

## **APPENDICES**

**APPENDIX A**  
**SOLID WASTE MANAGEMENT IN**  
**NONTHABURI MUNICIPALITY 2008**

**Table A-1** Solid waste generation in Nonthaburi Municipality (2008)

Month-year	SW (tons/Month)	SW tons/day	Pop.	SW kg/cap/day
Jan-08	7,973.50	257.21	265,455	0.97
Feb-08	7,812.72	269.40	265,444	1.02
Mar-08	8,184.64	264.02	265,328	1.00
Apr-08	8,197.20	273.24	265,115	1.03
May-08	8,962.06	289.10	264,990	1.09
Jun-08	8,432.35	281.08	264,954	1.06
Jul-08	8,261.35	266.50	264,762	1.01
Aug-08	7,857.15	253.46	264,744	0.96
Sep-08	7,785.29	259.51	264,649	0.98
Oct-08	8,097.52	261.21	264,581	0.99
Nov-08	7,401.42	246.71	265,618	0.93
Dec-08	7,645.24	246.62	264,485	0.93
<b>Total/year</b>	96,610.40	-	264,485	-
<b>Average</b>	8,050.87	264.00	265,010	1.00
<b>± SD.</b>	406.61	12.89	685.89	0.05

Source: Bureau of Environment and Health Nonthaburi Municipality

**Table A-2** Distance and diesel fuel consumption of collection system in Nonthaburi Municipality SWM (2008)

Month -year	Solid Waste (tons/ Month)	Diesel Consumption			Distances in Collection System		
		(L/Month)	(L/ton)	(L/day)	(km)	(km/day)	(km/L)
Jan-08	7,973.50	66,747.72	8.37	2,153.15	116,665.30	3,763.40	1.75
Feb-08	7,812.72	63,263.96	8.10	2,181.52	109,926.40	3,790.57	1.74
Mar-08	8,184.64	64,658.29	7.90	2,085.75	109,431.90	3,530.06	1.69
Apr-08	8,197.20	65,204.07	7.95	2,173.47	106,997.00	3,566.57	1.64
May-08	8,962.06	61,848.95	6.90	1,995.13	102,275.70	3,299.22	1.65
Jun-08	8,432.35	68,692.95	8.15	2,289.77	115,404.15	3,846.81	1.68
Jul-08	8,261.35	65,805.52	7.97	2,122.76	109,130.80	3,520.35	1.66
Aug-08	7,857.15	63,622.43	8.10	2,052.34	106,348.90	3,430.61	1.67
Sep-08	7,785.29	64,885.25	8.33	2,162.84	107,449.30	3,581.64	1.66
Oct-08	8,097.52	67,374.03	8.32	2,173.36	111,176.40	3,586.34	1.65
Nov-08	7,401.42	65,405.28	8.84	2,180.18	108,108.20	3,603.61	1.65
Dec-08	7,645.24	67,540.79	8.83	2,178.74	114,685.80	3,699.54	1.70
<b>Total</b>	96,610.40	785,049.24	-	-	1,317,599.85	-	-
<b>Average</b>	8,050.87	65,420.77	8.15	2,145.75	109,799.99	3,601.56	1.68
<b>± SD.</b>	406.61	1,965.26	0.50	74.90	4,152.48	155.46	0.03

\*The average rate of diesel consumption calculate from table A-2 was 7.4E-08 liters of diesel/kg of solid waste/kilometer

Source: Bureau of Environment and Health Nonthaburi Municipality

**Table A-3** Carbon emission from solid waste collection system in Nonthaburi Municipality SWM (2008)

Month-year	Diesel (L/ Month )	KgCE/Month	Diesel (L/TonSW)	kgCE /TonSW
Jan-08	66,747.72	53,331.43	8.37	6.69
Feb-08	63,263.96	50,547.90	8.10	6.47
Mar-08	64,658.29	51,661.97	7.90	6.31
Apr-08	65,204.07	52,098.05	7.95	6.36
May-08	61,848.95	49,417.31	6.90	5.51
Jun-08	68,692.95	54,885.67	8.15	6.51
Jul-08	65,805.52	52,578.61	7.97	6.36
Aug-08	63,622.43	50,834.32	8.10	6.47
Sep-08	64,885.25	51,843.31	8.33	6.66
Oct-08	67,374.03	53,831.85	8.32	6.65
Nov-08	65,405.28	52,258.82	8.84	7.06
Dec-08	67,540.79	53,965.09	8.83	7.06
<b>Total</b>	785,049.24	627,254.34	-	-
<b>Average</b>	65,420.77	52,271.20	8.15	6.51
<b>± SD.</b>	1,965.26	1,570.24	0.50	0.40

Source: Bureau of Environment and Health Nonthaburi Municipality

**Table A-4** Diesel fuel consumption in landfill operation of Nonthaburi Municipality SWM (2008)

Month-year	SW (tons/Month)	Diesel (L/Month)	Diesel (L/day)	Diesel (L/Ton)
Jan-08	7,973.495	16,801.47	541.98	2.11
Feb-08	7,812.715	15,486.43	534.01	1.98
Mar-08	8,184.635	16,837.41	543.14	2.06
Apr-08	8,197.195	16,220.03	540.67	1.98
May-08	8,962.060	16,291.04	525.52	1.82
Jun-08	8,432.345	16,339.71	544.66	1.94
Jul-08	8,261.345	16,328.24	526.72	1.98
Aug-08	7,857.150	16,533.53	533.34	2.10
Sep-08	7,785.290	15,865.12	528.84	2.04
Oct-08	8,097.515	16,247.31	524.11	2.01
Nov-08	7,401.420	15,930.02	531.00	2.15
Dec-08	7,645.235	16,283.39	525.27	2.13
<b>Total</b>	96,610.40	195,163.71	-	-
<b>Average</b>	8,050.87	16,263.64	533.27	2.02
<b>± SD.</b>	406.61	378.84	7.59	0.09

Source: Environmental Division Nonthaburi Province Administration Organization

**Table A-5** Carbon emission from landfill site operation in Nonthaburi Municipality SWM (2008)

Month-year	Diesel (L/Month )	KgCE/Month	Diesel (L/Ton)	kgCE/TonSW
Jan-08	16,801.47	13,424.37	2.11	1.68
Feb-08	15,486.43	12,373.66	1.91	1.58
Mar-08	16,837.41	13,453.09	2.06	1.64
Apr-08	16,220.03	12,959.80	1.98	1.58
May-08	16,291.04	13,016.54	1.82	1.45
Jun-08	16,339.71	13,055.43	1.94	1.55
Jul-08	16,328.24	13,046.26	1.98	1.58
Aug-08	16,533.53	13,210.29	2.10	1.68
Sep-08	15,865.12	12,676.23	2.04	1.63
Oct-08	16,247.31	12,981.60	2.01	1.60
Nov-08	15,930.02	12,728.09	2.15	1.72
Dec-08	16,283.39	13,010.43	2.13	1.70
<b>Total</b>	195,163.71	155,935.81	-	-
<b>Average</b>	16,263.64	12,994.65	2.02	1.62
<b>± SD.</b>	378.84	302.70	0.10	0.08

Source: Environmental Division Nonthaburi Province Administration Organization

**Table A-6** Methane and carbon sink from landfill site and recycle in Nonthaburi Municipality SWM (2008)

Month-year	SW Composition	Food Waste	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	SW Ton/mth	63.16%	5.04%	19.33%	5.80%	1.39%	0.63%	0.39%	2.07%	4.34%
Jan-08	7,973.50	5,036.06	401.47	1,540.88	462.46	110.43	49.83	30.70	164.65	346.05
Feb-08	7,812.72	4,934.51	393.37	1,509.81	453.14	108.21	48.83	30.08	161.33	339.07
Mar-08	8,184.64	5,169.42	412.10	1,581.68	474.71	113.36	51.15	31.51	169.01	355.21
Apr-08	8,197.20	5,177.35	412.73	1,584.11	475.44	113.53	51.23	31.56	169.27	355.76
May-08	8,962.06	5,660.44	451.24	1,731.92	519.80	124.12	56.01	34.50	185.07	388.95
Jun-08	8,432.35	5,325.87	424.57	1,629.55	489.08	116.79	52.70	32.46	174.13	365.96
Jul-08	8,261.35	5,217.87	415.96	1,596.50	479.16	114.42	51.63	31.81	170.60	358.54
Aug-08	7,857.15	4,962.58	395.61	1,518.39	455.71	108.82	49.11	30.25	162.25	341.00
Sep-08	7,785.29	4,917.19	391.99	1,504.51	451.55	107.83	48.66	29.97	160.77	337.88
Oct-08	8,097.52	5,114.39	407.71	1,564.84	469.66	112.15	50.61	31.18	167.21	351.43
Nov-08	7,401.42	4,674.74	372.66	1,430.32	429.28	102.51	46.26	28.50	152.84	321.22
Dec-08	7,645.24	4,828.73	384.94	1,477.44	443.42	105.89	47.78	29.43	157.87	331.80
(1)Total SW tons/year	96,610.40	61,019.13	4,864.33	18,669.96	5,603.4	1,338.05	603.82	371.95	1,995.00	4,192.89
(2)Factor CH <sub>4</sub> Prod. In Landfill kgCH <sub>4</sub> /ton	-	99.40	234.75	6.57	3.30	-	99.40	-	159.00	-
(3)Total CE of CH <sub>4</sub> from Landfill MTCE/Year	5,794.19	4,548.98	856.43	92.00	13.87	-	45.01	-	237.90	-
(4)Average Recycle Tons/day	-	-	1.81	0.26	0.57	5.18	-	-	-	-
(5)Recyclable Material Tons /year	2,859.96	-	661.78	94.39	207.40	1,896.39	-	-	-	-
(6)Conversion Factor MTCO <sub>2</sub> E/Short ton	-	-	-3.51	-1.5	-0.28	-5.4	-	-	-	-
(7)Total CE from recycle MTCE/Year	-3157.77	-	-574.71	-35.03	-14.37	-2533.66	-	-	-	-

Total CE of CH<sub>4</sub> from Landfill(3) =  $\sum$ [Total mass of each composition of MSW tons/year(1) x Factor CH<sub>4</sub> Prod. In Landfill kgCH<sub>4</sub>/ton(2)] x (12/16)/1000 = MTCE/year

Total CE from recycle(7) =  $\sum$ [Total mass of each Recyclable Material Tons /year(5)x Conversion Factor MTCO<sub>2</sub>E/Short ton(6)x(1.1023 short ton/MT)] x (12/44)=MTCE/year

Carbon storage in landfill (Appendix F (F.2))

**Table A-7** Scenario at 10% 25% and 35% recycle of Nonthaburi Municipality SWM

Month-year	SW Composition	Food Waste	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	SW Ton/mth	63.16%	5.04%	19.33%	5.80%	1.39%	0.63%	0.39%	2.07%	4.34%
Total SW tons/year	96,610.4	61,019.1	4,864.3	18,670.0	5,603.4	1,338.1	603.8	372.0	1,995.0	4,192.9
Factor CH4 Prod. In Landfill kgCH <sub>4</sub> /ton	-	99.4	234.75	6.57	3.30	-	99.40	-	159.00	-
Total CE of CH4 from Landfill MTCE/Year	5,794.19	4,548.98	856.43	92.00	13.87	-	45.01	-	237.90	-
Average Recycle Tons/day	-	-	1.81	0.26	0.57	5.2	-	-	-	-
Recyclable Material Tons /year	2,860.0	-	661.78	94.39	207.40	1,896.39	-	-	-	-
Conversion Factor MTCO <sub>2</sub> E/Short ton	-	-	-3.51	-1.5	-0.28	-5.4	-	-	-	-
Total CE from recycle MTCE/Year	-3,157.77	-	-574.71	-35.03	-14.37	2,533.66	-	-	-	-
Average kgCE/tonSW	60.0	74.6	176.1	4.9	2.5	-	74.6	-	119.3	0.0
10% Recycle Ton/year	3047.58	-	486.43	1,867.00	560.34	133.81	-	-	-	-
Reduction from recycle(10%)MTCE/year	-1619.58	-	-513.29	-841.90	-47.17	-217.22	-	-	-	-
Reduction 10%+base-line	-4777.35	-	1088.00	-876.94	-61.54	-2750.88	--	-	-	-
Total SW after R 10%	95,610.97	61,019.13	4,377.90	16,802.96	5,043.06	1,204.25	603.82	371.95	1,995.00	4,192.89
Total carbon from CH <sub>4</sub>	5697.96	4548.98	770.78	82.80	12.48	-	45.01	-	237.90	0.00
25% Recycle Ton/year	7618.94	-	1,216.08	4,667.49	1,400.85	334.51	-	-	-	-
Reduction from recycle(25%)MTCE/year	-4048.94	-	1283.21	-2104.76	-117.92	-543.04	-	-	-	-
Reduction 25%+base-line	-7206.71	-	1857.92	-2139.79	-132.29	-3076.71	--	-	-	-
Total SW after R 25%	91,039.60	61,019.13	3,648.25	14,002.47	4,202.55	1,003.54	603.82	371.95	1,995.00	4,192.89
Total carbon from CH <sub>4</sub>	5,553.61	4,548.98	642.32	69.00	10.40	-	45.01	-	237.90	-
35% Recycle Ton/year	10666.51	-	1,702.52	6,534.49	1,961.19	468.32	-	-	-	-
Reduction from recycle(35%)MTCE/year	-5668.51	-	1796.50	-2946.67	-165.08	-760.26	-	-	-	-
Reduction 35%+base-line	-8826.29	-	2371.21	-2981.70	-179.45	-3293.93	-	-	-	-
Total SW after R 35%	87,992.03	61,019.13	3,161.82	12,135.47	3,642.21	869.74	603.82	371.95	1,995.00	4,192.89
Total carbon from CH <sub>4</sub>	5,457.38	4,548.98	556.68	59.80	9.01	-	45.01	-	237.90	-

The same calculation as Table A-6 for carbon from methane and recycle  
Carbon storage in landfill (Appendix F (F.2))

**APPENDIX B**  
**SOLID WASTE MANAGEMENT IN**  
**KHON KAEN MUNICIPALITY 2008**

**Table B-1** Solid waste generation in Khon Kaen municipality 2008

Month-year	SW (tons/Month)	SW tons/day	Pop.	SW kg/cap/day
Jan-08	4,760.87	153.58	120,167	1.28
Feb-08	4,502.03	155.24	120,111	1.29
Mar-08	5,018.17	161.88	120,256	1.35
Apr-08	4,565.76	152.19	120,098	1.27
May-08	4,896.63	157.96	119,885	1.32
Jun-08	4,808.10	160.27	120,030	1.34
Jul-08	4,828.43	155.76	119,876	1.30
Aug-08	4,533.93	146.26	119,433	1.22
Sep-08	4,587.63	152.92	119,020	1.28
Oct-08	4,268.47	137.69	118,457	1.16
Nov-08	4,574.87	152.50	118,286	1.29
Dec-08	4,450.48	143.56	118,203	1.21
<b>Total/year</b>	55,795.37	-	118,203.00	-
<b>Average</b>	4,649.61	152.48	119,485.17	1.28
<b>± SD.</b>	221.22	6.98	785.90	0.05

Source: Sanitary Division Khon Kaen Municipality

**Table B-2** Distance and diesel fuel consumption of collection system in Khon Kaen municipality 2008

Month - year	SW (tons/Month)	Diesel (L/Month)	Diesel L/tons	Distance (km)	Distance (km/day)	km/L	Diesel (L/day)
Jan-08	4,760.87	7,188.91	1.51	40,118.20	1,294.14	5.58	231.9
Feb-08	4,502.03	6,978.15	1.55	41,256.10	1,422.62	5.91	240.63
Mar-08	5,018.17	7,348.84	1.46	38,219.90	1,232.90	5.20	237.06
Apr-08	4,565.76	6,116.61	1.34	38,303.00	1,276.77	6.26	203.89
May-08	4,896.63	7,736.68	1.58	41,587.80	1,341.54	5.38	249.57
Jun-08	4,808.10	8,269.94	1.72	40,232.40	1,341.08	4.86	275.66
Jul-08	4,828.43	7,918.62	1.64	39,465.20	1,273.07	4.98	255.44
Aug-08	4,533.93	8,132.65	1.79	42,055.20	1,356.62	5.17	262.34
Sep-08	4,587.63	8,838.62	1.93	42,300.00	1,410.00	4.79	294.62
Oct-08	4,268.47	7,939.35	1.86	42,634.00	1,375.29	5.37	256.11
Nov-08	4,574.87	7,960.27	1.74	41,125.00	1,370.83	5.17	265.34
Dec-08	4,450.48	7,254.28	1.63	42,798.00	1,380.58	5.90	234.01
<b>Total/year</b>	55,795.37	91,682.93	-	490,094.80	-	-	-
<b>Average</b>	4,649.61	7,640.24	1.65	40,841.23	1,339.62	5.38	250.55
<b>± SD.</b>	221.22	710.39	0.17	1582.74	58.70	0.45	23.48

\*The average rate of diesel consumption calculate from table B-2 was 1.23E-08 liters of diesel/kg of solid waste/kilometer

Source: Bureau of Environment and Health Khon Kaen Municipality

**Table B-3** Distance and diesel fuel consumption of solid waste at transfer system in Khon Kaen municipality 2008

Month-year	SW (tons/Month)	SW (tons/day)	Distance km	Diesel L	Diesel (L/tonSW)
Jan-08	4,760.87	153.58	12,648	12,245	2.57
Feb-08	4,502.03	155.24	11,832	11,455	2.54
Mar-08	5,018.17	161.88	12,648	12,245	2.44
Apr-08	4,565.76	152.19	12,240	11,850	2.60
May-08	4,896.63	157.96	12,648	12,245	2.50
Jun-08	4,808.10	160.27	12,240	11,850	2.46
Jul-08	4,828.43	155.76	12,648	12,245	2.54
Aug-08	4,533.93	146.26	12,648	12,245	2.70
Sep-08	4,587.63	152.92	12,240	11,850	2.58
Oct-08	4,268.47	137.69	12,648	12,245	2.87
Nov-08	4,574.87	152.50	12,240	11,850	2.59
Dec-08	4,450.48	143.56	12,648	12,245	2.75
<b>Total/year</b>	55,795.37	-	149,328.00	144,570.00	31.15
<b>Average</b>	4,649.61	152.48	12,444.00	12,047.50	2.60
<b>± SD.</b>	213.81	6.98	275.07	266.31	0.12

Source: Bureau of Environment and Health Khon Kaen Municipality

**Table B-4** Diesel fuel consumption at landfill operation for Khon Kaen municipality  
2008

Month-year	SW (tons/Month)	Diesel (L/Month)	Diesel (L/day)	Diesel (L/Ton)
Jan-08	4,760.87	4,580.00	147.74	0.96
Feb-08	4,502.03	4,148.99	148.18	0.92
Mar-08	5,018.17	4,610.00	148.71	0.92
Apr-08	4,565.76	4,649.97	155.00	1.02
May-08	4,896.63	3,770.00	121.61	0.77
Jun-08	4,808.10	3,538.00	117.93	0.74
Jul-08	4,828.43	2,032.00	65.55	0.42
Aug-08	4,533.93	2,736.00	88.26	0.60
Sep-08	4,587.63	3,384.09	112.80	0.74
Oct-08	4,268.47	5,200.00	167.74	1.22
Nov-08	4,574.87	5,040.00	168.00	1.10
Dec-08	4,450.48	5,160.00	166.45	1.16
<b>Total/year</b>	55,795.37	48,849.05	-	-
<b>Average</b>	4,649.61	4,070.75	134.00	0.88
<b>± SD.</b>	221.22	1038.93	34.39	0.25

Source: Sanitary Division Khon Kaen Municipality

**Table B-5** Carbon emission from solid waste collection system in Khon Kaen municipality 2008

Month-year	Diesel (L/Month)	KgCE/Month	Diesel (L/Ton)	kgCE /TonSW
Jan-08	7,188.91	5,743.94	1.51	1.21
Feb-08	6,978.15	5,575.54	1.55	1.24
Mar-08	7,348.84	5,871.73	1.46	1.17
Apr-08	6,116.61	4,887.17	1.34	1.07
May-08	7,736.68	6,181.61	1.58	1.26
Jun-08	8,269.94	6,607.68	1.72	1.37
Jul-08	7,918.62	6,326.98	1.64	1.31
Aug-08	8,132.65	6,497.99	1.79	1.43
Sep-08	8,838.62	7,062.06	1.93	1.54
Oct-08	7,939.35	6,343.54	1.86	1.49
Nov-08	7,960.27	6,360.26	1.74	1.39
Dec-08	7,254.28	5,796.17	1.63	1.30
<b>Total/year</b>	91,682.93	73,254.66	-	-
<b>Average</b>	7,640.24	6,104.56	1.65	1.32
<b>± SD.</b>	710.39	567.60	0.17	0.14

**Table B-6** Carbon emission from transfer station of SWM of Khon Kaen municipality  
2008

Month-year	Diesel (L/Month)	KgCE/Month	Diesel (L/Ton)	kgCE/TonSW
Jan-08	12,245	9,783.76	2.57	2.06
Feb-08	11,455	9,152.55	2.54	2.03
Mar-08	12,245	9,783.76	2.44	1.95
Apr-08	11,850	9,468.15	2.60	2.07
May-08	12,245	9,783.76	2.50	2.00
Jun-08	11,850	9,468.15	2.46	1.97
Jul-08	12,245	9,783.76	2.54	2.03
Aug-08	12,245	9,783.76	2.70	2.16
Sep-08	11,850	9,468.15	2.58	2.06
Oct-08	12,245	9,783.76	2.87	2.29
Nov-08	11,850	9,468.15	2.59	2.07
Dec-08	12,245	9,783.76	2.75	2.20
<b>Total/year</b>	144,570.00	115,511.43	-	-
<b>Average</b>	12,047.50	9,625.95	2.60	2.07
<b>± SD.</b>	266.31	212.78	0.12	0.10

**Table B-7** Carbon emission from landfill site operation of SWM of Khon Kaen municipality 2008

Month-year	Diesel (L/Month)	KgCE/Month	Diesel (L/Ton)	kgCE/TonSW
Jan-08	4,580.00	3,659.42	0.96	0.77
Feb-08	4,148.99	3,315.04	0.92	0.74
Mar-08	4,610.00	3,683.39	0.92	0.73
Apr-08	4,649.97	3,715.33	1.02	0.81
May-08	3,770.00	3,012.23	0.77	0.62
Jun-08	3,538.00	2,826.86	0.74	0.59
Jul-08	2,032.00	1,623.57	0.42	0.34
Aug-08	2,736.00	2,186.06	0.60	0.48
Sep-08	3,384.09	2,703.89	0.74	0.59
Oct-08	5,200.00	4,154.80	1.22	0.97
Nov-08	5,040.00	4,026.96	1.10	0.88
Dec-08	5,160.00	4,122.84	1.16	0.93
<b>Total/year</b>	48,849.05	39,030.39	-	-
<b>Average</b>	4,070.75	3,252.53	0.88	0.70
<b>± SD.</b>	1038.93	830.11	0.25	0.20

**Table B-8** Methane and carbon sink from landfill site and recycle in Khon Kaen municipality SWM 2008

Month-year	SW Compositio n	Food Waste	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	SW Ton/mth	73.66	7.17	14.29	2.05	0.62	0.3	0.34	0.71	0.86
Jan-08	4,760.87	3,506.86	341.35	680.33	97.60	29.52	14.28	16.19	33.80	40.94
Feb-08	4,502.03	3,316.20	322.80	643.34	92.29	27.91	13.51	15.31	31.96	38.72
Mar-08	5,018.17	3,696.38	359.80	717.10	102.87	31.11	15.05	17.06	35.63	43.16
Apr-08	4,565.76	3,363.14	327.36	652.45	93.60	28.31	13.70	15.52	32.42	39.27
May-08	4,896.63	3,606.86	351.09	699.73	100.38	30.36	14.69	16.65	34.77	42.11
Jun-08	4,808.10	3,541.65	344.74	687.08	98.57	29.81	14.42	16.35	34.14	41.35
Jul-08	4,828.43	3,556.62	346.20	689.98	98.98	29.94	14.49	16.42	34.28	41.52
Aug-08	4,533.93	3,339.69	325.08	647.90	92.95	28.11	13.60	15.42	32.19	38.99
Sep-08	4,587.63	3,379.25	328.93	655.57	94.05	28.44	13.76	15.60	32.57	39.45
Oct-08	4,268.47	3,144.15	306.05	609.96	87.50	26.46	12.81	14.51	30.31	36.71
Nov-08	4,574.87	3,369.85	328.02	653.75	93.78	28.36	13.72	15.55	32.48	39.34
Dec-08	4,450.48	3,278.22	319.10	635.97	91.23	27.59	13.35	15.13	31.60	38.27
(1)Total SW tons/year	55,795.37	41,098.87	4,000.53	7,973.16	1,143.81	345.93	167.39	189.70	396.15	479.84
(2)Factor CH4 Prod. In Landfill kgCH4/ton	-	99.40	234.75	6.57	3.30	-	99.40	-	159.00	-
(3)Total CE of CH <sub>4</sub> from Landfill MTCE/Year	3,870.10	3,063.92	704.34	39.29	2.83	-	12.48	-	47.24	-
(4)Average Recycle Tons/day	1.25	-	0.423	0.396	0.103	0.326	-	-	-	-
(5)Recyclabl e Material Tons /year	456.768	-	154.818	144.936	37.698	119.316	-	-	-	-
(6)Conversio n Factor MTCO <sub>2</sub> E/Short ton	-	-	-3.51	-1.5	-0.28	-5.4	-	-	-	-
(7)Total CE from recycle MTCE/Year	-350.262	-	-134.45	-53.79	-2.61	-159.41	-	-	-	-

Total CE of CH<sub>4</sub> from Landfill(3) =  $\sum$ [Total mass of each composition of MSW tons/year(1) x Factor CH<sub>4</sub> Prod. In Landfill kgCH<sub>4</sub>/ton(2)] x (12/16)/1000 = MTCE/year

Total CE from recycle(7) =  $\sum$ [Total mass of each Recyclable Material Tons /year(5)x Conversion Factor MTCO<sub>2</sub>E/Short ton(6)x(1.1023 short ton/MT)] x (12/44)=MTCE/year

**Table B-9** Scenario at 10% 25% and 35% recycle of Khon Kaen municipality SWM

Month-year	SW Composition	Food Waste	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	SW Ton/mth	73.66	7.17	14.29	2.05	0.62	0.3	0.34	0.71	0.86
Total SW tons/year	55,795.4	41,098.9	4,000.5	7,973.2	1,143.8	345.9	167.4	189.7	396.1	479.8
Factor CH <sub>4</sub> Prod. In Landfill kgCH <sub>4</sub> /ton	0.0	99.4	234.8	6.6	3.3	0.0	99.4	0.0	159.0	0.0
Total CE of CH <sub>4</sub> from Landfill MTCE/Year	3,870.1	3,063.9	704.3	39.3	2.8	0.0	12.5	0.0	47.2	0.0
Average Recycle Tons/day	-	-	0.4	0.4	0.1	0.3	-	-	-	-
Recyclable Material Tons /year	456.8	0.0	154.8	144.9	37.7	119.3	0.0	0.0	0.0	0.0
Conversion Factor MTCO <sub>2</sub> E/Short ton	-	-	-3.5	-1.5	-0.3	-5.4	-	-	-	-
Total CE from recycle MTCE/Year	-350.3	-	-134.4	-53.8	-2.6	-159.4	-	-	-	-
Average kgCE/tonSW	69.36	74.55	176.06	4.93	2.48	0.00	74.55	0.00	119.25	0.00
10% Recycle Ton/year	1346.34		400.05	797.32	114.38	34.59	-	-	-	-
Reduction from recycle(10%)MTC E/year	-847.46		-422.14	-359.54	-9.63	-56.16	-	-	-	-
Reduction 10%+base-line	-1197.73		-556.59	-413.33	-12.24	-215.57	-	-	-	-
Total SW after R 10%	54,449.03	41,098.87	3,600.48	7,175.84	1,029.42	311.34	167.39	189.70	396.15	479.84
Total carbon from CH <sub>4</sub>	3795.46	3063.92	633.91	35.36	2.55	0.00	12.48	0.00	47.24	0.00
25% Recycle Ton/year	3365.86		1,000.13	1,993.29	285.95	86.48				
Reduction from recycle(25%)MTC E/year	-2118.66		1055.34	-898.86	-24.07	-140.40				
Reduction 25%+base-line	-2468.92		1189.79	-952.65	-26.68	-299.81				
Total SW after R 25%	52,429.52	41,098.87	3,000.40	5,979.87	857.85	259.45	167.39	189.70	396.15	479.84
Total carbon from CH <sub>4</sub>	3,683.49	3,063.92	528.26	29.47	2.12	-	12.48	-	47.24	-
35% Recycle Ton/year	4712.20		1,400.18	2,790.61	400.33	121.08				
Reduction from recycle(35%)MTC E/year	-2966.13		1477.48	-1258.40	-33.70	-196.55				
Reduction 35%+base-line	-3316.39		1611.93	-1312.19	-36.31	-355.97				
Total SW after R 35%	51,083.18	41,098.87	2,600.34	5,182.55	743.47	224.86	167.39	189.70	396.15	479.84
Total carbon from CH <sub>4</sub>	3,608.84	3,063.92	457.82	25.54	1.84	-	12.48	-	47.24	-

The same calculation as Table B-8 for carbon from methane and recycle

Carbon storage in landfill (Appendix F (F.2))

**APPENDIX C**  
**SOLID WASTE MANAGEMENT IN**  
**PHITSANULOK MUNICIPALITY 2008**

**Table C-1** Solid waste generation in Phitsanulok municipality 2008

Month-year	SW (tons/Month)	SW tons/day	Pop.	SW kg/cap/day
Jan-08	2,237.87	72.19	78,139	0.92
Feb-08	2,147.55	74.05	78,112	0.95
Mar-08	2,216.27	71.49	77,989	0.92
Apr-08	2,266.01	75.53	78,003	0.97
May-08	2,617.77	84.44	77,995	1.08
Jun-08	2,421.19	80.71	77,921	1.04
Jul-08	2,359.03	76.10	77,651	0.98
Aug-08	2,456.97	79.26	77,823	1.02
Sep-08	2,298.54	76.62	77,678	0.99
Oct-08	2,277.51	73.47	77,565	0.95
Nov-08	2,185.76	72.86	77,488	0.94
Dec-08	2,025.02	65.32	77,340	0.84
<b>Total</b>	27,509.48	-	77,340	-
<b>Average</b>	2,292.46	75.17	77,808.67	0.97
<b>± SD.</b>	155.96	4.91	259.85	0.06

Source: Bureau of Environment and Health Phitsanulok Municipality

**Table C-2** Distance and diesel fuel consumption of collection system in Phitsanulok municipality 2008

Month -year	SW (tons/Month)	Diesel (L/Month)	Diesel L/tons	Distance (km)	Distance (km/day)	km/L	Diesel (L/day)
Jan-08	2,237.87	11,157.35	4.99	36,184.12	1,167.23	3.24	359.91
Feb-08	2,147.55	11,108.95	5.17	34,723.74	1,197.37	3.13	383.07
Mar-08	2,216.27	12,915.14	5.83	35,834.87	1,155.96	2.77	416.62
Apr-08	2,266.01	12,389.67	5.47	36,639.12	1,221.30	2.96	412.99
May-08	2,617.77	12,760.34	4.87	42,326.71	1,365.38	3.32	411.62
Jun-08	2,421.19	13,069.87	5.40	39,148.22	1,304.94	3.00	435.66
Jul-08	2,359.03	12,474.91	5.29	38,143.16	1,230.42	3.06	402.42
Aug-08	2,456.97	11,774.00	4.79	39,726.75	1,281.51	3.37	379.81
Sep-08	2,298.54	13,062.62	5.68	37,165.09	1,238.84	2.85	435.42
Oct-08	2,277.51	12,322.16	5.41	36,825.06	1,187.91	2.99	397.49
Nov-08	2,185.76	12,561.05	5.75	35,341.47	1,178.05	2.81	418.70
Dec-08	2,025.02	11,126.16	5.49	32,742.47	1,056.21	2.94	358.91
<b>Total</b>	27,509.48	146,722.21	-	444,800.77	-	-	-
<b>Average</b>	2,292.46	12,226.85	5.35	37,066.73	1,215.43	3.04	401.05
<b>± SD.</b>	155.96	749.94	0.34	2,521.67	79.41	0.19	26.02

\*The rate of diesel consumption calculate from table C-2 was 1.45E-07 liters of diesel/kg of solid waste/kilometer

Source: Bureau of Environment and Health Phitsanulok Municipality

**Table C-3** Distance and diesel fuel consumption of solid waste transfer system in Phitsanulok municipality 2008

Month-year	SW (tons/Month)	Distance (km)	Diesel (L)	Diesel (L/ton)	Km/L
Jan-08	2,237.87	12,586	3412	1.41	3.69
Feb-08	2,147.55	11,774	2748	1.37	4.28
Mar-08	2,216.27	12,586	3496	1.42	3.60
Apr-08	2,266.01	12,180	3133	1.34	3.89
May-08	2,617.77	14,384	3518	1.37	4.09
Jun-08	2,421.19	12,180	2778	1.26	4.38
Jul-08	2,359.03	12,586	3496	1.33	3.60
Aug-08	2,456.97	12,586	3332	1.28	3.78
Sep-08	2,298.54	12,180	2919	1.32	4.17
Oct-08	2,277.51	12,586	2797	1.38	4.50
Nov-08	2,185.76	12,180	2991	1.39	4.07
Dec-08	2,025.02	10,788	2529	1.33	4.27
<b>Total</b>	27,509.48	148,596.00	37,149.00	-	-
<b>Average</b>	2,292.46	12,383.00	3,095.75	1.351	4.03
<b>± SD.</b>	155.96	814.07	347.83	0.05	0.31

Source: Bureau of Environment and Health Phitsanulok Municipality

**Table C-4** Diesel fuel consumption at MBT operation for Phitsanulok municipality  
2008

Month-year	SW (tons/Month)	Diesel (L/Month)	Diesel (L/tonSW)	Diesel (L/day)
Jan-08	2,237.87	9,645.11	4.31	311.13
Feb-08	2,147.55	10,472.46	4.88	361.12
Mar-08	2,216.27	8,336.01	3.76	268.9
Apr-08	2,266.01	10,556.01	4.66	351.87
May-08	2,617.77	11,643.34	4.45	375.59
Jun-08	2,421.19	12,166.34	5.02	405.54
Jul-08	2,359.03	9,154.34	3.88	295.3
Aug-08	2,456.97	10,152.64	4.13	327.5
Sep-08	2,298.54	11,246.60	4.89	374.89
Oct-08	2,277.51	10,145.98	4.45	327.29
Nov-08	2,185.76	9,548.95	4.37	318.3
Dec-08	2,025.02	8,757.60	4.32	282.5
<b>Total</b>	27,509.48	121,825.38	-	-
<b>Average</b>	2,292.46	10,152.12	4.428	333.329
<b>± SD.</b>	155.96	1,152.23	0.39	41.36

Source: Bureau of Environment and Health Phitsanulok Municipality

**Table C-5** Carbon emission from solid waste collection system in Phitsanulok municipality 2008

Month-year	Diesel (L/Month)	KgCE/Month	Diesel (L/Ton)	kgCE /TonSW
Jan-08	11,157.35	8,914.72	4.99	3.98
Feb-08	11,108.95	8,876.05	5.17	4.13
Mar-08	12,915.14	10,319.20	5.83	4.66
Apr-08	12,389.67	98,99.35	5.47	4.37
May-08	12,760.34	10,195.51	4.87	3.89
Jun-08	13,069.87	10,442.83	5.40	4.31
Jul-08	12,474.91	9,967.45	5.29	4.23
Aug-08	11,774.00	9,407.43	4.79	3.83
Sep-08	13,062.62	10,437.03	5.68	4.54
Oct-08	12,322.16	9,845.41	5.41	4.32
Nov-08	12,561.05	10,036.28	5.75	4.59
Dec-08	11,126.16	8,889.80	5.49	4.39
<b>Total</b>	146,722.21	117,231.05	-	-
<b>Average</b>	12,226.85	9,769.254	5.35	4.271
<b>± SD.</b>	749.94	599.20	0.34	0.27

**Table C-6** Carbon emission from transfer station of SWM of Phitsanulok municipality 2008

Month-year	Diesel (L/Month)	KgCE/Month	Diesel (L/Ton)	kgCE /TonSW
Jan-08	3147	2,517.20	3.20	1.12
Feb-08	2944	2,354.80	3.34	1.10
Mar-08	3147	2,517.20	3.23	1.14
Apr-08	3045	2,436.00	3.16	1.08
May-08	3596	2,876.80	3.13	1.10
Jun-08	3045	2,436.00	2.96	1.01
Jul-08	3147	2,517.20	3.04	1.07
Aug-08	3147	2,517.20	2.92	1.02
Sep-08	3045	2,436.00	3.12	1.06
Oct-08	3147	2,517.20	3.15	1.11
Nov-08	3045	2,436.00	3.28	1.11
Dec-08	2697	2,157.60	3.03	1.07
<b>Total</b>	37,149.00	29,719.20	-	-
<b>Average</b>	3,095.750	2,476.60	3.13	1.081
<b>± SD.</b>	203.52	162.81	0.13	0.04

**Table C-7** Electricity consumption and carbon equivalent in transfer station and MBT of Phisanulok MSW 2008

Month-year	Transfer station				MBT			
	Electricity	kgCE/	kWh/	kgCE/	Electricity	kgCE/	kWh/	kgCE/
	(kWh)	month	TonSW	TonSW	(kWh)	month	TonSW	TonSW
Jan-08	16,913.81	2,587.81	7.88	1.21	2949.12	451.22	1.32	0.20
Feb-08	8,490.54	1,299.05	3.83	0.59	1990.97	304.62	0.93	0.14
Mar-08	7,080.39	1,083.30	3.12	0.48	2286.8	349.88	1.03	0.16
Apr-08	6,399.54	979.13	2.44	0.37	2632.21	402.73	1.16	0.18
May-08	5,855.20	895.85	2.42	0.37	3115.27	476.64	1.19	0.18
Jun-08	5,873.73	898.68	2.49	0.38	3115.27	476.64	1.29	0.20
Jul-08	6,577.38	1,006.34	2.68	0.41	2474.32	378.57	1.05	0.16
Aug-08	3,359.51	514.01	1.46	0.22	2423.59	370.81	0.99	0.15
Sep-08	4,153.51	635.49	1.82	0.28	2473.18	378.40	1.08	0.16
Oct-08	8,079.29	1,236.13	3.70	0.57	4993.1	763.94	2.19	0.34
Nov-08	4,154.65	635.66	2.05	0.31	2448.1	374.56	1.12	0.17
Dec-08	4,058.89	621.01	0.15	0.02	3319.9	507.94	1.64	0.25
<b>Total</b>	80,996.44	12,392.46	-	-	34,221.83	5,235.94	-	-
<b>Average</b>	6,749.70	1,032.70	2.837	0.434	2,851.819	436.328	1.248	0.191
<b>± SD.</b>	3,594.76	550.00	1.87	0.29	780.05	119.35	0.35	0.05

Source: Bureau of Environment and Health Phitsanulok Municipality

**Table C-8** Carbon emission from MBT operation of SWM of Phitsanulok municipality 2008

Month-year	Diesel (L/Month)	KgCE/Month	Diesel (L/Ton)	kgCE /TonSW
Jan-08	9,645.11	7706.44	4.31	3.44
Feb-08	10,472.46	8367.50	4.88	3.90
Mar-08	8,336.01	6660.47	3.76	3.01
Apr-08	10,556.01	8434.25	4.66	3.72
May-08	11,643.34	9303.03	4.45	3.55
Jun-08	12,166.34	9720.91	5.02	4.01
Jul-08	9,154.34	7314.32	3.88	3.10
Aug-08	10,152.64	8111.96	4.13	3.30
Sep-08	11,246.60	8986.03	4.89	3.91
Oct-08	10,145.98	8106.64	4.45	3.56
Nov-08	9,548.95	7629.61	4.37	3.49
Dec-08	8,757.60	6997.32	4.32	3.46
<b>Total</b>	121,825.38	97,338.48	-	-
<b>Average</b>	10,152.12	8,111.540	4.428	3.538
<b>± SD.</b>	1,152.23	920.63	0.39	0.31

**Table C-9** Carbon sink and recycle from MBT of SWM of Phitsanulok municipality  
2008

Month-year	SW Composition	Food Waste	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	SW Ton/mth	68.59	2.53	20.59	1.61	1.45	0.89	0.29	1.51	2.54
Jan-08	2,237.87	1,534.96	56.62	460.78	36.03	32.45	19.92	6.49	33.79	56.84
Feb-08	2,147.55	1,473.00	54.33	442.18	34.58	31.14	19.11	6.23	32.43	54.55
Mar-08	2,216.27	1,520.14	56.07	456.33	35.68	32.14	19.72	6.43	33.47	56.29
Apr-08	2,266.01	1,554.26	57.33	466.57	36.48	32.86	20.17	6.57	34.22	57.56
May-08	2,617.77	1,795.53	66.23	539.00	42.15	37.96	23.30	7.59	39.53	66.49
Jun-08	2,421.19	1,660.69	61.26	498.52	38.98	35.11	21.55	7.02	36.56	61.50
Jul-08	2,359.03	1,618.06	59.68	485.72	37.98	34.21	21.00	6.84	35.62	59.92
Aug-08	2,456.97	1,685.24	62.16	505.89	39.56	35.63	21.87	7.13	37.10	62.41
Sep-08	2,298.54	1,576.57	58.15	473.27	37.01	33.33	20.46	6.67	34.71	58.38
Oct-08	2,277.51	1,562.14	57.62	468.94	36.67	33.02	20.27	6.60	34.39	57.85
Nov-08	2,185.76	1,499.21	55.30	450.05	35.19	31.69	19.45	6.34	33.00	55.52
Dec-08	2,025.02	1,388.96	51.23	416.95	32.60	29.36	18.02	5.87	30.58	51.44
(1)Total SW tons/year	27,509.48	18,868.75	695.99	5,664.20	442.90	398.89	244.83	79.78	415.39	698.74
(2)Average Recycle Tons/day	-	-	0.512	0.852	0.115	0.623	-	-	-	-
(3)Recyclable Material Tons /year	915.23	0.00	187.44	311.65	42.25	228.09	0.00	0.00	0.00	145.79
(4)Conversion Factor MTCO <sub>2</sub> E/Short ton	-	-	-3.51	-1.5	-0.28	-5.4	-	-	-	-
(5)Total CE from recycle MTCE/Year	-712.17	-	-197.79	-140.54	-3.56	-370.29	-	-	-	-

Total CE from recycle(5)=  $\sum$ [Total mass of each Recyclable Material Tons /year(3)x Conversion Factor MTCO<sub>2</sub>E/Short ton(4)x(1.1023short ton/MT)]x(12/44)] = MTCE/year

**Table C-10** Scenario at 10% 25% and 35% recycle of Phisanulok Municipality SWM

Month-year	SW	Food	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	Composition	Waste								
	SW Ton/mth	68.59	2.53	20.59	1.61	1.45	0.89	0.29	1.51	2.54
Total SW tons/year	27,509.5	18,868.8	696.0	5,664.2	442.9	398.9	244.8	79.8	415.4	698.7
Average Recycle Tons/day	-	-	0.512	0.852	0.115	0.623	-	-	-	-
Recyclable Material Tons /year	915.2	-	187.4	311.6	42.3	228.1	-	-	-	--
Conversion Factor	-	-	-3.5	-1.5	-0.3	-5.4	-	-	-	-
MTCO <sub>2</sub> E/Short ton	-	-	-3.5	-1.5	-0.3	-5.4	-	-	-	-
Total CE from recycle MTCE/Year	<b>-712.17</b>	-	-197.79	-140.54	-3.56	-370.29	-	-	-	-
10% Recycle Ton/year	720.20	-	69.60	566.42	44.29	39.89	-	-	-	-
Reduction from recycle(10%)MTCE/year	-397.35	-	-73.44	-255.42	-3.73	-64.75	-	-	-	-
Reduction 10%+base-line	-1109.51	-	-271.23	-395.96	-7.28	-435.04	-	-	-	-
Total SW after R 10%	26,789.28	18,868.75	626.39	5,097.78	398.61	359.00	244.83	79.78	415.39	698.74
25% Recycle Ton/year	1800.50	-	174.00	1,416.05	110.73	99.72	-	-	-	-
Reduction from recycle(25%)MTCE/year	-993.37	-	-183.60	-638.56	-9.32	-161.89	-	-	-	-
Reduction 25%+base-line	-1705.53	-	-381.39	-779.09	-12.88	-532.17	-	-	-	-
Total SW after R 25%	25,708.98	18,868.75	521.99	4,248.15	332.18	299.17	244.83	79.78	415.39	698.74
35% Recycle Ton/year	2520.69	-	243.60	1,982.47	155.02	139.61	-	-	-	-
Reduction from recycle(35%)MTCE/year	-1390.71	-	-257.04	-893.98	-13.05	-226.64	-	-	-	-
Reduction 35%+base-line	-2102.88	-	-454.83	-1034.51	-16.61	-596.93	-	-	-	-
Total SW after R 35%	24,988.79	18,868.75	452.39	3,681.73	287.89	259.28	244.83	79.78	415.39	698.74

The same calculation as Table C-9 for carbon from recycle

Carbon storage in landfill (Appendix F (F.2))

**APPENDIX D**  
**SOLID WASTE MANAGEMENT IN**  
**PHUKET MUNICIPALITY 2008**

**Table D-1** Solid waste generation in Phuket municipality 2008

Month-year	SW (tons/Month)	SW tons/day	Pop.	SW kg/cap/day
Jan-08	3,050.44	98.4	75,989	1.29
Feb-08	2,932.07	101.11	76,209	1.33
Mar-08	2,962.80	95.57	76,346	1.25
Apr-08	2,891.87	96.4	76,224	1.26
May-08	3,293.97	106.26	76,432	1.39
Jun-08	2,898.69	96.62	76,201	1.27
Jul-08	3,045.79	98.25	76,112	1.29
Aug-08	3,021.70	97.47	76,345	1.28
Sep-08	2,914.69	97.16	76,219	1.27
Oct-08	3,059.71	98.7	76,338	1.29
Nov-08	2,905.11	96.84	76,311	1.27
Dec-08	2,815.96	90.84	76,276	1.19
<b>Total</b>	35,792.77	-	76,276	-
<b>Average</b>	2,982.73	97.8	76,250.17	1.28
<b>± SD.</b>	124.18	3.59	119.24	0.05

Source: Bureau of Public Work Phuket Municipality

**Table D-2** Distance and diesel fuel consumption of collection system in Phuket municipality 2008

Month -year	SW (tons/Month)	Diesel (L/Month)	Diesel L/tons	Distance (km)	Distance (km/day)	km/L	Diesel (L/day)
Jan-08	3,050.44	10,440	3.42	27,973.68	902.38	2.68	336.77
Feb-08	2,932.07	10,700	3.65	27,557.86	950.27	2.58	368.97
Mar-08	2,962.80	10,950	3.70	28,497.31	919.27	2.60	353.23
Apr-08	2,891.87	10,950	3.79	27,815.07	927.17	2.54	365.00
May-08	3,293.97	10,950	3.32	31,682.57	1,022.02	2.89	353.23
Jun-08	2,898.69	10,440	3.60	26,582.07	886.07	2.55	348.00
Jul-08	3,045.79	9,685	3.18	25,911.12	835.84	2.68	312.42
Aug-08	3,021.70	10,700	3.54	28,400.31	916.14	2.65	345.16
Sep-08	2,914.69	10,190	3.50	26,088.74	869.62	2.56	339.67
Oct-08	3,059.71	10,190	3.33	27,386.79	883.44	2.69	328.71
Nov-08	2,905.11	10,440	3.59	26,640.95	888.03	2.55	348.00
Dec-08	2,815.96	10,440	3.71	25,823.45	833.01	2.47	336.77
<b>Total</b>	35,792.77	126,075.00	-	330,359.92	-	-	-
<b>Average</b>	2,982.73	10,506.25	3.53	27,529.99	902.77	2.62	344.66
<b>± SD.</b>	124.18	376.33	0.18	1,610.64	51.20	0.11	15.42

\*The rate of diesel consumption calculate from table D-2 was 1.29E-07 liters of diesel/kg of solid waste/kilometer

Source: Bureau of Environment and Health Phuket Municipality

**Table D-3** Diesel fuel consumption at landfill operation for Phuket municipality (2008)

Month-year	SW (tons/Month)	Diesel (L/Month)	Diesel (L/day)	Diesel (L/TonSW)
Jan-08	635.85	330.00	10.66	0.52
Feb-08	832.19	321.00	11.08	0.39
Mar-08	2,106.06	1,047.00	33.76	0.50
Apr-08	964.75	525.00	17.51	0.54
May-08	1,228.65	253.00	8.15	0.21
Jun-08	589.16	226.00	7.53	0.38
Jul-08	594.55	286.00	9.21	0.48
Aug-08	2,031.35	906.00	29.21	0.45
Sep-08	727.98	305.00	10.18	0.42
Oct-08	633.32	364.00	11.76	0.58
Nov-08	960.34	497.00	16.57	0.52
Dec-08	860.01	224.00	7.24	0.26
<b>Total</b>	12,164.18	5,284.90	-	-
<b>Average</b>	1,013.68	440.41	14.41	0.44
<b>± SD.</b>	527.59	269.09	8.65	0.11

Source: Bureau of Public Work Phuket Municipality

**Table D-4.1** Total quantity of solid waste from Phuket province operate by Phuket municipality

Month-year	TotalSW T/month	WetSW to Incin tons/Month	WetSW to Incin. tons/day	DrySW to Incin. tons/Month	DrySW to Incin. tons/day
Jan-08	15,411.85	9,541.69	307.80	7,834.36	252.72
Feb-08	15,242.25	7,340.16	253.11	6,399.56	220.67
Mar-08	15,809.91	9,673.01	312.03	7,726.56	249.24
Apr-08	15,627.64	10,024.64	334.15	7,793.13	259.77
May-08	16,370.59	1,544.44	49.82	1,392.53	44.92
Jun-08	16,207.26	8,257.61	275.25	6,157.27	205.24
Jul-08	16,601.16	10,249.87	330.64	7,761.90	250.38
Aug-08	15,588.97	8,747.59	282.18	6,381.12	205.84
Sep-08	14,902.80	7,632.65	254.42	6,312.33	210.41
Oct-08	15,176.26	9,876.74	318.60	7,796.89	251.51
Nov-08	15,387.03	9,495.59	316.52	8,016.44	267.21
Dec-08	20,940.50	9,256.41	298.59	9,362.78	302.03
<b>Total</b>	193,266.21	101,640.39	-	82,934.87	-
<b>Average</b>	16,105.52	8,470.03	277.76	6,911.24	226.66
<b>± SD.</b>	1,605.07	2,372.05	76.75	1,976.23	63.97

Source: Bureau of Public Work Phuket Municipality

**Table D-4.2** Electricity production and carbon equivalent from incinerator by using solid waste as a fuel in Phuket province operate by Phuket municipality (2008)

Month -year	Wet SW to Incin tons /Month	Electricity kWh/Month	Electricity kWh/day	Wet SW kWh/ton	Total .kgCE	Prod.kgCE kWh/tonSW
Jan-08	9,541.69	1,198,900	38,674	125.65	183,432	19.22
Feb-08	7,340.16	1,043,700	35,990	142.19	159,686	21.76
Mar-08	9,673.01	1,167,900	37,674	120.74	178,689	18.47
Apr-08	10,024.64	1,139,200	37,973	113.64	174,298	17.39
May-08	1,544.44	209,000	6,742	135.32	31,977	20.70
Jun-08	8,257.61	865,700	28,857	104.84	132,452	16.04
Jul-08	10,249.87	996,500	32,145	97.22	152,465	14.87
Aug-08	8,747.59	948,800	30,606	108.46	145,166	16.60
Sep-08	7,632.65	986,000	32,867	129.18	150,858	19.76
Oct-08	9,876.74	1,173,100	37,842	118.77	179,484	18.17
Nov-08	9,495.59	1,186,900	39,563	124.99	181,596	19.12
Dec-08	9,256.41	1,072,800	34,606	115.9	164,138	17.73
<b>Total</b>	101,640.39	11,988,500	-	-	1,834,240.50	-
<b>Average</b>	8,470.03	999,041.67	32,795.00	119.74	152,853.38	18.32
<b>± SD.</b>	2,372.05	270,650.59	8,890.47	12.82	41,409.54	1.96

Source: Bureau of Public Work Phuket Municipality

**Table D-4.3** Electricity use in Phuket municipality incinerator (2008)

Month-year	USE					
	Electricity use in Plant	Electricity from PEA	Total Use.in. Incineration	Use Electricity kWh/tonSW	Total.Use. kgCE	Use.kgCE /tonSW
Jan-08	605,917	10,663	616,580	64.62	94,337	9.89
Feb-08	515,400	54,353	569,753	77.62	87,172	11.88
Mar-08	647,113	13,462	660,575	68.29	101,068	10.45
Apr-08	657,901	14,648	672,549	67.09	102,900	10.26
May-08	112,813	88,001	200,814	130.02	30,725	19.89
Jun-08	469,088	57,886	526,974	63.82	80,627	9.76
Jul-08	594,074	33,100	627,174	61.19	95,958	9.36
Aug-08	501,240	84,160	585,400	66.92	89,566	10.24
Sep-08	505,520	58,100	563,620	73.84	86,234	11.30
Oct-08	623,580	13,700	637,280	64.52	97,504	9.87
Nov-08	636,540	5,300	641,840	67.59	98,202	10.34
Dec-08	692,158	89,500	781,658	84.45	119,594	12.92
<b>Total</b>	6,561,344	522,873	7,084,217	-	1,083,885	-
<b>Average</b>	546,778.67	43,572.75	590,351.42	74.16	90,323.77	11.35
<b>± SD.</b>	154,438.20	32,411.90	138,859.87	18.78	21,245.56	2.87

Source: Bureau of Public Work Phuket Municipality

**Table D-4.4** Electricity sale to PEA from Phuket municipality incinerator (2008)

Electricity from total production sale.to PEA				
Month-year	Total sale. to PEA kWh/mth	Electricity Sale to PEA kWh/ton SW	Carbon from Electricity sale to PEA kgCE/month	Carbon from Electricity Sale .kgCE/tonSW
Jan-08	592,983	62.15	90,726	9.51
Feb-08	528,300	71.97	80,830	11.01
Mar-08	520,787	53.84	79,680	8.24
Apr-08	481,299	48.01	73,639	7.35
May-08	96,187	62.28	14,717	9.53
Jun-08	396,612	48.03	60,682	7.35
Jul-08	402,426	39.26	61,571	6.01
Aug-08	447,560	51.16	68,477	7.83
Sep-08	480,480	62.95	73,513	9.63
Oct-08	549,520	55.64	84,077	8.51
Nov-08	550,360	57.96	84,205	8.87
Dec-08	380,642	41.12	58,238	6.29
<b>Total</b>	5,427,156	-	830,355	-
<b>Average</b>	452,263.00	54.53	69,196.24	8.34
<b>± SD.</b>	130,913.95	9.61	20,029.83	1.47

Source: Bureau of Public Work Phuket Municipality

**Table D-4.5** The electricity production of Phuket municipality solid waste proportional to solid waste from Phuket province (2008)

Month-year	SW Phuket. to Incinerator tons/Month	Electricity.Production from Phuket incin. kWh/Month	Total kgCE/year from Phuket.Mun. incineration
Jan-08	2,414.59	303,390.01	46,418.67
Feb-08	2,099.89	298,583.41	45,683.26
Mar-08	856.75	103,441.65	15,826.57
Apr-08	1,927.12	218,998.40	33,506.75
May-08	2,065.32	279,488.18	42,761.69
Jun-08	2,309.53	242,122.79	37,044.79
Jul-08	2,451.24	238,311.50	36,461.66
Aug-08	990.35	107,417.98	16,434.95
Sep-08	2,186.71	282,483.29	43,219.94
Oct-08	2,426.39	288,191.47	44,093.30
Nov-08	1,954.77	244,335.59	37,383.35
Dec-08	1,955.95	226,690.82	34,683.70
<b>Total</b>	23,639	2,833,455	433,519
<b>Average</b>	1,969.88	236,121.26	36,126.55
<b>± SD.</b>	524.58	67,303.16	10,297.38

Source: Bureau of Public Work Phuket Municipality

**Table D-4.6** The quantity of electricity and carbon equivalent use in incineration proportion of solid waste from Phuket municipality (2008)

Month-year	Electricity use in incineration kWh/Month	Electricity use in incineration kgCE/year	Electricity.sale. to PEA kWh/Month	Electricity.sale.to PEA kgCE/year
Jan-08	156,029.87	23872.57	147,360.14	22,546.10
Feb-08	162,995.87	24938.37	135,587.53	20,744.89
Mar-08	58,507.55	8951.65	44,934.10	6,874.92
Apr-08	129,289.99	19781.37	89,708.41	13,725.39
May-08	268,541.33	41086.82	10,946.84	1,674.87
Jun-08	147,386.41	22550.12	94,736.38	14,494.67
Jul-08	149,987.73	22948.12	88,323.76	13,513.54
Aug-08	66,275.80	10140.20	41,142.17	6,294.75
Sep-08	161,473.86	24705.50	121,009.42	18,514.44
Oct-08	156,558.40	23953.44	131,633.07	20,139.86
Nov-08	132,129.37	20215.79	112,206.21	17,167.55
Dec-08	165,170.29	25271.06	61,520.52	9,412.64
<b>Total</b>	1,754,346.49	268,415.01	1,079,109.00	165,104.00
<b>Average</b>	146,195.54	22,367.92	89,925.71	13,758.63
<b>± SD.</b>	52,763.73	8,072.85	42,704.26	6,533.75

**Table D-4.7** Diesel fuel consumption and carbon equivalent of Phuket MSW incineration (2008)

Month-year	SW to Incin.	L/tonSW	Diesel L.PK	kgCE/Mth	kgCE/TonSW
Jan-08	2414.59	0.0000	0.00	0.00	0.00
Feb-08	2099.89	0.3638	763.84	610.31	0.29
Mar-08	856.75	0.0000	0.00	0.00	0.00
Apr-08	1927.12	0.2793	538.27	430.08	0.22
May-08	2065.32	0.0000	0.00	0.00	0.00
Jun-08	2309.53	0.5958	1376.05	1099.46	0.48
Jul-08	2451.24	0.2439	597.87	477.70	0.19
Aug-08	990.35	0.6539	647.59	517.42	0.52
Sep-08	2186.71	0.5332	1166.03	931.66	0.43
Oct-08	2426.39	0.1671	405.35	323.87	0.13
Nov-08	1954.77	0.1685	329.38	263.17	0.13
Dec-08	1955.95	0.5261	1029.07	822.23	0.42
<b>Total</b>	23638.59	-	6,853.44	5,475.90	-
<b>Average</b>	1,969.88	0.29	571.12	456.32	0.24
<b>SD.</b>	524.58	0.24	459.33	367.00	0.19

**Table D-5** Carbon emission from solid waste collection system in Phuket Municipality 2008

Month-year	Diesel (L/Month)	KgCE/Month	Diesel (L/Ton)	kgCE /TonSW
Jan-08	10,440	8,352	3.42	2.74
Feb-08	10,700	8,560	3.65	2.92
Mar-08	10,950	8,760	3.70	2.96
Apr-08	10,950	8,760	3.79	3.03
May-08	10,950	8,760	3.32	2.66
Jun-08	10,440	8,352	3.60	2.88
Jul-08	9,685	7,748	3.18	2.54
Aug-08	10,700	8,560	3.54	2.83
Sep-08	10,190	8,152	3.50	2.80
Oct-08	10,190	8,152	3.33	2.66
Nov-08	10,440	8,352	3.59	2.87
Dec-08	10,440	8,352	3.71	2.97
<b>Total</b>	126,075.00	100,733.93	-	-
<b>Average</b>	10,506.25	8,405.00	3.53	2.82
<b>± SD.</b>	376.33	301.06	0.18	0.15

**Table D-6** Carbon emission from landfill site operation of SWM of Phuket Municipality 2008

Month-year	Diesel (L/Month)	KgCE/Month	Diesel (L/Ton)	kgCE /TonSW
Jan-08	330.00	264	0.52	0.42
Feb-08	321.00	257	0.39	0.31
Mar-08	1,047.00	836	0.50	0.40
Apr-08	525.00	420	0.54	0.43
May-08	253.00	202	0.21	0.16
Jun-08	226.00	181	0.38	0.31
Jul-08	286.00	228	0.48	0.38
Aug-08	906.00	724	0.45	0.36
Sep-08	305.00	244	0.42	0.34
Oct-08	364.00	291	0.58	0.46
Nov-08	497.00	397	0.52	0.41
Dec-08	224.00	179	0.26	0.21
<b>Total</b>	5,284.90	4,222.64	-	-
<b>Average</b>	440.41	352.33	0.44	0.35
<b>± SD.</b>	269.09	215.27	0.11	0.09

**Table D-7** Methane and carbon sink from landfill site and recycle of SWM of Phuket Municipality

Month-year	SW Composition	Food Waste	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	SW Ton/mth	65.64	6.56	19.28	4.09	0.35	-	0.03	0.64	3.41
Jan-08	635.85	417.37	41.71	122.59	26.01	2.23	-	0.19	4.07	21.68
Feb-08	832.19	546.25	54.59	160.45	34.04	2.91	-	0.25	5.33	28.38
Mar-08	2106.06	1,382.41	138.16	406.05	86.14	7.37	-	0.63	13.48	71.82
Apr-08	964.75	633.26	63.29	186.00	39.46	3.38	-	0.29	6.17	32.90
May-08	1228.65	806.48	80.60	236.88	50.25	4.30	-	0.37	7.86	41.90
Jun-08	589.16	386.72	38.65	113.59	24.10	2.06	-	0.18	3.77	20.09
Jul-08	594.55	390.26	39.00	114.63	24.32	2.08	-	0.18	3.81	20.27
Aug-08	2031.35	1,333.38	133.26	391.64	83.08	7.11	-	0.61	13.00	69.27
Sep-08	727.98	477.84	47.76	140.35	29.77	2.55	-	0.22	4.66	24.82
Oct-08	633.32	415.71	41.55	122.10	25.90	2.22	-	0.19	4.05	21.60
Nov-08	960.34	630.37	63.00	185.15	39.28	3.36	-	0.29	6.15	32.75
Dec-08	860.01	564.51	56.42	165.81	35.17	3.01	-	0.26	5.50	29.33
(1)Total SW tons/year	12164.18	8050.20	804.53	2364.53	501.60	42.92	-	3.68	78.49	418.21
(2)Factor CH <sub>4</sub> Prod. In Landfill kgCH <sub>4</sub> /ton	-	99.40	234.75	6.57	3.30	-	99.40	-	159.00	-
(3)Total CE of CH <sub>4</sub> from Landfill MTCE/Year	764.04	600.14	141.65	11.65	1.24	0.00	0.00	0.00	9.36	0.00
(4)Average Recycle Tons/day			0.461	0.545	1.370	0.013				
(5)Recyclable Material Tons /year	874.06		168.58	199.37	501.46	4.65				
(6)Conversion Factor MTCO <sub>2</sub> E/Short ton			-3.51	-1.50	-0.28	-5.40				
(7)Total CE from recycle MTCE/Year	-317.56		-177.89	-89.90	-42.21	-7.55				

$$\text{Total CE of CH}_4 \text{ from Landfill(3)} = \sum[\text{Total mass of each composition of MSW tons/year(1)} \times \text{Factor CH}_4 \text{ Prod. In Landfill kgCH}_4\text{/ton(2)}] \times (12/16)/1000 = \text{MTCE/year}$$

$$\text{Total CE from recycle(7)} = \sum[\text{Total mass of each Recyclable Material Tons /year(5)} \times \text{Conversion Factor MTCO}_2\text{E/Short ton(6)} \times (1.1023 \text{ short ton/MT})] \times (12/44) = \text{MTCE/year}$$

Carbon storage in landfill (Appendix F (F.2))

**Table D-8** Scenario at 10% 25% and 35% recycle of Phuket Municipality SWM (Landfill)

Month-year	SW Composition	Food Waste	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	SW Ton/mth	65.64	6.56	19.28	4.09	0.35	0.00	0.03	0.64	3.4
Total SW tons/year	12,164.2	7,984.6	798.0	2,345.3	497.5	42.6	0.0	3.6	77.9	414.8
Factor CH <sub>4</sub> Prod kgCH <sub>4</sub> /ton	-	99.40	234.75	6.57	3.30	-	99.40	-	159.00	-
Total CE of CH <sub>4</sub> from Landfill MTCE/Year	764.04	600.14	141.65	11.65	1.24	-	-	-	9.36	-
Average Recycle Tons/day	0.812	-	0.157	0.185	0.466	0.004	-	-	-	-
Recyclable Material Tons /year	874.06	-	168.58	199.37	501.46	4.65	-	-	-	-
Conversion Factor MTCO <sub>2</sub> E/Short ton	-	-	-3.51	-1.5	-0.28	-5.4	-	-	-	-
Total CE from recycle MTCE/Year	-317.56	-	177.89	-89.90	-42.21	-7.55	-	-	-	-
Average kgCE/tonSW	62.81	74.55	176.06	4.93	2.48	0.00	0.00	0.00	119.25	0.00
10% Recycle Ton/year	371.36	-	80.45	236.45	50.16	4.29	-	-	-	-
Reduction from recycle(10%)MTC E/year	-202.71	-	-84.89	-106.63	-4.22	-6.97	-	-	-	-
Reduction 10%+base-line	-520.27	-	262.78	-196.53	-46.43	-14.52	-	-	-	-
Total SW after R 10%	11,892.82	8,050.20	724.08	2,128.08	451.44	38.63	-	3.68	78.49	418.21
Total carbon from CH <sub>4</sub>	748.59	600.14	127.48	10.49	1.12	0.00	0.00	0.00	9.36	0.00
25% Recycle Ton/year	928.40	-	201.13	591.13	125.40	10.73	-	-	-	-
Reduction from recycle(25%)MTC E/year	-506.78	-	212.24	-266.57	-10.56	-17.42	-	-	-	-
Reduction 25%+base-line	-824.33	-	390.13	-356.47	-52.77	-24.97	-	-	-	-
Total SW after R 25%	11,335.78	8,050.20	603.40	1,773.40	376.20	32.19	-	3.68	78.49	418.21
Total carbon from CH <sub>4</sub>	725.41	600.14	106.24	8.74	0.93	-	-	-	9.36	-
35% Recycle Ton/year	1299.76	-	281.59	827.59	175.56	15.02	-	-	-	-
Reduction from recycle(35%)MTC E/year	-709.49	-	297.13	-373.19	-14.78	-24.39	-	-	-	-
Reduction 35%+base-line	-1027.05	-	-475.02	-463.09	-56.99	-31.94	-	-	-	-
Total SW after R 25%	10,964.42	8,050.20	522.94	1,536.95	326.04	27.90	-	3.68	78.49	418.21
Total carbon from CH <sub>4</sub>	709.95	600.14	92.07	7.57	0.81	-	-	-	9.36	-

The same calculation as Table D-7 for carbon from methane and recycle

Carbon storage in landfill (Appendix F (F.2))

**Table D-9** Carbon from fossil and from organic carbon emitted from incinerator and recycle of SWM of Phuket Municipality (Incineration)

Month-year	SW Composition	Food Waste	Paper	Plastic	Glass	Metal	Wood	Rubber	Cloths	Others
	SW Ton/mth	65.64	6.56	19.28	4.09	0.35	-	0.03	0.64	3.41
Jan-08	2414.59	1,584.94	158.40	465.53	98.76	8.45	-	0.72	15.45	82.34
Feb-08	2099.89	1,378.36	137.75	404.86	85.89	7.35	-	0.63	13.44	71.61
Mar-08	856.75	562.37	56.20	165.18	35.04	3.00	-	0.26	5.48	29.22
Apr-08	1927.12	1,264.96	126.42	371.55	78.82	6.74	-	0.58	12.33	65.71
May-08	2065.32	1,355.68	135.48	398.19	84.47	7.23	-	0.62	13.22	70.43
Jun-08	2309.53	1,515.97	151.50	445.28	94.46	8.08	-	0.69	14.78	78.75
Jul-08	2451.24	1,608.99	160.80	472.60	100.26	8.58	-	0.74	15.69	83.59
Aug-08	990.35	650.07	64.97	190.94	40.51	3.47	-	0.30	6.34	33.77
Sep-08	2186.71	1,435.36	143.45	421.60	89.44	7.65	-	0.66	13.99	74.57
Oct-08	2426.39	1,592.68	159.17	467.81	99.24	8.49	-	0.73	15.53	82.74
Nov-08	1954.77	1,283.11	128.23	376.88	79.95	6.84	-	0.59	12.51	66.66
Dec-08	1955.95	1,283.89	128.31	377.11	80.00	6.85	-	0.59	12.52	66.70
Total SW tons/year	23638.59	15582.01	1557.25	4576.80	970.91	83.09	-	7.12	151.93	809.49
C-CO <sub>2</sub> from fossil MTCE/ton	See Appendix F for all scenarios									
C-CO <sub>2</sub> from biomass	See Appendix F for all scenarios									
10% Recycle tons/year	718.80		155.73	457.68	97.09	8.31				
Total SW after R 10%	23,019.79	15,582.01	1,401.53	4,119.12	873.82	74.78	-	7.12	151.93	809.49
25% Recycle tons/year	1797.01		389.31	1,144.20	242.73	20.77				
Total SW after R 25%	21,941.58	15,582.01	1,167.94	3,432.60	728.18	62.31	-	7.12	151.93	809.49
35% Recycle tons/year	2515.82		545.04	1,601.88	339.82	29.08				
Total SW after R 35%	21,222.78	15,582.01	1,012.21	2,974.92	631.09	54.01	-	7.12	151.93	809.49
Total CE from recycle MTCE/Year	-317.56		-177.89	-89.90	-42.21	-7.55				

**APPENDIX E**  
**METHANE FROM LANDFILL**

Methane emitted from landfill is calculated by using emission factor in Table E-1 All CO<sub>2</sub> has its origin from bio-available carbon and is therefore not accounted for global warming.

**Table E-1** Methane from landfilling

Waste fraction	CH <sub>4</sub> (kg/ton)	
Food, garden waste	99.4	
Newspaper, magazines	240	} 234.75
Milk cartons	213	
Mixed cardboard	240	
Other paper	246	
Plastic foil	19.0	} 6.57
Hard plastic packaging	0.3	
Other plastic	0.4	
Textiles	159	
Glass	3.3	

Sandgren, J., et. al., 1996.

**Table E-2** Carbon storage for solid waste components (EPA, 2010)

Material/Product	Ratio of Carbon Storage to Dry Weight (gram C/dry gram)	Ratio of Dry Weight to Wet Weight	Ratio of Carbon Storage to Wet Weight (gram C/wet gram)	Amount of Carbon Stored (MTCO <sub>2</sub> E per Wet Short Ton)
Corrugated Containers	0.26	0.95	0.25	0.82
Magazines/Third-Class Mail	0.26	0.95	0.25	0.82
Newspaper	0.42	0.95	0.40	1.33
Office Paper	0.05	0.95	0.05	0.16
Phone Books	0.42	0.95	0.40	1.33
Textbooks	0.05	0.95	0.05	0.16
Dimensional Lumber	0.38	0.90	0.34	1.14
Medium-Density Fiberboard	0.38	0.90	0.34	1.14
Food Scraps	0.08	0.30	0.02	0.08
Yard Trimmings	0.31	0.55	0.19	0.63
Grass	0.24	0.30	0.07	0.24
Leaves	0.39	0.70	0.27	0.90
Branches	0.38	0.90	0.34	1.14
Mixed MSW	0.08	0.84	0.07	0.22
Drywall	0.03	0.94	0.03	0.09
Wood Flooring	0.38	0.75	0.29	0.95

The calculation for the amount of carbon stored in land fill are as follow:

$\sum C_s$  Total carbon fixation that are store in the landfill. MTCE/year

$$= \text{Tons of mixed MSW} \times 0.22 \text{ MTCO}_2\text{E/Short Ton} \times (1.1023 \text{ Short Ton/MT}) \times (12/44) = \text{MTCE /year}$$

**Table E-3** GHG Emissions for Recycling (MTCO<sub>2</sub>E/Short ton of material recovered)

(a) Material	(b) Recycled Input Credit: <sup>a</sup> Process Energy	(c) Recycled Input Credit: <sup>a</sup> Transportation Energy	(d) Recycled Input Credit: <sup>a</sup> Process Non-Energy	(e) Forest Carbon Storage	(f) GHG Reductions from Using Recycled Inputs Instead of Virgin Inputs (f = b + c + d + e)
Aluminum Cans	-10.76	-0.42	-2.43	-	-13.61
Steel Cans	-1.76	-0.04	-	-	-1.80
Copper Wire	-4.91	-0.06	-	-	-4.97
Glass	-0.12	-0.02	-0.14	-	-0.28
HDPE	-1.23	0.00	-0.15	-	-1.38
LDPE	-1.53	0.00	-0.15	-	-1.67
PET	-1.44	0.00	-0.08	-	-1.52
Corrugated Containers	0.01	-0.05	-0.01	-3.06	-3.10
Magazines/Third-Class Mail	-0.01	-	-	-3.06	-3.07
Newspaper	-0.75	-0.03	-	-2.02	-2.80
Office Paper	0.22	-	-0.02	-3.06	-2.85
Phone Books	-0.64	-	-	-2.02	-2.65
Textbooks	-0.05	-	-	-3.06	-3.11
Dimensional Lumber	0.07	0.01	-	-2.53	-2.46
Medium-Density Fiberboard	0.05	0.02	-	-2.53	-2.47
Food Scraps	NA	NA	NA	NA	NA
Yard Trimmings	NA	NA	NA	NA	NA
Grass	NA	NA	NA	NA	NA
Leaves	NA	NA	NA	NA	NA
Branches	NA	NA	NA	NA	N
Mixed Paper					
Paper (general)	-0.34	-0.11	-0.01	-3.06	-3.51
Mixed Paper (primarily residential)	-0.34	-0.11	-0.01	-3.06	-3.51
Mixed Paper (primarily from offices)	-0.43	-0.11	-0.00	-3.06	-3.60
Mixed Metals	-4.50	-0.16	-0.74	-	-5.40
Mixed Plastics	-1.38	0.00	-0.12	-	-1.50
Mixed Recyclables	-0.37	-0.04	-0.05	-2.41	-2.87
Mixed Organics	NA	NA	NA	NA	NA
Mixed MSW	NA	NA	NA	NA	NA
Carpet	-5.42	-0.06	-1.74	-	-7.22
Personal Computers	-1.50	-0.04	-0.73	-	-2.26
Clay Bricks	NA	NA	NA	NA	NA
Concrete	-0.00	-0.01	-	-	-0.01
Fly Ash	-0.42	-	-0.45	-	-0.87
Tires	-0.46	0.07	-	-	-0.39
Asphalt Concrete	-0.03	-0.05	-	NA	-0.08
Asphalt Shingles	-0.11	0.02	-	NA	-0.09
Drywall	0.01	0.03	-	-	0.03
Fiberglass Insulation	NA	NA	NA	NA	NA
Vinyl Flooring	NA	NA	NA	NA	NA
Wood Flooring	NA	NA	NA	NA	NA

NA = Not applicable.

- = Zero emissions.

Note that totals may not add due to rounding, and more digits may be displayed than are significant. Negative values denote GHG emission reductions or carbon storage.

<sup>a</sup> Material that is recycled after use is then substituted for virgin inputs in the production of new products. This credit represents the difference in emissions that results from using recycled inputs rather than virgin inputs. The credit accounts for loss rates in collection, processing and remanufacturing. Recycling credit is based on closed- and open-loop recycling, depending on material.

## APPENDIX F

### BACKGROUND CALCULATIONS

The Appendix G illustrates background calculation of emissions to air and water from incineration in the base scenario in section F.1 and F.2, respectively. Calculation of the anaerobic digestion as the unit process in scenario 4, 6 and 7 is illustrated in section F.3.

#### F.1 Air Emissions from Combustion in the incineration

Period of calculation	2008
Days of incineration	322 days
Amount of MSW incinerated	101,640 (23,639) tons
Stack diameter	1.5 m.
Average flue gas velocity	14.89 m/s

Average concentration of gas emitted from stack

CO      55.88 ppm    (by periodic measurement)

CO<sub>2</sub>    10.69 %    (by periodic measurement)

$$\begin{aligned}
 \text{Flow rate of flue gas} &= \text{Average flue gas velocity} \times \text{Cross sectional area of} \\
 \text{stack} &= (14.89 \text{ m/s}) \times \left( \frac{\pi \times 1.5^2}{4} \text{ m}^2 \right) \\
 &= 26.313 \text{ m}^3/\text{s}
 \end{aligned}$$

Volume of flue gas generated during incineration of 1 ton MSW

$$\begin{aligned}
 &= \frac{\text{Flow rate of flue gas} \times \text{Period of incineration}}{\text{Amount of MSW incinerated}} \\
 &= \frac{(26.313 \text{ m}^3 / \text{s}) \times (322 \times 24 \times 3600 \text{ s})}{101,640 \text{ tons}} \\
 &= 7,202.368 \text{ m}^3
 \end{aligned}$$

Amount of gas emitted from stack per ton MSW incinerated can be calculated as:

Amount of gas (volume unit) = Concentration of gas × Volume of flue gas

At STP, gas 1 mol has a volume of 22.4 L

Amount of gas (mass unit) = (grams/mol of gas) × Volume of gas / 22.4 L

Therefore,

$$\begin{aligned} \text{Amount of CO} &= 55.88 \text{ ppm} \times 7,202.368 \text{ m}^3 \times 10^3 \text{ L/m}^3 = 402.468 \text{ L} \\ &= 28 \text{ g} \times 402.468 \text{ L} / (22.4 \text{ L} \times 10^3 \text{ g/kg}) = 0.503 \text{ kg} \end{aligned}$$

$$\text{Amount of Carbon} = 0.503 \times 12/28 = 0.216 \text{ kgC}$$

$$\begin{aligned} \text{Amount of CO}_2 &= 10.69 \% \times 7,202.368 \text{ m}^3 \times 10^3 \text{ L/m}^3 = 769,933 \text{ L} \\ &= 44 \text{ g} \times 769,933 \text{ L} / (22.4 \text{ L} \times 10^3 \text{ g/kg}) = 1,512 \text{ kg} \end{aligned}$$

$$\text{Amount of Carbon} = 1,512 \text{ kgCO}_2 \times 12/44 = 412.36 \text{ kgCE}$$

Since CO<sub>2</sub> generated from MSW incineration is classified and divided as biomass CO<sub>2</sub> (from combustion of paper, food waste, and other organic waste) and fossil CO<sub>2</sub> (mainly from combustion of plastic waste), fossil CO<sub>2</sub> generated from plastic waste combustion is needed to be calculated.

Emission factor for CO<sub>2</sub> from incineration is obtained from Sundqvist et. al. (1997). The oxidation of C to CO<sub>2</sub> has been assumed to be 96.7%. The C content in mixed plastic waste has been assumed to be 0.75 kg/kg waste. Therefore,

$$\begin{aligned} \text{Emission factor of C} &= 0.967 \text{ kg} \times 0.75 \text{ kg C/kg plastic waste} \\ &= 0.72525 \text{ kg C/kg plastic waste} \end{aligned}$$

In Phuket incineration plant, from 1 ton of MSW incinerated, plastics account for 19.28 % by weight = 192.8 kg./ ton of MSW

$$\text{Fossil C generated from plastic combustion} = 192.8 \times 0.72525 = 139.83 \text{ kgCE/ ton of MSW}$$

$$\text{Biomass CE} = 412.36 - 139.83 = 272.53 \text{ kg/ ton of MSW}$$

Therefore, estimated carbon emitted from incineration in the inventory year 2008 was

1. Total fossil C generated from plastic combustion = 101,640 tons x 139.83 kgC/ ton = 14,212,321.2 kgC/year = 14,212 MTCE/year
2. Proportional for Phuket Municipality Total fossil C generated from plastic combustion = 23,639 tons x 139.83 kgC/ ton = 3,305,441.37 kgC/year 3,305 MTCE/year

3. Total Biomass C generated from Biomass combustion = 101,640 tons x 272.53 kgC/ ton = 27,699,949 kgCE/year = 27,700 MTCE/year
4. Proportional for Phuket Municipality Total Biomass C generated from plastic combustion = 23,639 tons x 272.53 kgC/ ton = 6,442,336.67 kgC/year 6,442 MTCE/year
5. In case of plastic recycle at 10%, 25% and 35% assume that the emission was the same the calculation of carbon emission are as follow
  - 5.1 At 10% recycle  $192.8 \times 0.9 \times 0.72525 = 125.85$  kgCE/ ton of MSW  
 C-fossil  $125.85 \times 23,019$  tonSW = 2,896,941.15 kgCE/ ton of MSW  
 C-biomass  $(412.36 - 125.85) \times 23,019$  tonSW = 6,595,173.69 kgCE/ tonSW
  - 5.2 At 25% recycle  $192.8 \times 0.75 \times 0.72525 = 104.87$  kgCE/ ton of MSW  
 C-fossil  $104.87 \times 21,941$  tonSW = 2,300,952.67 kgCE/ ton of MSW  
 C-biomass  $(412.36 - 104.87) \times 21,941$  tonSW = 6,746,638.09 kgCE/ tonSW
  - 5.3 At 35% recycle  $192.8 \times 0.65 \times 0.72525 = 90.89$  kgCE/ ton of MSW  
 C-fossil  $90.89 \times 21,223$  tonSW = 1,928,958.47 kgCE/ ton of MSW  
 C-biomass  $(412.36 - 90.89) \times 21,223$  tonSW = 6,822,577.81 kgCE/ tonSW

The total mass of solid waste input in incineration decrease due to recycle.

## F.2 Carbon Storage in Landfill

$$\sum C_s = \text{Tons of mixed MSW/year} \times 0.22 \text{ MTCO}_2\text{E/Short Ton} \times (1.1023) \times (12/44) = \text{MTCE/year}$$

### Nonthaburi Municipality Scenarios

$$\text{Base-line} = 96,610.40 \times 0.22 \times (1.1023) \times (12/44) = 6389.62 \text{ MTCE/year}$$

$$10\% \text{ Recycle} = 95,610.97 \times 0.22 \times (1.1023) \times (12/44) = 6323.52 \text{ MTCE/year}$$

$$25\% \text{ Recycle} = 91,039.60 \times 0.22 \times (1.1023) \times (12/44) = 6021.18 \text{ MTCE/year}$$

$$35\% \text{ Recycle} = 87,992.03 \times 0.22 \times (1.1023) \times (12/44) = 5819.62 \text{ MTCE/year}$$

### Khon Kaen Municipality Scenarios

$$\text{Base-line} = 56,252.14 \times 0.22 \times (1.1023) \times (12/44) = 3690.19 \text{ MTCE/year}$$

$$10\% \text{ Recycle} = 54,449.03 \times 0.22 \times (1.1023) \times (12/44) = 3601.15 \text{ MTCE/year}$$

$$25\% \text{ Recycle} = 52,429.52 \times 0.22 \times (1.1023) \times (12/44) = 3467.58 \text{ MTCE/year}$$

$$35\% \text{ Recycle} = 51,083.18 \times 0.22 \times (1.1023) \times (12/44) = 3378.54 \text{ MTCE/year}$$

#### Phitsanulok Municipality Scenarios

$$\text{Base-line} = 28,424.71 \times 0.22 \times (1.1023) \times (12/44) = 1819.42 \text{ MTCE/year}$$

$$10\% \text{ Recycle} = 26,789.28 \times 0.22 \times (1.1023) \times (12/44) = 1771.79 \text{ MTCE/year}$$

$$25\% \text{ Recycle} = 25,708.98 \times 0.22 \times (1.1023) \times (12/44) = 1700.34 \text{ MTCE/year}$$

$$35\% \text{ Recycle} = 24,988.79 \times 0.22 \times (1.1023) \times (12/44) = 1652.71 \text{ MTCE/year}$$

#### Phuket Municipality Scenarios

$$\text{Base-line} = 12164.18 \times 0.22 \times (1.1023) \times (12/44) = 804.51 \text{ MTCE/year}$$

$$10\% \text{ Recycle} = 11,892.82 \times 0.22 \times (1.1023) \times (12/44) = 786.57 \text{ MTCE/year}$$

$$25\% \text{ Recycle} = 11,335.78 \times 0.22 \times (1.1023) \times (12/44) = 749.73 \text{ MTCE/year}$$

$$35\% \text{ Recycle} = 10,964.42 \times 0.22 \times (1.1023) \times (12/44) = 725.16 \text{ MTCE/year}$$

**F.3** The calculation for the kgCE from diesel and electricity consumption used average carbon equivalent per ton of solid waste multiply by proportional to the mass of solid waste that change by % recycling in each scenarios.