375	0.369	0.364	0.36	0.356
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Vehicle	HC	6.73	5.79	5.03	4.41	3.89	3.47	3.11	2.82	2.58	2.38	2.21	2.07
	CO	23.25	18.48	14.95	12.31	10.32	8.8	7.64	6.75	6.06	5.55	5.17	4.9
	NOx	16.28	14.51	13.11	12.02	11.16	10.51	10.04	9.71	9.53	9.48	9.56	9.78
	FCp	0	0	0	0	0	0	0	0	0	0	0	0
	FCd	0.599	0.509	0.465	0.438	0.42	0.407	0.398	0.39	0.385	0.38	0.376	0.372
	FCg	0	0	0	0	0	0	0	0	0	0	0	0

Notes : Unit : g/km for HC, CO and NOx, l/km for FCp and FCd, and m^3N/km for FCg

Table A 11.23 Emission Factor for Year 2000, Morning Peak for CPA

Vehicle	Item	Average Travel Speed (km/h)											
		10	15	20	25	30	35	40	45	50	55	60	65
Motor cycle	HC	35.87	24.56	18.86	15.64	13.63	12.22	11.14	10.24	9.47	8.82	8.27	7.84
	CO	59.33	40.5	31.08	25.78	22.45	20.11	18.28	16.76	15.46	14.34	13.43	12.73
	NOx	0.19	0.17	0.16	0.16	0.16	0.16	0.17	0.18	0.19	0.19	0.2	0.2
	FCp	0.067	0.054	0.047	0.043	0.041	0.039	0.037	0.036	0.035	0.035	0.034	0.034
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Car	HC	4.52	3	2.25	1.83	1.55	1.34	1.17	1.02	0.9	0.8	0.72	0.66
	CO	42.21	27.36	20.31	16.37	13.82	11.94	10.41	9.12	8.03	7.13	6.42	5.9
	NOx	1.72	1.76	1.82	1.89	1.96	2.03	2.09	2.15	2.2	2.24	2.28	2.31
	FCp	0.131	0.107	0.095	0.088	0.084	0.08	0.078	0.076	0.074	0.073	0.072	0.071
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Public Bus	HC	6.64	5.71	4.96	4.34	3.84	3.42	3.07	2.78	2.54	2.34	2.18	2.04
	CO	22.05	17.53	14.18	11.68	9.78	8.34	7.24	6.4	5.75	5.26	4.9	4.64
	NOx	14.23	12.69	11.47	10.51	9.76	9.19	8.77	8.49	8.33	8.29	8.36	8.55
	FCp	0	0	0	0	0	0	0	0	0	0	0	0
	FCd	0.582	0.493	0.449	0.422	0.404	0.392	0.382	0.375	0.369	0.364	0.36	0.356
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Vehicle	HC	6.27	5.39	4.68	4.1	3.62	3.23	2.9	2.63	2.4	2.21	2.06	1.93
	CO	21.44	17.04	13.78	11.35	9.51	8.11	7.04	6.22	5.59	5.11	4.76	4.51
	NOx	14.85	13.24	11.96	10.96	10.18	9.59	9.16	8.86	8.7	8.65	8.73	8.92
	FCp	0	0	0	0	0	0	0	0	0	0	0	0
	FCd	0.599	0.509	0.465	0.438	0.42	0.407	0.398	0.39	0.385	0.38	0.376	0.372
	FCg	0	0	0	0	0	0	0	0	0	0	0	0

Notes : Unit : g/km for HC, CO and NOx, l/km for FCp and FCd, and m^3N/km for FCg

Table A 11.24 Emission Factor for Year 1997, All Day Average for Study Area

Vehicle	Item	Average Travel Speed (km/h)											
		10	15	20	25	30	35	40	45	50	55	60	65
Motor	HC	36.91	25.27	19.41	16.1	14.02	12.58	11.46	10.54	9.75	9.07	8.51	8.07
cycle	CO	60.78	41.49	31.84	26.41	23	20.6	18.73	17.17	15.83	14.69	13.76	13.04
	NOx	0.2	0.18	0.17	0.17	0.17	0.17	0.18	0.19	0.2	0.2	0.21	0.21
	FCp	0.067	0.054	0.047	0.043	0.041	0.039	0.037	0.036	0.035	0.035	0.034	0.034
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Car	HC	5.04	3.37	2.55	2.07	1.76	1.52	1.33	1.17	1.03	0.91	0.82	0.75
	CO	48.7	31.72	23.64	19.12	16.18	13.99	12.21	10.7	9.42	8.36	7.53	6.92
	NOx	1.87	1.92	1.98	2.06	2.13	2.21	2.28	2.34	2.4	2.45	2.49	2.53
	FCp	0.131	0.107	0.096	0.089	0.084	0.081	0.078	0.076	0.074	0.073	0.072	0.071
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Public	HC	6.99	6.02	5.23	4.58	4.04	3.6	3.24	2.93	2.68	2.47	2.3	2.15
Bus	CO	22.76	18.09	14.64	12.05	10.1	8.61	7.47	6.6	5.93	5.43	5.06	4.79
	NOx	14.49	12.92	11.68	10.7	9.94	9.36	8.94	8.65	8.49	8.44	8.52	8.71
	FCp	0	0	0	0	0	0	0	0	0	0	0	0
	FCd	0.563	0.476	0.432	0.405	0.388	0.375	0.366	0.359	0.353	0.348	0.344	0.341
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Heavy	HC	6.04	5.2	4.52	3.96	3.49	3.11	2.8	2.53	2.31	2.13	1.98	1.86
Vehicle	CO	20.26	16.1	13.03	10.73	8.99	7.67	6.65	5.88	5.28	4.83	4.5	4.27
	NOx	15.24	13.58	12.28	11.25	10.45	9.84	9.39	9.09	8.92	8.88	8.95	9.15
	FCp	0	0	0	0	0	0	0	0	0	0	0	0
	FCd	0.581	0.492	0.448	0.422	0.404	0.392	0.382	0.375	0.369	0.364	0.36	0.357
	FCg	0	0	0	0	0	0	0	0	0	0	0	0

Notes : Unit : g/km for HC, CO and NOx, l/km for FCp and FCd, and m^3N/km for FCg

Table A 11.25 Emission Factor for Year 2020, All Day Average for Study Area

Vehicle	Item	Average Travel Speed (km/h)											
		10	15	20	25	30	35	40	45	50	55	60	65
Motor cycle	HC	13.47	9.22	7.08	5.87	5.12	4.59	4.18	3.85	3.56	3.31	3.1	2.94
	CO	19.38	13.23	10.15	8.42	7.33	6.57	5.97	5.48	5.05	4.69	4.39	4.16
	NOx	0.08	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09
	FCp	0.047	0.038	0.033	0.03	0.028	0.027	0.026	0.025	0.025	0.024	0.024	0.024
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0	0	0	0	0	0	0	0	0	0	0	0
Car	HC	0.54	0.36	0.27	0.22	0.19	0.16	0.14	0.13	0.11	0.1	0.09	0.08
	CO	10.66	6.79	4.97	3.97	3.33	2.87	2.5	2.19	1.93	1.72	1.55	1.43
	NOx	0.47	0.48	0.5	0.52	0.54	0.56	0.58	0.6	0.61	0.62	0.63	0.65
	FCp	0.071	0.059	0.052	0.048	0.046	0.044	0.042	0.041	0.041	0.04	0.039	0.039
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0.023	0.019	0.016	0.015	0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011
Public Bus	HC	1.29	1.11	0.97	0.85	0.75	0.67	0.6	0.54	0.5	0.46	0.42	0.4
	CO	2.36	1.88	1.52	1.25	1.05	0.89	0.78	0.69	0.62	0.56	0.53	0.5
	NOx	0.76	0.68	0.61	0.56	0.52	0.49	0.47	0.45	0.44	0.44	0.44	0.45
	FCp	0	0	0	0	0	0	0	0	0	0	0	0
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0.618	0.525	0.478	0.45	0.432	0.418	0.409	0.401	0.395	0.389	0.385	0.382
Heavy Vehicle	HC	1.34	1.15	1	0.87	0.77	0.69	0.62	0.56	0.51	0.47	0.44	0.41
	CO	2.19	1.74	1.41	1.16	0.97	0.83	0.72	0.64	0.57	0.52	0.49	0.46
	NOx	0.84	0.75	0.68	0.62	0.57	0.54	0.52	0.5	0.49	0.49	0.49	0.5
	FCp	0	0	0	0	0	0	0	0	0	0	0	0
	FCd	0	0	0	0	0	0	0	0	0	0	0	0
	FCg	0.655	0.558	0.51	0.481	0.461	0.448	0.437	0.429	0.423	0.417	0.413	0.409

Notes : Unit : g/km for HC, CO and NOx, l/km for FCp and FCd, and m^3N/km for FCg

Appendix 12

Table 12.1 Cost Estimates of SMURT-KL MASTER PLAN (continued)

Unit: RM million

1. Arterial Transport Facility Development Projects

Project	Project No.	Investment (RM million)	Land (RM million)	Total (RM million)
I-1 NEW RAIL PROJECTS				
(1) New LRT Development (Damansara-Cheras)	RT-1	5,174.0	52.5	5,226.5
Subtotal-NEW RAIL PROJECTS		5,174.0	52.5	5,226.5
I-2 TRUNK BUS SYSTEM				
(1) Trunk Bus System	BS-1			
- Damansara		1.8	21.7	23.5
- Genting Klang		4.9	100.7	105.6
- Cheras		4.0	158.2	162.2
- Ampang		4.4	7.5	11.9
- Kepong		4.2	45.9	50.0
- Puchong		6.1	124.6	130.8
(2) Bus Priority Lane Reversible Lane	BS-2	19.6	0.0	19.6
Exclusive Bus Lane				
Subtotal-TRUNK BUS SYSTEM		45.0	458.5	503.5
I-3 HIGHWAY PROJECTS				
1) CURRENT PLAN (COMMITED)				
(1) New Pantai Highway	HW-1	834.6	362.0	1,196.6
Subang Jaya - Jalan Templer				
Jalan Templer - Jalan.Bangsar				
(2) KLIA Dedicated Highway	HW-2			
Sectio Pandan Roundabout - Technology Park		2,366.0	373.0	2,739.0
Sectio Technology Park - KLIA		(1,274.0)		
(3) Kajang Traffic Dispersal Ring Road (Balakong-SG.Long-Semenyih-UPM Junction)	HW-3	1,300.0	65.0	1,365.0
(4) Western KL Traffic Dispersal Scheme	HW-4	793.0	416.0	1,209.0
(5) Pandan Corridor Extension	HW-5	165.1	187.0	352.1
(6) KL Elevated Inner Ring Road	HW-6	591.5	1,582.0	2,173.5
Sectio SG.Besi - KLCC				
Sectio Jln. Duta - KLCC				
Project	**Project No.**	**Investment (RM million)**	**Land (RM million)**	**Total (RM million)**
(7) KL Transit Route	HW-7	893.1	100.0	993.1
Packa upgrading Jln. Kuching				
Packa upgrading Jln. Duta				
Packa Damansara Transit Route				
(8) Kuala Lumpur-Rawang Expressway	HW-8	507.0	42.0	549.0
(9) Wangsa-Keramat Expressway	HW-9	507.0	37.0	544.0
Kg.Relawan - Wangsa maju				
Kg. Dato Kermat - Kg. Pandan				
(10) Kajang-Serembang Expressway	HW-10	(325.0)		
Kajang - Serembang				
(11) Kajang Bypass	HW-11	(6.5)		
(12) Shah Alam-Rawang Expressway	HW-12	(570.7)		
Sg.Damansara - Tmn. Subang I/C				
Tmn. Subang I/C - Paya Jaras I/C				
Paya Jaras I/C - Kuang System I/C				
(14) KL Outer Ring Road	HW-13	(6,045.0)		
Subtotal-Current Plan of Highway Projects		7,957.3	3,164.0	11,121.3

Table 12.1 Cost Estimates of SMURT-KL MASTER PLAN (continued)

2) NEWLY PROPOSED						
(1) Under Ground Expressway				HW-14	2,027.4	122.3	2,149.7
(2) Arterial Road 1 (KL Elevated HWY-Wangsa Keramat)				HW-15	297.1	300.6	597.7
(3) Arterial Road 2 (KL Elevated-New Pantai)				HW-16	389.5	67.9	457.4
(4) Local Road 1	Jalan Genting Kelang	-	Jalan Damansara	HW-17	104.5	120.1	224.6
(5) Local Road 2	Jalan Yap Kwan	-	Jalan Datuk Abu Malik	HW-18	4.0	6.0	10.0
(6) Local Road 3	Jalan Conlay	-	Jalan Raya Chulan	HW-19	1.7	6.4	8.2
(7) Local Road 4	S.G. Besi	-	Jalan Teuterarn	HW-20	5.4	15.1	20.5
(8) Local Road 5	Jalan Pantai	-	Jaln Gasing	HW-21	7.8	18.2	26.0
(9) Local Road 6	KL - Seremban	-	Jalan Syed	HW-22	5.4	16.4	21.8
(10) Local Road 7	Jaln Ipoh	-	Jalan Sentul	HW-23	5.1	23.8	28.9
(11) Local Road 8	Fontage of North-East Expressway			HW-24	8.4	29.4	37.8
(12) Local Road 9	Jalan Cheras	-	Jalan 3/29 1A	HW-25	3.0	12.6	15.6
(13) Connecting Link 1 (to Petaling Jaya)				HW-26	10.1	15.7	25.9
(14) Connecting Link 2 (Shah Alam Expressway-Federal Highway)				HW-27	5.5	8.8	14.3
Subtotal-Newly Proposed					2,874.9	763.3	3,638.3
Subtotal-HIGHWAY PROJECTS					10,832.2	3,927.3	14,759.6
Total-MAJOR TRANSPORT FACILITY DEVELOPMENT PROJECTS					16,051.2	4,438.4	20,489.6

2. Public Transport-Enhancing Projects

Project	Project No.	Investment (RM million)	Land (RM million)	Total (RM million)
1) Inter-modal Facility				
(1) Transferring System	PT-1			
Sultan Ismail, P. Ramlee and Wawasan Stations		2.8	0.0	2.8
Bank Negara and Bandaruya		1.0	0.0	1.0
(2) Rail Station Plaza and Park and Ride Facility	RT-2			
- Ampang Station		0.6	0.2	0.8
- Masjit Jamek Station		0.2	0.1	0.3
- 6 Stations (Gombak-Dato Keramat / LRT 2)		2.3	0.8	3.2
- 5 stations (Setia Jaya-Petaling / KTMB)		2.0	0.7	2.7
- 5 Stations (Kg. Pasir-Lambah Pantai / PRT)		2.0	0.7	2.7
- 2 Stations (Rawang Line / KTMB)		0.9	0.3	1.2
- 2 Stations (Batu Cave Line /KTMB)		0.9	0.3	1.2
(3) Fare System Planning				
2) Improvement of Access Road to Railway Stations				
(1) Access to Railway Station	RT-3			
- Ampang (LRT 1/Ampang Line)		1.0	0.6	1.6
- Campaka (LRT 1/Ampang Line)		0.3	5.6	5.9
- Pandan Indah (LRT 1/Ampang Line)		0.1	2.2	2.3
- Pandan Jaya (LRT 1/Ampang Line)		0.8	3.4	4.1
3) Relocation of Inter-state Bus Terminal	RT-4			
- Klang Bus Terminal		1.4	4.5	5.9
- Bydraya Bus Terminal		4.5	15.0	19.5
4) New Railway Station (KTMB)	RT-5	3.0		3.0
Cuepacs				
Total-PUBLIC TRANSPORT-ENHENSING PROJECTS		23.5	34.4	58.0

Table 12.1 Cost Estimates of SMURT-KL MASTER PLAN

3. Trafic Control/Management in CPA

Project	Project No.	Investment (RM million)	Land (RM million)	Total (RM million)
3-1 TRAFIC CONTROL/MANAGEMENT				
1) Traffic Signal Control System	CP-1			
- Traffic Signal Light Coordination System & Signal Phase System		1.0	0.0	1.0
2) Improvement of No-signalised Roundabout & Others	CP-2			
- Improvement of Roundabout (Pudu)		0.6	6.0	6.6
- Traffic Signalized Intersection		0.2	0.0	0.2
Jalan Pajang - Jalan Tun Razak				
Jalan Pudu - Jalan Yew				
Jalan Syed Putra				
Jalan Stan Hisyamuddin - Jalan Kinabalu				
Jalan Pudu - Jalan Tun Perak				
- Channelaization System		0.1	0.0	0.1
3) Improvement of Pedestrian Facilities.	CP-4			
- Signalized Pedestrian Crossing		12.9	0.0	12.9
- Pedestrian Crossing Bridge		17.0	0.0	17.0
- Scramble Pedestrian Crossing		0.0	0.0	0.0
- Pedestrian-friendly Sidewalk		8.9	4.7	13.5
Jalan Raya Abudullah				
Jalan Ampang				
Jalan Sultan Ismail				
Jalan Ramlee				
Jalan Raja Chulan				
Subtotal-Trafic Control/Management		40.6	10.7	51.3
3-2 AREA PRICING				
1) Area pricing	CP-5	5.1	0.0	5.1
Total-TRAFFIC CONTROL/MANAGEMENT IN CPA		45.7	10.7	56.4

4. Transport Information System & others

Project	Project No.	Investment (RM million)	Land (RM million)	Total (RM million)
4-1 TRANSPORT INFORMATION SYSTEM				
1) Bus Location System	IS-1	23.1	0.0	23.1
2) Modernization and Improvement Current System (First Stage)	IS-2	10.0	0.0	10.0
- Parking Guidance System				
3) Navigation and Route Guidance System (Second Stage)	IS-3	20.0	0.0	20.0
4) Automated Driving System (Third Stage) & Others	IS-4			
Subtotal-Trafic Information System		53.1	0.0	53.1
4-2 PROJECT FOR FREIGHT MOVEMENT				
1) Truck Terminal	ZZ-3	99.6	60.0	159.6
Total-TRANSPORT INFORMATION SYSTEM & OTHERS		152.8	60.0	212.8

GRAND TOTAL	16,273.2	4,543.5	20,816.7

Appendix 12.2: Economic Evaluation

1. Vehicle Operation Cost

(1) Vehicle Type and Characteristics

The vehicle costs and its characteristics are prepared in Table 12.2.1. The unit cost of the representative vehicles of five types is calculated based on the models in the Table.

Table 12.2.1 Type of Vehicles and Characteristics

	Passenger Car 1)	Passenger Car 2)	Van 1)	Van 2)	Small Lorry	Heavy Lorry	Bus 1)	Bus 2)	Motorcycle
Fuel Tupe	Gasoline		Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Gasoline
Government Approved STD	36,354	31,266	31,197	32,965	30,865	87,960	230,000	475,000	4,234
Additional Accesaries	6,758	1,766	3,700	2,330	8,705	21,000	40,900	40,900	400
Excise Duty	6,028	4,751	8,487				12,900	17,000	
Sales Tax	3,389	2,859	3,678	3,024	2,891	8,314		20,500	
Road Tax per Year	214	130	489	1,366	1,002	4,752			65
Registration Fee/Permitt Fee	150	150	500	180	255	160			5
Number Plate	85	85	80	25	150	160			20
HP Ownership Claim /Inspection Fee	50	50	350	335	400	625			15
Insurance per year	1,580	1,371	1,577	1,653	1,696	5,800			259
On the Road Price	54,607	42,478	50,057	41,878	45,964	128,771	283,800	553,400	4,997
including Tyre Cost of	440	440	540	540	1,150	3,920	8,760	8,760	72
Net Vehicle Price	42,722	32,642	34,707	35,090	38,820	105,665	262,140	507,140	4,577
Transfer Item	9,866	8,025	13,234	4,595	4,298	13,386	12,900	37,500	90
Costs included in Vehicle Operation Cost	2,020	1,811	2,117	2,193	2,846	9,720	8,760	8,760	331
Total Financial Cost	54,607	42,478	50,057	41,878	45,964	128,771	283,800	553,400	4,997
Financial Vehicle Price	52,587	40,667	47,940	39,685	43,118	119,051	275,040	544,640	4,667
Economic Vehicle price	42,722	32,642	34,707	35,090	38,820	105,665	262,140	507,140	4,577
Annual Mileage (km/yr)	20,000	20,000	34,000	34,000	50,000	70,000	70,000	70,000	10,000
Annual Usage Hour (hr/yr)	500	500	850	850	1,430	2,000	2,000	2,000	500
Annual Average-round Seed	40	40	40	40	35	35	35	35	20
Life Period	10	10	10	10	10	10	10	10	7
Parts Cost Ratio to Vehicle Price	3.0%	3.0%	5.0%	5.0%	7.0%	10.0%	3.0%	3.0%	3.0%

Passenger Car 1)	Proton WIRA 1.5GL (M)
Passenger Car 2)	Proton WIRA 1.3GL (M)
Van 1)	Ford Econovan (ST95 FM1-1789CC)
Van 2)	Toyota Dyna Hiace C/CAB(D)/LY100R-TBMBS3(2446cc)
Small Lorry	Mitsubishi Canter Guts/FB11B8RDG1 (Load Capacity: 2.5 ton)
Heavy Lorry	Mitsubishi FM617/MHRG1 (EURO 1)
Bus 1)	OPTARE (44 passengers)
Bus 2)	Average of IVECO and MAN (69 and 66 passengers)
Motorcycle	AN 110F

Source: Malaysian Industrial Development Authority
INTRAKOTA Komsosit SDN. BHD.
Motor Sale companies in Kuala Lumpur

(2) Unit Running Cost of Vehicle per Vehicle-km

1) Lubricant Cost

a. Fuel and Lubricant Price

Table 12.2.2 Fuel and Lubricant Prices

Unit: RM per liter

	Premium	Diesel	Gasoline Engine Oil	Diesel Engine Oil		
Sales Price (RM/ltr)	1.10	0.65	6.40	3.86	-	5.65
Duty & Sales Tax	0.48	0.17	0.32	0.19	-	0.28
Economic cost	0.62	0.48	6.08	3.67	-	5.37
Coversion Factor	0.56	0.74	0.95	0.95	-	0.95

b. Lubricant Cost per Vehicle-km

Table 12.2.3 Lubricant Cost per Vehicle-km

	Passenger Car/Van	Small Lorry	Heavy Lorry	Bus	Motor-cycle
Lubricant Cost (RM/ltr)	6.07	4.76	4.76	4.76	6.40
Economic Cost (RM/ltr)	5.77	4.52	4.52	4.52	6.08
Running Km/ltr	700	180	170	170	3,000
Financil Unit Cost/km	0.009	0.026	0.028	0.028	0.002
Economic Unit Cost/km	0.008	0.025	0.027	0.027	0.002

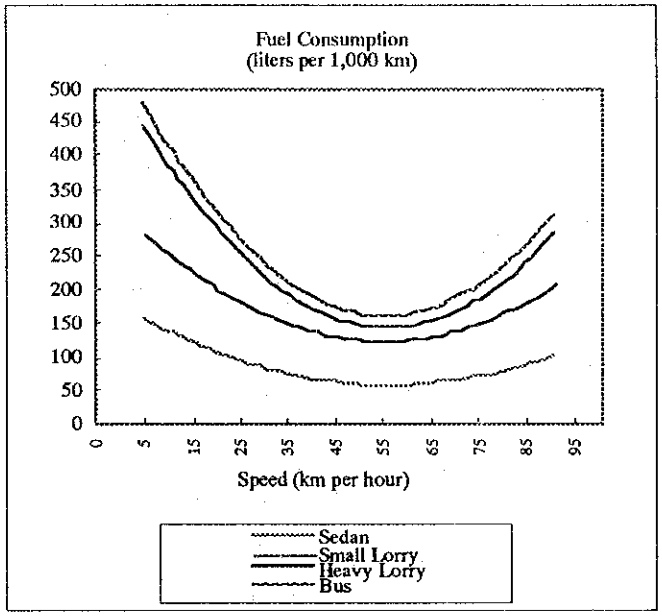
2) Tyre Cost per Vehicle-km

Table 12.2.4 Tyre Cost per Vehicle-km

	Passenger Car/Van	Small Lorry	Heavy Lorry	Bus	Motorcycle
Size	155RS13	900x20x14PR	1000x20x14PR	900x20x14PR	
Sales Price per Set of Tyre (RM)	440	1,150	3,920	8,760	72
Duty Excise & Sales Tax	40.0	104.5	356.4	796.4	6.5
Net price	400.0	1,045.5	3,563.6	7,963.6	65.5
Tyre Life (KM)	50,000	30,000	30,000	60,000	30,000
Financial Unit Tyre Cost/km	0.009	0.038	0.131	0.146	0.002
Economic Unit Tyre Cost/km	0.008	0.035	0.119	0.133	0.002

3) Fuel Cost per Vehicle-km

As the fuel consumption varies with vehicle speed and running distance, the fuel cost per vehicle-km is estimated based on the fuel consumption formula and fuel price.



Note: Formula of Fuel Consumption:

Passenger Car	Y = 0.03719 S*S	-	4.19966 S	+	175.9911
Bus	Y = 0.12292 S*S	-	13.68742 S	+	541.0279
Small Lorry	Y = 0.06427 S*S	-	7.06130 S	+	318.3326
Heavy Lorry	Y = 0.11462 S*S	-	12.85594 S	+	503.7179

Where: Y = Fuel consumption (liter/1,000 km)
S = Vehicle running speed (km per hour)

Figure 12.2.1 Fuel Consumption Curve by Vehicle Speed

4) Maintenance Cost

Maintenance cost consists of the part costs and the maintenance labour costs as shown in Table 12.2.5.

Table 12.2.5 Maintenance Cost per Vehicle-km

	Passenger Car/Van	Small Lorry	Heavy Lorry	Bus	Motorcycle
(1) Parts Cost					
Annual Parts Cost Ratio to Vehicle Price	3.0%	7.0%	10.0%	3.0%	3.0%
Annual Average Mileage (km/year)	20,000	50,000	70,000	70,000	10,000
Unit Financial Part Cost	0.070	0.060	0.170	0.206	0.014
Unit Economic Part Cost	0.056	0.054	0.151	0.192	0.014
(2) Maintenance Labour Cost					
Labour Cost (RM per Month)	1,765.0	1,765.0	1,765.0	1,765.0	1,765.0
Financial Unit Labour Cost (RM/hr)	10.09	10.09	10.09	10.09	10.09
Convesion Factor of Labour Cost	1.00	1.00	1.00	1.00	1.00
Labour Hours/1,000km	1.00	10.00	24.50	30.00	1.00
Unit Financial Labour Cost/km	0.010	0.101	0.247	0.303	0.010
Unit Economic Labour Cost/km	0.010	0.101	0.247	0.303	0.010
(3) Unit Financial Maintenance Cost/km	0.080	0.161	0.417	0.508	0.024
Unit Economic Maintenance Cost/km	0.066	0.155	0.398	0.494	0.024

Source: Annual part cost ratio refers to KLORR, JICA in 1996
Labour cost is estimated based on "Occupational Wage Survey in the Manufacturing Sector in 1995 and multiplied by the growth rate reported of private sector wage agreement Ministry of Human Resources in 1998.

5) Depreciation

As the vehicle costs vary with running distance and time, the depreciation of vehicle is divided into vehicle operation cost and fixed cost as shown in Table 12.2.9. The salvage value and the share between time and distance related is referred to the recent relevant study in Kuala Lumpur.

Table 12.2.6 Depreciation of Vehicle

	Passenger Car/Van	Small Lorry	Heavy Lorry	Bus	Motorcycle
Financial Price of Vehicle (RM)	46,890	43,118	119,051	479,960	4,667
Economic Price of Vehicle(RM)	37,087	38,820	105,665	447,380	4,577
Life Period (years)	10	10	10	10	7
Salvage Value	20%	15%	15%	15%	20%
Distant Related Portion	50%	70%	70%	70%	50%
Time related portion	50%	30%	30%	30%	50%
Runinning Distannces (km)	200,000	500,000	700,000	700,000	70,000
Runinning Hours (hrs)	5,000	14,300	20,000	20,000	3,500
Financial Depreciation Cost /Distant Portion (RM/km)	0.094	0.051	0.101	0.408	0.027
Economic Depreciation Cost /Distant Portion (RM/km)	0.074	0.046	0.090	0.380	0.026
Financial Depreciation Cost /Time Portion (RM/hr)	3.751	0.769	1.518	6.119	0.533
Economic Depreciation Cost /Time portion (RM/hr)	2.967	0.692	1.347	5.704	0.523

Source: Salvage value and demarcation of distant and time portion refer to KLORR, JICA in 1996

6) Unit Running Cost of Vehicle per Vehicle-km

Table 12.2.7 shows the unit running cost of five types of vehicles in the speed of 55 km per hour as an example.

Table 12.2.7 Unit Running Cost per Vehicle-km (Speed: 55 Km per Hour)

RM/Vehicle-km

	Passenger Car	Small Lorry	Heavy Lorry	Bus	Motorcycle
Financial Cost					
Fuel Cost	0.056	0.081	0.093	0.104	0.015
Lubricant Cost	0.009	0.026	0.028	0.028	0.002
Tyre Cost	0.009	0.038	0.131	0.146	0.002
Maintenance Cost	0.080	0.161	0.417	0.508	0.024
Depreciation	0.094	0.051	0.101	0.408	0.027
Total	0.248	0.358	0.770	1.194	0.071
Economic Cost					
Fuel Cost	0.033	0.060	0.069	0.077	0.009
Lubricant Cost	0.008	0.025	0.027	0.027	0.002
Tyre Cost	0.008	0.035	0.119	0.133	0.002
Maintenance Cost	0.066	0.155	0.398	0.494	0.024
Depreciation	0.074	0.046	0.090	0.380	0.026
Total	0.189	0.321	0.702	1.111	0.063

Source: JICA Study Team

(3) Fixed Operation Cost of Vehicle

1) Depreciation

Refer to Table 12.2.6.

2) Interest Cost

The interest cost is estimated to be 10 % of the residual value of vehicle cost in the individual year during the vehicle life period.

3) Crew Cost

Crew cost is calculated based on the number of crew per vehicle as shown in Table 12.2.8.

Table 12.2.8 Crew Cost per Hour

	Passenger Car	Small Lorry	Heavy Lorry	Bus
Crew Wage (RM/month)		1,300	1,300	1,300
Crew Wage (RM/hr)		7.43	7.43	7.43
Number of Crew		1.7	2	1
Economic Crew Cost/hr (RM/hr)		12.629	14.857	7.429
Financial Crew Cost/hr (RM/hr)		12.629	14.857	7.429

Source: Occupational Survey in the Manufacturing Sector, 1995
Private Sector Wage Agreement, Ministry of Human Resources

2. Traffic Accidents

Table 12.2.9 Traffic Casualties by Transport Mode in Japan

	Total Passenger-km (million)	Casualty		Rate per million passenger-km	
		Death	Injured	Death	Injured
Rail	1,655,500	88	176	0.000053	0.000106
Bus	424,500	343	25,352	0.000808	0.059722
Passenger Car	2,333,800	27,300	1,999,325	0.011698	0.856682

Source: Rail 6 years 1982-1987
Road 6 years 1983-1988

Table 12.3.1: Cost-Benefit Analysis

(SMURT-KL Master Plan)

Unit: RM million

	Total 1999-2040	NPV 1999-2040	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. Economic Cost (Incremental Cost)																								
1) Arterial Transport Facility Development																								
(1) New Rail Projects	5,362	565	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	802	1,202	1,202	1,034
(2) Trunk Bus System	46	331	108	108	29	29	29	29	29	29	29	29	29	29	0	0	0	0	0	0	0	0	0	-180
(3) Highway Projects	8,824	6,030	4	4	1,067	1,073	1,079	1,085	1,091	1,097	1,103	1,109	1,115	1,121	325	327	330	332	335	337	339	342	344	346
2) Public Transport-Enhancing Projects	17	22	0	0	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	2	2	2
3) Traffic Control / Management in CPA	26	9	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
4) Transport Information System & Others	37	22	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10
Total Cost	14,313	6,978	124	125	1,100	1,106	1,112	1,118	1,124	1,130	1,136	1,142	1,148	1,154	328	330	333	335	337	340	1,144	1,547	1,561	1,215
2. Benefit (Cost Saving)																								
1) Vehicle Operation Cost Saving																								
(1) Running Cost Saving	231	152		44	54	60	64	64	61	53	41	23	-1	-30	-37	-45	-52	-59	-66	-74	-81	-87	-94	-95
(2) Fixed Cost Saving	70,930	4,043		-16	24	67	114	164	218	277	339	407	480	558	622	692	767	600	819	907	1,002	1,104	1,214	1,371
Subtotal	71,161	4,196		28	77	127	178	228	279	330	380	430	479	527	585	648	715	540	753	834	921	1,017	1,120	1,276
2) Passenger Traveling Cost Saving	283,677	10,644		-25	27	85	149	218	295	378	470	570	679	798	955	1,130	1,326	1,545	1,788	2,059	2,360	2,694	3,064	3,807
3) Accident Reduction 100%	4,889	1,117		0	27	53	78	102	126	149	173	196	219	242	259	277	296	316	337	359	382	407	433	461
Total Benefit 1)+2)+3)	359,726	15,957		2	131	265	404	549	700	858	1,023	1,196	1,377	1,567	1,799	2,055	2,337	2,401	2,878	3,251	3,663	4,117	4,617	5,544
1)+2)	354,837	14,840																						
3. Evaluation Index																								
Net Benefit	340,525	7,862	-124	-122	-996	-894	-786	-671	-550	-422	-286	-142	10	172	1,212	1,448	1,709	1,750	2,204	2,553	2,137	2,163	2,622	3,867
Net Benefit (including accident reduction)	345,413	8,979	-124	-122	-969	-841	-708	-569	-424	-273	-113	54	229	413	1,471	1,724	2,005	2,066	2,540	2,911	2,520	2,570	3,056	4,328
1) Net Present Value 7,862																								
Net Present Value including benefit of accident reduction 8,979																								
Discount Rate= 12%																								
2) B/C Ratio (r=12%) 2.13																								
B/C Ratio (r=12%) including benefit of accident reduction 2.29																								
3) Internal Rate of Return 18.8%																								
IRR including benefit of accident reduction 20.4%																								

Table 12.3.1: Cost-Benefit Analysis

(SMURT-KL Master Plan)

Unit: RM million

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1. Economic Cost (Incremental Cost)																				
1) Arterial Transport Facility Development																				
(1) New Rail Projects	174	176	177	178	180	181	182	184	185	187	188	190	191	193	194	196	198	199	201	-2,431
(2) Trunk Bus System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-288
(3) Highway Projects	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	-7,058
2) Public Transport-Enhancing Projects	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-42
3) Traffic Control / Management in CPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	-4
4) Transport Information System & Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	-19
Total Cost	258	260	261	262	264	265	266	268	269	271	272	274	275	277	278	280	282	283	297	-9,840
2. Benefit (Cost Saving)																				
1) Vehicle Operation Cost Saving																				
(1) Running Cost Saving	-90	-84	-77	-69	-61	-52	-41	-30	-18	-4	11	27	44	63	84	106	129	155	182	211
(2) Fixed Cost Saving	1,525	1,629	1,739	1,855	1,977	2,105	2,240	2,383	2,533	2,690	2,856	3,031	3,215	3,408	3,611	3,824	4,048	4,284	4,532	5,716
Subtotal	1,435	1,546	1,662	1,785	1,916	2,053	2,199	2,353	2,515	2,686	2,867	3,058	3,259	3,471	3,694	3,930	4,178	4,439	4,714	5,928
2) Passenger Traveling Cost Saving	4,239	4,715	5,238	5,812	6,444	7,137	7,899	8,735	9,652	10,659	11,764	12,975	14,303	15,760	17,356	19,105	21,022	23,123	25,424	27,944
3) Accident Reduction 100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Benefit 1)+2)+3)	5,675	6,260	6,900	7,598	8,359	9,191	10,098	11,087	12,167	13,345	14,631	16,033	17,562	19,231	21,050	23,035	25,200	27,562	30,138	33,872
1)+2)																				
3. Evaluation Index																				
Net Benefit	5,416	6,001	6,639	7,335	8,096	8,926	9,831	10,820	11,898	13,075	14,359	15,759	17,287	18,954	20,772	22,755	24,919	27,279	29,841	43,712
Net Benefit (including accident reductio	5,416	6,001	6,639	7,335	8,096	8,926	9,831	10,820	11,898	13,075	14,359	15,759	17,287	18,954	20,772	22,755	24,919	27,279	29,841	43,712
1) Net Present Value 7,862																				
Net Present Value including benefit of a	c	c																		
8,979																				
Discount Rate= 12%																				
2) B/C Ratio (r=12%) 2.13																				
B/C Ratio (r=12%) including benefit of a	c																			
2.29																				
3) Internal Rate of Return 18.8%																				
IRR including benefit of accident reductio																				
20.4%																				

Table12.3.2: Cost-Benefit Analysis
(Trunk Bus Case)

Unit: RM million

	Total 1999-2040	NPV 1999-2040	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. Economic Cost (Incremental Cost)																								
1) Arterial Transport Facility Development																								
(1) New Rail Projects	0	0																						
(2) Trunk Bus System	46	346	108	108	29	29	29	29	29	29	29	29	29	29	0	0	0	0	0	0	0	0	0	0
(3) Highway Projects	0	0																						
2) Public Transport-Enhancing Projects	17	22	0	0	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	2	2	2
3) Traffic Control / Management in CPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4) Transport Information System & Others	37	22	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10
Total Cost	101	390	118	118	33	33	33	33	33	33	33	33	33	33	2	2	2	2	2	2	2	2	12	12
2. Benefit (Cost Saving)																								
1) Vehicle Operation Cost Saving																								
(1) Running Cost Saving	-2,349	120		46	44	43	41	39	37	36	34	32	30	28	18	8	-2	-13	-24	-36	-48	-61	-75	-89
(2) Fixed Cost Saving	7,388	-30		-33	-31	-29	-27	-26	-24	-22	-19	-17	-15	-13	-5	4	13	-92	-61	-53	-44	-34	-22	-10
Subtotal	5,039	90		13	13	13	13	14	14	14	14	15	15	15	14	12	11	-105	-85	-89	-92	-95	-97	-98
2) Passenger Traveling Cost Saving	27,217	1,576		-2	13	29	47	67	88	112	138	166	196	230	248	268	289	311	336	362	391	421	454	489
3) Accident Reduction																								
Total Benefit	32,256	1,666		11	26	43	61	81	102	126	152	180	211	245	261	280	300	207	251	273	298	326	357	391
3. Evaluation Index																								
Net Benefit	32,156	1,276	-118	-107	-6	10	28	48	70	93	119	148	179	212	259	277	298	204	249	271	296	324	345	379
1) Net Present Value 1,276																								
Discount Rate= 12%																								
2) B/C Ratio (r=12%) 4.28																								
3) Internal Rate of Return 27.5%																								

Table12.3.2: Cost-Benefit Analysis
(Trunk Bus Case)

Unit: RM million

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1. Economic Cost (Incremental Cost)																				
1) Arterial Transport Facility Development																				
(1) New Rail Projects																				
(2) Trunk Bus System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-468
(3) Highway Projects																				
2) Public Transport-Enhancing Projects	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-42
3) Traffic Control / Management in CPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4) Transport Information System & Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	-19
Total Cost	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10	-528
2. Benefit (Cost Saving)																				
1) Vehicle Operation Cost Saving																				
(1) Running Cost Saving	-93	-97	-101	-105	-109	-113	-116	-119	-122	-125	-128	-130	-132	-133	-135	-136	-136	-136	-136	-135
(2) Fixed Cost Saving	66	83	103	123	145	169	195	223	253	286	321	358	399	442	488	538	592	649	710	1,801
Subtotal	-27	-14	1	18	36	57	79	104	131	161	193	228	267	308	354	403	456	513	575	1,666
2) Passenger Traveling Cost Saving	524	562	602	646	692	743	797	856	919	987	1,062	1,142	1,229	1,324	1,428	1,540	1,663	1,798	1,945	2,105
3) Accident Reduction																				
Total Benefit	497	548	603	663	729	799	876	959	1,050	1,148	1,255	1,370	1,496	1,633	1,781	1,943	2,119	2,311	2,519	3,772
3. Evaluation Index																				
Net Benefit	496	547	603	663	728	799	876	959	1,049	1,147	1,254	1,370	1,496	1,632	1,781	1,943	2,118	2,310	2,509	4,300
1) Net Present Value **1,276**																				
Discount Rate= 12%																				
2) B/C Ratio (r=12%) **4.28**																				
3) Internal Rate of Return **27.5%**																				

Table 12.3.3: Cost-Benefit Analysis
(Highway Intensive Case)

Unit: RM million

	Total 1999-2040	NPV 1999-2040	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. Economic Cost (Incremental Cost)																								
1) Arterial Transport Facility Development																								
(1) New Rail Projects	0	0																						
(2) Trunk Bus System	0	0																						
(3) Highway Projects	8,824	6,030	4	4	1,067	1,073	1,079	1,085	1,091	1,097	1,103	1,109	1,115	1,121	325	327	330	332	335	337	339	342	344	346
2) Public Transport-Enhancing Projects	17	22	0	0	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	2	2	2
3) Traffic Control / Management in CPA	0	0																						
4) Transport Information System & Others	0	0																						
Total Cost	8,842	6,051	4	4	1,071	1,077	1,083	1,089	1,095	1,101	1,107	1,112	1,118	1,124	327	329	332	334	337	339	341	344	346	348
2. Benefit (Cost Saving)																								
1) Vehicle Operation Cost Saving																								
(1) Running Cost Saving	-11,464	-555		-2	9	17	22	22	19	10	-3	-22	-47	-79	-98	-118	-139	-160	-181	-203	-226	-249	-272	-295
(2) Fixed Cost Saving	61,023	3,514		-6	28	66	107	151	198	249	304	364	428	497	551	610	673	463	699	773	853	939	1,033	1,134
Subtotal	49,559	2,959		-8	38	83	128	173	217	260	302	342	381	418	453	492	535	303	518	570	627	691	761	839
2) Passenger Traveling Cost Saving	258,548	10,469		-32	33	104	183	269	364	469	584	709	847	997	1,139	1,297	1,473	1,668	1,886	2,128	2,398	2,696	3,028	3,396
3) Accident Reduction																								
Total Benefit	308,108	13,428		-40	71	187	311	442	581	729	885	1,052	1,228	1,415	1,592	1,788	2,007	1,971	2,404	2,698	3,025	3,387	3,789	4,235
3. Evaluation Index																								
Net Benefit	299,266	7,376	-4	-44	-1,000	-890	-772	-647	-514	-372	-221	-61	109	291	1,265	1,459	1,676	1,637	2,068	2,359	2,683	3,044	3,443	3,886
1) Net Present Value 7,376																								
Discount Rate= 12%																								
2) B/C Ratio (r=12%) 2.22																								
3) Internal Rate of Return 19.3%																								

Table 12.3.3: Cost-Benefit Analysis
(Highway Intensive Case)

Unit: RM million

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1. Economic Cost (Incremental Cost)																				
1) Arterial Transport Facility Development																				
(1) New Rail Projects																				
(2) Trunk Bus System																				
(3) Highway Projects	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	-7,058
2) Public Transport-Enhancing Projects	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-42
3) Traffic Control / Management in CPA																				
4) Transport Information System & Others																				
Total Cost	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	-7,099
2. Benefit (Cost Saving)																				
1) Vehicle Operation Cost Saving																				
(1) Running Cost Saving	-310	-325	-340	-356	-372	-388	-405	-422	-439	-457	-476	-494	-514	-533	-553	-574	-595	-617	-639	-661
(2) Fixed Cost Saving	1,290	1,377	1,469	1,566	1,669	1,777	1,892	2,013	2,141	2,276	2,419	2,570	2,729	2,897	3,075	3,263	3,461	3,670	3,891	5,464
Subtotal	980	1,052	1,129	1,210	1,297	1,389	1,487	1,591	1,701	1,819	1,943	2,075	2,215	2,364	2,522	2,689	2,866	3,053	3,252	4,803
2) Passenger Traveling Cost Saving	3,782	4,207	4,675	5,190	5,756	6,379	7,063	7,815	8,642	9,549	10,546	11,640	12,841	14,158	15,603	17,187	18,925	20,830	22,918	25,206
3) Accident Reduction																				
Total Benefit	4,762	5,259	5,804	6,400	7,053	7,768	8,550	9,406	10,343	11,368	12,489	13,715	15,056	16,522	18,124	19,876	21,791	23,883	26,170	30,009
3. Evaluation Index																				
Net Benefit	4,679	5,176	5,721	6,317	6,970	7,684	8,467	9,323	10,260	11,285	12,406	13,632	14,973	16,439	18,041	19,793	21,708	23,800	26,087	37,108
1) Net Present Value **7,376**																				
Discount Rate= 12%																				
2) B/C Ratio (r=12%) **2.22**																				
3) Internal Rate of Return **19.3%**																				

Table 12.3.4: Cost-Benefit Analysis
(Base Case)

Unit: RM million

	Total 1999-2040	NPV 1999-2040	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. Economic Cost (Incremental Cost)																								
1) Arterial Transport Facility Development																								
(1) New Rail Projects	0	0																						
(2) Trunk Bus System	46	346	108	108	29	29	29	29	29	29	29	29	29	29	0	0	0	0	0	0	0	0	0	0
(3) Highway Projects	8,824	6,030	4	4	1,067	1,073	1,079	1,085	1,091	1,097	1,103	1,109	1,115	1,121	325	327	330	332	335	337	339	342	344	346
2) Public Transport-Enhancing Projects	17	22	0	0	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	2	2	2
3) Traffic Control / Management in CPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4) Transport Information System & Others	37	22	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10
Total Cost	8,925	6,419	122	122	1,100	1,106	1,112	1,118	1,124	1,130	1,136	1,142	1,147	1,153	328	330	332	335	337	339	342	344	356	359
2. Benefit (Cost Saving)																								
1) Vehicle Operation Cost Saving																								
(1) Running Cost Saving	-7,647	-299		32	39	43	44	41	34	23	7	-15	-42	-76	-91	-105	-120	-135	-151	-166	-182	-198	-213	-229
(2) Fixed Cost Saving	62,971	3,463		-32	3	41	82	127	175	227	282	343	408	478	534	595	661	657	710	788	873	964	1,064	1,171
Subtotal	55,325	3,164		-0	42	84	126	168	209	250	289	328	366	401	443	490	541	521	559	622	691	767	850	942
2) Passenger Traveling Cost Saving	207,700	9,685		-0	69	145	229	322	423	535	657	790	936	1,096	1,222	1,361	1,514	1,682	1,867	2,070	2,293	2,537	2,806	3,100
3) Accident Reduction																								
Total Benefit	263,025	12,849		-0	111	230	356	490	632	785	946	1,119	1,302	1,497	1,666	1,851	2,055	2,204	2,426	2,692	2,983	3,304	3,656	4,042
3. Evaluation Index																								
Net Benefit	254,100	6,430	-122	-122	-989	-876	-756	-628	-491	-345	-189	-23	155	344	1,338	1,521	1,723	1,869	2,089	2,352	2,642	2,960	3,300	3,683
1) Net Present Value 6,430																								
Discount Rate= 12%																								
2) B/C Ratio (r=12%) **2.00**																								
3) Internal Rate of Return **18.7%**																								

Table 12.3.4: Cost-Benefit Analysis
(Base Case)

Unit: RM million

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1. Economic Cost (Incremental Cost)																				
1) Arterial Transport Facility Development																				
(1) New Rail Projects																				
(2) Trunk Bus System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-468
(3) Highway Projects	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	-7,058
2) Public Transport-Enhancing Projects	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-42
3) Traffic Control / Management in CPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4) Transport Information System & Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	-19
Total Cost	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	93	-7,585
2. Benefit (Cost Saving)																				
1) Vehicle Operation Cost Saving																				
(1) Running Cost Saving	-237	-245	-253	-261	-269	-277	-285	-293	-300	-308	-315	-323	-330	-337	-344	-350	-357	-363	-369	-374
(2) Fixed Cost Saving	1,320	1,412	1,510	1,613	1,722	1,837	1,960	2,089	2,225	2,369	2,522	2,683	2,853	3,033	3,223	3,423	3,635	3,858	4,095	5,443
Subtotal	1,083	1,167	1,257	1,352	1,453	1,561	1,675	1,796	1,925	2,061	2,206	2,360	2,523	2,696	2,879	3,073	3,278	3,496	3,726	5,069
2) Passenger Traveling Cost Saving	3,403	3,734	4,095	4,487	4,915	5,382	5,890	6,443	7,046	7,703	8,418	9,196	10,044	10,967	11,972	13,066	14,258	15,555	16,967	18,504
3) Accident Reduction																				
Total Benefit	4,487	4,901	5,351	5,839	6,368	6,942	7,565	8,239	8,971	9,764	10,624	11,556	12,567	13,663	14,851	16,139	17,536	19,050	20,692	23,573
3. Evaluation Index																				
Net Benefit	4,403	4,818	5,268	5,756	6,285	6,859	7,481	8,156	8,887	9,680	10,540	11,473	12,483	13,579	14,767	16,055	17,452	18,967	20,599	31,158
1) Net Present Value 6,430																				
Discount Rate= 12%																				
2) B/C Ratio (r=12%) 2.00																				
3) Internal Rate of Return 18.7%																				

Table 12.3.5: Cost-Benefit Analysis
(Base Case with Area Pricing)

Unit: RM million

	Total 1999-2040	NPV 1999-2040	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. Economic Cost (Incremental Cost)																								
1) Arterial Transport Facility Development																								
(1) New Rail Projects	0	0																						
(2) Trunk Bus System	46	346	108	108	29	29	29	29	29	29	29	29	29	29	0	0	0	0	0	0	0	0	0	0
(3) Highway Projects	8,824	6,030	4	4	1,067	1,073	1,079	1,085	1,091	1,097	1,103	1,109	1,115	1,121	325	327	330	332	335	337	339	342	344	346
2) Public Transport-Enhancing Projects	17	22	0	0	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	2	2	2
3) Traffic Control / Management in CPA	26	9	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
4) Transport Information System & Others	37	22	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10
Total Cost	8,951	6,428	124	125	1,100	1,106	1,112	1,118	1,124	1,130	1,136	1,142	1,148	1,154	328	330	333	335	337	340	342	345	359	361
2. Benefit (Cost Saving)																								
1) Vehicle Operation Cost Saving																								
(1) Running Cost Saving	-885	124		44	54	60	64	64	61	53	41	23	-1	-30	-38	-45	-53	-60	-68	-75	-83	-90	-97	-104
(2) Fixed Cost Saving	70,306	4,013		-16	24	67	114	164	218	277	339	407	480	558	622	692	766	598	818	905	999	1,101	1,210	1,328
Subtotal	69,421	4,137		28	77	127	178	228	279	330	380	430	479	527	584	646	714	538	750	829	916	1,011	1,113	1,225
2) Passenger Traveling Cost Saving	270,499	10,288		-25	27	85	149	218	295	378	470	570	679	798	955	1,130	1,326	1,545	1,788	2,059	2,360	2,694	3,064	3,474
3) Accident Reduction 100%	4,889	1,117		0	27	53	78	102	126	149	173	196	219	242	259	277	296	316	337	359	382	407	433	461
Total Benefit 1)+2)+3)	344,809	15,542		2	131	265	404	549	700	858	1,023	1,196	1,377	1,567	1,798	2,053	2,335	2,398	2,874	3,247	3,658	4,111	4,610	5,159
1)+2)	339,920	14,425																						
3. Evaluation Index																								
Net Benefit	330,969	7,997	-124	-122	-996	-894	-786	-671	-550	-422	-286	-142	10	172	1,211	1,446	1,707	1,748	2,200	2,548	2,934	3,360	3,818	4,337
Net Benefit (including accident reduction)	335,858	9,114	-124	-122	-969	-841	-708	-569	-424	-273	-113	54	229	413	1,470	1,723	2,003	2,063	2,537	2,907	3,316	3,767	4,251	4,798

1) Net Present Value 7,997

Net Present Value including benefit of accident reduction 9,114

Discount Rate= 12%

2) B/C Ratio (r=12%) 2.24

B/C Ratio (r=12%) including benefit of accident reduction 2.42

3) Internal Rate of Return 19.0%

IRR including benefit of accident reduction 20.6%

Table 12.3.5: Cost-Benefit Analysis
(Base Case with Area Pricing)

Unit: RM million

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1. Economic Cost (Incremental Cost)																				
1) Arterial Transport Facility Development																				
(1) New Rail Projects																				
(2) Trunk Bus System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-468
(3) Highway Projects	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	-7,058
2) Public Transport-Enhancing Projects	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-42
3) Traffic Control / Management in CPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	-4
4) Transport Information System & Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	-19
Total Cost	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	96	-7,589
2. Benefit (Cost Saving)																				
1) Vehicle Operation Cost Saving																				
(1) Running Cost Saving	-102	-99	-96	-92	-87	-82	-76	-69	-61	-52	-43	-32	-20	-7	8	24	41	60	80	102
(2) Fixed Cost Saving	1,499	1,601	1,709	1,823	1,943	2,069	2,202	2,342	2,489	2,644	2,808	2,979	3,160	3,350	3,550	3,760	3,981	4,213	4,457	6,056
Subtotal	1,397	1,502	1,613	1,731	1,855	1,987	2,126	2,273	2,428	2,592	2,765	2,948	3,140	3,344	3,558	3,784	4,022	4,273	4,537	6,158
2) Passenger Traveling Cost Saving	3,904	4,378	4,897	5,466	6,089	6,772	7,519	8,336	9,229	10,204	11,269	12,431	13,698	15,079	16,585	18,224	20,008	21,950	24,063	26,359
3) Accident Reduction 100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Benefit 1)+2)+3)	5,302	5,880	6,510	7,196	7,944	8,759	9,645	10,609	11,657	12,796	14,034	15,379	16,838	18,423	20,143	22,008	24,031	26,223	28,600	32,517
1)+2)																				
3. Evaluation Index																				
Net Benefit	5,218	5,796	6,426	7,112	7,860	8,675	9,561	10,525	11,573	12,712	13,950	15,294	16,754	18,339	20,059	21,924	23,947	26,139	28,504	40,106
Net Benefit (including accident reduction	5,218	5,796	6,426	7,112	7,860	8,675	9,561	10,525	11,573	12,712	13,950	15,294	16,754	18,339	20,059	21,924	23,947	26,139	28,504	40,106
1) Net Present Value 7,997																				
Net Present Value including benefit of a c c																				
9,114																				
Discount Rate= 12%																				
2) B/C Ratio (r=12%) 2.24																				
B/C Ratio (r=12%) including benefit of a c																				
2.42																				
3) Internal Rate of Return 19.0%																				
IRR including benefit of accident reductio																				
20.6%																				

Appendix 13

Appendix Table 13.1.1 Number of Train per Day

Time of Day	6.00-7.00	7.00-9.00	9.00-16.00	16.00-18.00	18.00-24.00	Total
1) Headway in Minutes	15	5	15	5	15	
Number of Train / direction	4	24	28	24	24	104
2) KTMB N. - S.Line	30	20	30	20	30	
Number of Train / direction	2	6	14	6	12	40
3) KTMB W. Line	30	15	30	15	30	
Number of Train / direction	2	8	14	8	12	44

Appendix Table 13.1.2 Necessary Number of Train and Cars per Day

Company			Length	Operating	Travel	Time for	Headway	No. of
Name	No.	Line		Speed(km/h)	Time(Mun.)	Turn Around	(PeakHour)	Train
KTMB	1	N.S.Line	105.0	54	116	5	20	13.9
	2	W.Line	43.0	32	80	5	15	13.0
STAR	3	Amp.Line	15.2	37	25	5	5	13.6
	4	S.P.Line	11.8	37	19	5	5	11.1
PUTRA	5	Section 1	14.1	37	21	5	5	12.0
	6	Section 2	14.9	37	24	5	5	13.3
PRT	7	N.Section	8.0	37	19	5	5	11.0
	8	S.Section	8.0	37	10	5	5	6.9
KTMB	9	B.Cave	7.6	32	14	5	15	3.0
STAR	10	Kepong Line	9.1	37	15	5	5	9.1
LRT-1	11	Cheras Line	5.4	37	9	5	5	6.3
LRT-2	12	Daman.Line	11.9	37	19	5	5	11.2

Note : Number of train per day was assumed as

1. KTMB has 18 sets of EMU.
2. According to the STAR, 30 trains (3 - Vehicle) will serve on the completed 27 km long line.
3. PUTRA will serve 70 two - car unit.
4. PRT use 14 4 - car units for initial operation

Source: KTMB,STAR,PUTRA and PRT

Appendix Table 13.1.3 Estimation of Electricity of Rail Based Transport

Company			Length	No. of	Electricity	Annual
Name	No.	Line		Train/day	Cost/Train	(Mill.RM)
KTMB	1	N.S.Line	105.0	80	109536	40.0
	2	W.Line	43.0	88	49,343	18.0
STAR	3	Amp.Line	15.2	208	41,227	15.0
	4	S.P.Line	11.8	208	32,005	11.7
PUTRA	5	Section 1	14.1	208	38,244	14.0
	6	Section 2	14.9	208	40,414	14.8
PRT	7	N.Section	8.0	208	21,699	7.9
	8	S.Section	8.0	208	21,699	7.9
KTMB	9	B.Cave	7.6	88	8,721	3.2
STAR	10	Kepong Line	9.1	208	24,682	9.0
LRT-1	11	Cheras Line	5.4	208	14,647	5.3
LRT-2	12	Damansara Line	11.9	208	32,277	11.8

Note: Electricity cost was assumed as 13.04 RM per train-km

Appendix 14

Appendix Table 14.1 Progress of Urban Transport Policy in Klang Valley

	Issues/Targets	Prospects	Progress
Sixth Malaysia Plan 1991-1995	**General** *Improvement of transport modes *Privatization and user charge *Information technology	*Inter-urban road network development *Upgrade of urban road network *Railway modernization *Dispersal policy by rural area development *Integrated transport system	*Capacity constraints in transport infrastructure *Serious traffic Congestion in urban * Lack of an efficient public transport system
	Urban Road Transport Policy *Traffic dispersal scheme * Congestion problems in Klang Valley	*North-South Link Expressway *Shah Alam Expressway *Widening of Federal Road II *Improvement of road maintenance *Decrease road traffic accidents	*New Klang Valley Expressway *Widening of Federal Road II *Dynamic vehicle responsive traffic signal control system:24 intersections *Construction of ring road, interchange,etc
	Urban Public Transport Policy *Improvement of public transport **Road-based transport** **Non-road-based transport**	*Increase public transport demand *Improvement of bus service quality *Provision of LRT system *Double tracking of railway *Introduction of railway commuter service(KL-Port Klang-Subang International Airport, Seremban-Rawang) *Corporization of KTM	*LRT System I construction *Corporatize KTM(1992) *KTM commuter development(Rawang-KL-Seremban, KL-Port Klang)
Mid-Term Review of the Sixth Malaysia Plan 1991-1995	**General** *Capacity constraints in transport infrastructure *Serious traffic Congestion in urban areas *Privatisation *Capacity expansion, improvement of efficiency and quality of services	*Expect private sector's performance *Increase transport capacity *Improvement of transport quality *Enhancement of non-road-based-transport *Traffic Demand Management	*Insufficient transport capacity because of rapid economic growth *Lack of efficient public transport
	Urban Road Transport Policy *Follow "Highway Network Development Plan".1993	*East-West Link(Kuantan-Port Klang) *Upgrade KL-Karak Highway *Ring road construction *North-South Link Expressway *Dynamic vehicle responsive traffic signal control system: 99 intersections	*Middle Ring Road II *Istana Negara-Selak Selatan Road *Puchong-Sungai Besi Road *Five interchanges *North-South Central Link(KLIA-Klang Valley) *Dynamic vehicle responsive traffic signal control system: 98 intersections
	Urban Public Transport Policy *Lack of efficient public transport *Development of an efficient and integrated system **Road-based transport** **Non-road-based transport** *Fuel efficient and environment-friendly rail-based transport is expected	*Greater use of public transport mode *By the end of the decade, more than half of commuter transport should be carried by public transport. *Improvement of service by the consolidated bus companies *LRT System II construction *KTM double tracking *Integrated KTM commuter with feeder bus and the Monorail *Monorail system construction *Integrated railway complex: Brickfields	*Amalgamation of 8 bus companies into two(1994) *Upgrade of bus terminals and depots *LRT System I, Phase II construction *KTM commuter in operation(Rawang-KL-Seremban, Sentul-Port Klang, Kajang-Seremban)

Appendix Table 14.1 Progress of Urban Transport Policy in Klang Valley (continued)

	Issues/Targets	Prospects	Progress
Seventh Malaysia Plan 1996-2000	**General** *Increase capacity and improve productivity *Insufficient transport capacity because of rapid economic growth	*Supply-driven approach *Long term integrated planning *Promotion of multimodalism *Further expansion to rural areas *Continuous review and strict enforcement on projects	
	Urban Road Transport Policy *Follow "Highway Network Development Plan",1993	*New North Klang Straits By-pass *Elevated Highway over Sungai Gombak *Dynamic vehicle responsive traffic signal control system: additional 150 *Study on Traffic Demand Management	
	Urban Public Transport Policy *Further development of an efficient, integrated, multimodal and environment-friendly public transport	*Physical Integration (bus, taxi and parking lots at LRT stations) *Route Integration (feeder service to LRT and KTM commuter service) *Ticket Integration(rail and bus)	
	Road-based transport	*Improvement of bus service through the amalgamation *Bus route information system, information board *Bus priority and exclusive lanes *Move terminals from CBD	*Abolition of the Mini bus services *Bus priority lanes *Bus priority signals
	Non-road-based transport	*LRT System I, Phase II in operation *LRT System II in operation *New LRT corridor in Klang Valley *Enhance KTM commuter transport capacity *Integrated Railway Complex:Brickfield	*LRT System I, Phase I and II in operation *LRT System I feeder service in operation

Source: Summarised by the Study Team based on Sixth Malaysia Plan 1991-1995
: Mid-Term Review of the Sixth Malaysia Plan 1991-1995
: Seventh Malaysia Plan 1996-2000