SUMMARY REPORT

THE STUDY OF EMISSION FACTOR FOR ELECTRICITY GENERATION OF THAILAND IN YEAR 2010

Rationale

Thailand realizes the seriousness of climate change as a global threat and it has been contributing to international efforts to address climate change issues. Thailand ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 28th December 1994 and the Kyoto Protocol on 28th August 2002. As a Non-Annex I country, Thailand promotes the implementation of the **Clean Development Mechanisms (CDM)** under the Kyoto Protocol in order to encourage greenhouse gas (GHG) limitation and reduction in the country, as well as to promote the sustainable development business in developing countries.

Thailand Greenhouse Gas Management Organization (Public Organization): TGO was established by Royal Decree on Establishment of Thailand Greenhouse Gas Management Organization (Public Organization) in year 2007 (B.E. 2550). It is presently a public organization under the Ministry of Natural Resources and Environment (MNRE). Besides being the Thailand's Designated National Authority for the Clean Development Mechanism (Thai DNA), which is responsible for review and approval the CDM projects, TGO also has other roles including as an implementing agency on GHG emission reduction in Thailand, promoting: low carbon activities, investment and marketing on GHG emission reductions, establishing the GHG information center, Including encouraging the capacity building and outreach for CDM stakeholders, in term of government and private sectors.

The Grid Emission Factor of Thailand is a main issue for calculating the Certified Emission Reductions (CERs) of the CDM projects that generate and transmit electricity to the national grid must use an emission factor that represents the quantity of CO_2 emits from electricity generation. The CDM project developers in Thailand used the variant grid emission factor values to calculate the CERs by themselves. Consequently, the amounts of CERs are so different and cause problems in the validation process.

In order to support the project developers to use the accurate value of the Thailand Grid Emission Factor for calculating CERs of CDM projects in Thailand. The TGO's Board appoints the working group for study the emission factor for electricity generation of Thailand in year 2009. The study results are as the following:

Calculation for the emission factor of electricity generation

The emission factor of electricity generation can be calculated by **Methodological Tool (Version 02.2.1) "Tool to calculate the emission factor for an electricity system"** that was approved by the CDM Executive Board on 29 September 2011 (EB 63, Annex 19). The parameters of this methodological tool are listed below.

Parameter	SI Unit	Description
$EF_{grid,CM,y}$	tCO_2/MWh	Combined margin CO_2 emission factor for the project electricity system in year *y*
$EF_{grid,OM,y}$	tCO_2/MWh	Operating margin CO_2 emission factor for the project electricity system in year *y*
$EF_{grid,BM,y}$	tCO_2/MWh	Build margin CO_2 emission factor for the project electricity system in year *y*

The calculated emission factor can be used for the calculation of emission reductions of CDM projects that generate and transmit electricity to the Thai national grid or replace electricity consumption from the Thai national grid.

Identification of the electricity system

In Thailand, the electricity transmission line system is considered as a single grid system due to the transmission lines are networked all of the country area.

Electricity Generating Authority of Thailand (EGAT) regulate electricity generation and main transmission system, meanwhile Metropolitan Electricity Authority (MEA) is responsible for electricity distribution system in Bangkok and vicinity area, and Provincial Electricity Authority (PEA) is responsible for electricity distribution system in the rest of country.

Method to determine the operating margin emission factor

The calculation of the operating margin (OM) emission factor (*EFgrid,OM,y*) is based on the one of the following methods:

1) Simple OM
2) Simple Adjusted OM
3) Dispatch Data Analysis OM
4) Average OM

According to Thailand's data, the Simple OM method (ex ante option) is the most appropriate method that requires the latest 3 years data including the quantity of electricity generation, fuel types and fuel consumption of each fuel type. In this study, used the electricity statistic data in the years 2008 – 2010 due to as the following:

1. In Thailand, the electricity data that generate and transmit to the national grid system are available. While, the off-grid electricity data are not available.

2. The low-cost/must-run (LC/MR) power plants include hydropower and renewable power plants. The quantity of electricity that was generated by LC/MR, constitute less than 50% of the total grid generation in average of the 5 most recent years (in the years 2006 – 2010). Therefore, LC/MR data are not included in the OM calculation.

The operating margin emission factor can be calculated by the equation (1), follows with the Simple OM (option B)

$$EF_{grid,OMsimple,y} = \frac{\sum_i \left(FC_{i,y} \times NCV_{i,y} \times EF_{CO_2,i,y}\right)}{EG_y} \quad (1)$$

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$FC_{i,y}$	=	Amount of fossil fuel type *i* consumed in the project electricity system in year *y* (mass or volume unit)
$NCV_{i,y}$	=	Net Calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO_2,i,y}$	=	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
EG_y	=	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must run power plants/units, in year *y* (MWh)
i	=	All fossil fuel types combusted in power sources in the project electricity system in year *y*
y	=	The relevant year as per the data vintage chosen

The Net Calorific Value (NCV) is obtained from data that provided by Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. The CO_2 emission factor of fossil fuel follows IPCC default values in the ***2006 IPCC Guidelines for National Greenhouse Gas Inventories***. The values of CO_2 emission from combustion of fossil fuel (per unit of fossil fuel) are shown in Table 1.

Table 1 Net Calorific Value and CO_2 emission per unit of each type of fossil fuel

Fuel type [A]	Unit	Net Calorific Value [1] (MJ/Unit)	CO_2 Emission [2] (tCO_2/TJ)	CO_2 Emission ($kgCO_2/Unit$)
Natural Gas	scf.	1.02	54.30	0.0554
Lignite	ton	10,470.00	90.90	951.7230
Bituminous	ton	26,370.00	89.50	2,360.1150
Bunker	liter	39.77	75.50	3.0026
Diesel	liter	36.42	72.60	2.6441

[1] Electric Power in Thailand 2010, Department of Alternative Energy Development and Efficiency, Ministry of Energy

[2] IPCC default values at the lower limit as provide in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

[A] See Table: Comparison of name of fuel type

The quantity of electricity was generated and transmitted to the national grid can be obtained from the Electricity Statistic Annual Report 2008 – 2010 that provided by EGAT.

The quantity of electricity generation data is categorized by electricity generation system, group of power producer (EGAT, IPP and SPP) and type of power plant (LC/MR and Non LC/MR) as shown in Table 2. And the data of type and quantity of fossil fuel consumption in electricity generation are categorized by type of power producer (EGAT, IPP and SPP) as shown in Table 3.

VSPP is the renewable power plant such as biogas, biomass, hydropower, wind power and solar power which install the capacity equal or less than 10 MW and is considered as LC/MR power plant. However, VSPP power plants are non-firm and can supply only a small quantity of electricity to the national grid compared to other power plants. In year 2010, the quantity of electricity was generated by VSPP power plants, was supplied to the distribution system of PEA was 1,155.10 GWh [3] (0.72% of the total electricity was generated in 2010).

Thus, this study does not include quantity of electricity that was generated and supplied by VSPP in the calculation. The total quantity of electricity was transmitted to the national grid (only Non LC/MR) in the years 2008 – 2010 was 424,913.67 GWh.

[3] Provincial Electricity Authority

Table 2 Quantity of electricity was generated and transmitted to the national grid [4]

Generation System	Grid Generation (GWh)				
	EGAT	IPP	SPP	Total	%
2010					
Summary	78,517.70	67,775.98	13,897.27	160,190.96	100.00
Non LC/MR	73,185.41	67,775.98	11,642.33	152,603.73	95.26
LC/MR [5]	5,332.30	—	2,254.94	7,587.23	4.74
Thermal	27,289.03	15,408.42	2,162.89	44,860.34	
Combined-Cycle	38,338.71	52,367.56	8,655.76	99,362.04	
Gas Turbine	276.30	—	823.67	1,099.97	
Diesel Engine	3.98	—	—	3.98	
Hydropower	5,325.20	—	23.64	5,348.84	
Renewable Energy	7.10	—	2,231.30	2,238.40	
Electricity Import	7,277.39	—	—	7,277.39	
2009					
Summary	66,488.10	64,840.72	13,971.37	145,300.19	100.00
Non LC/MR	59,541.66	64,840.72	11,811.42	136,193.80	93.73
LC/MR	6,946.44	—	2,159.95	9,106.39	6.27
Thermal	23,463.69	12,388.03	2,225.63	38,077.35	
Combined-Cycle	33,164.46	52,452.69	8,752.19	94,369.35	
Gas Turbine	309.63	—	833.60	1,143.23	
Diesel Engine	1.44	—	—	1.44	
Hydropower	6,941.74	—	23.97	6,965.71	
Renewable Energy	4.70	—	2,135.98	2,140.68	
Electricity Import	2,602.43	—	—	2,602.43	
2008					
Summary	63,719.02	67,420.14	14,092.83	145,232.00	100.00
Non LC/MR	56,791.19	67,420.14	11,904.81	136,116.14	93.72
LC/MR	6,927.83	—	2,188.03	9,115.86	6.28
Thermal	26,778.89	14,398.34	1,996.83	43,174.06	
Combined-Cycle	26,449.20	53,021.80	9,029.90	88,500.90	
Gas Turbine	659.33	—	878.07	1,537.41	
Diesel Engine	2.30	—	—	2.30	
Hydropower	6,926.02	—	28.77	6,954.79	
Renewable Energy	1.81	—	2,159.26	2,161.07	
Electricity Import	2,901.47	—	—	2,901.47	

[4] Electricity Statistic Annual Report 2008 – 2010, Electricity Generating Authority of Thailand

[5] LC/MR power plants include hydropower and renewable energy (including biomass, solar and geothermal power)

Table 3 Amount of fossil fuel consumed by power plants [6]

Fuel type	Unit	Fuel Consumption			
		EGAT	IPP	SPP	Total
2010					
Natural Gas	scf.	430,662,249,446	491,131,955,423	151,290,468,150	1,073,084,673,019
Lignite	ton	16,043,174	—	—	16,043,174
Bituminous	ton	—	3,646,898	1,855,262	5,502,160
Bunker	liter	140,084,467	87,347,782	5,797,497	233,229,746
Diesel	liter	11,865,427	10,853,795	1,307,336	24,026,558
2009					
Natural Gas	scf.	369,146,214,392	459,228,417,361	140,550,086,056	968,924,717,809
Lignite	ton	15,818,265	—	—	15,818,265
Bituminous	ton	—	3,645,721	1,840,527	5,486,248
Bunker	liter	111,039,065	38,180,874	8,797,506	158,017,445
Diesel	liter	12,140,891	—	1,685,046	13,825,937
2008					
Natural Gas	scf.	340,739,529,461	490,866,999,785	145,410,364,035	977,016,893,281
Lignite	ton	16,407,465	—	—	16,407,465
Bituminous	ton	—	3,711,791	1,866,776	5,578,567
Bunker	liter	247,441,682	93,212,260	9,555,452	350,209,394
Diesel	liter	6,792,039	43,698,832	1,451,087	51,941,958

[6] Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

Table 4 shows the calculated CO_2 emission from electricity generation in the years 2008 - 2010 categorized by type of fossil fuel. The total emissions during the 3-years period were 254,714,130 tCO_2.

The OM emission factor was calculated by the equation (1) and follows with the Simple OM method option B (ex ante option) that is shown in Table 5. The OM emission factor is 0.5994 tCO_2/MWh.

Table 4 Quantity of CO_2 emission was emitted from electricity generation in the years 2008 - 2010

Fuel type	Fuel Consumption		CO_2 Emission ($kgCO_2$/Unit)	CO_2 Emission ($kgCO_2$)
	Unit	Volume		
2010				
Total				88,452,088
Natural Gas	scf.	1,073,084,673,019	0.0554	59,433,868
Lignite	ton	16,043,174	951.7230	15,268,658
Bituminous	ton	5,502,160	2,360.1150	12,985,730
Bunker	liter	233,229,746	3.0026	700,304
Diesel	liter	24,026,558	2.6441	63,528
2009				
Total				82,178,673
Natural Gas	scf.	968,924,717,809	0.0554	53,664,864
Lignite	ton	15,818,265	951.7230	15,054,607
Bituminous	ton	5,486,248	2,360.1150	12,948,176
Bunker	liter	158,017,445	3.0026	474,469
Diesel	liter	13,825,937	2.6441	36,557
2008				
Total				84,083,369
Natural Gas	scf.	977,016,893,281	0.0554	54,113,058
Lignite	ton	16,407,465	951.7230	15,615,362
Bituminous	ton	5,578,567	2,360.1150	13,166,060
Bunker	liter	350,209,394	3.0026	1,051,551
Diesel	liter	51,941,958	2.6441	137,339

Table 5 Operating Margin Emission Factor (Ex ante option)

Year	CO_2 Emission (tCO_2)	Grid Consumption (GWh)	OM Emission Factor (tCO_2/MWh)
2010	88,452,088	152,603.73	0.5796
2009	82,178,673	136,193.80	0.6034
2008	84,083,369	136,116.14	0.6177
Summary	254,714,130	424,913.67	0.5994

Method to determine the build margin emission factor

The group of power units is used for calculating the build margin (BM) emission factor which can be determined following with the option 1 (*ex ante*) and condition (b) [B]:

"(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the gird most recently and that comprise 20% AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET\geq 20\%}$, in MWh)"

The group of power units that supply electricity to the grid most recently (sorted by the Commercial Operation Date (COD) which is the date when the power unit starts to supply electricity to the grid) and their annual quantity of electricity generation comprise larger than or equal to 20% of total annual electricity generation (in year 2010) are shown in Table 6. And fuel consumption of these power units are shown in Table 7

Table 6 Quantity of electricity was generated by the most recently built power plants [7]

Power Unit	Grid Generation [7] (GWh)	COD
1. North Bangkok Power Plant (Unit 01)	1,584.22	19-Nov-10
2. Bangpakong Power Plant (Unit 05)	4,643.22	16-Sep-09
3. Phu Kieaw Bio Power Project 2	79.46	15-Sep-09
4. Dan Chang Bio Power Project 2	76.75	15-Sep-09
5. South Bangkok Power Plant (Unit 03)	4,431.92	1-Mar-09
6. Chana Power Plant (Unit 01)	5,090.02	15-Jul-08
7. Ratchaburi Power Company Limited (RPCL) (Unit 1&2)	7,124.72	1-Jun-08
8. Gulf Power Generation Co., Ltd. (Unit 1&2)	9,903.93	1-Mar-08
Summary	32,934.25	
Percentage as of 2010 Grid Generation (160,190.96 GWh)	20.56	

[7] Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

[B] See Methodological Tool (Version 02.2.1) "Tool to calculate the emission factor for an electricity system"

Table 7 Fuel consumptions of the most recently built power plants as listed in Table 6 [8]

Fuel type	Fuel Consumption		CO_2 Emission ($kgCO_2$/Unit)	CO_2 Emission (tCO_2)
	Unit	Volume		
Total				
Natural Gas	scf.	251,512,881,819	0.0554	13,930,292
Lignite	ton	—	951.7230	—
Bituminous	ton	—	2,360.1150	—
Bunker	liter	—	3.0026	—
Diesel	liter	1,179,772	2.6441	3,119

[8] Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

Table 8 Calculation of the build margin emission factor

Year	CO_2 Emission (tCO_2)	Grid Consumption (GWh)	BM Emission Factor (tCO_2/MWh)
2010	13,933,412	32,934.25	0.4231

As shown in Table 6, the annual quantity of electricity generation that generated by the most recently built power units which comprise 32,934.25 GWh (20.56% of the total electricity generated in year 2010 which is 160,190.96 GWh).

As shown in Table 7, the CO_2 emission of the most recently built power units is emitted from fossil fuel consumption which comprise 20,991,690 tonCO_2.

As shown in table 8, the BM emission factor that calculated by the equation (1), is 0.4231 tCO_2/MWh.

Method to determine the combined margin emission factor

The combined margin (CM) emission factor can be calculated by the equation (2):

$$EF_{grid,CM,y} = \left(EF_{grid,OM,y} \times w_{OM}\right) + \left(EF_{grid,BM,y} \times w_{BM}\right) \quad (2)$$

$EF_{grid,CM,y}$	=	Combined margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EF_{grid,OM,y}$	=	Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
w_{OM}	=	Weighting of operating margin emission factor
w_{BM}	=	Weighting of build margin emission factor

The weighting of OM emission factor and BM emission factor for calculate CM emission factor is categorized by type of CDM project, as shown in Table 9.

Table 9 Weighting of operating and build margin emissions factor for general CDM projects and wind and solar power generation CDM projects

CDM project type	w_{OM}	w_{BM}
General project	0.50	0.50
Wind and solar power generation project	0.75	0.25

The CM emission factors that were calculated by the equation (2) follow with the **Methodological Tool (Version 02.2.1) "Tool to calculate the emission factor for an electricity system"** are shown in Table 10. The CM emission factor of general CDM project is 0.5113 tCO_2/MWh and the CM emission factor of wind and solar power generation project is 0.5554 tCO_2/MWh.

Table 10 Calculation of combined margin emission factor

CDM project type	Emission Factor (tCO_2/MWh)		
	$EF_{grid,OM}$	$EF_{grid,BM}$	$EF_{grid,CM}$
General project	0.5994	0.4231	0.5113
Wind and solar power generation project	0.5994	0.4231	0.5554

Reference Table Comparison of name of fuel type from the various reports

Report [9]	DEDE [10] (Thailand)	IPCC [11]
Natural Gas	Natural Gas (Dry)	Natural Gas
Lignite	Lignite (Mae Moh)	Lignite
Bituminous	Coal Import	Other Bituminous Coal
Bunker	Fuel Oil	Residual Fuel Oil
Diesel	Diesel	Diesel Oil

[9] The study of emission factor for electricity generation of Thailand in year 2010

[10] Electric Power in Thailand 2010, Department of Alternative Energy Development and Efficiency, Ministry of Energy

[11] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

LIST OF THE COMMITTEE FOR THE STUDY OF EMISSION FACTOR FOR ELECTRICITY GENERATION OF THAILAND IN YEAR 2010

1. Mr. Chaiwat Muncharoen — Chairman
   Thailand Greenhouse Gas Management Organization
   (Public Organization)

2. Mr. Bundit Limmeechokchai — Committee
   Sirindhorn International Institute of Technology

3. Miss Areerat Yoohoon — Committee
   Department of Alternative Energy Development and Efficiency

4. Mr. Kitti Kumpeera — Committee
   Independent Expert

5. Miss Chananan Buakhiew — Committee
   Energy Policy and Planning Office

6. Mrs. Somying Kunanopparat — Committee
   Department of Industrial Works

7. Mr. Saksan Sangdow — Committee
   Pollution Control Department

8. Mr. Narumit Kiniman — Committee
   Electricity Generating Authority of Thailand

9. Miss Awnsiri Chawanapong — Committee
   Metropolitan Electricity Authority

10. Mrs. Arom Theeraleekul — Committee
    Provincial Electricity Authority

11. Mr. Rongphet Bunchuaidee — Committee and Secretary
    Thailand Greenhouse Gas Management Organization
    (Public Organization)

ปริมาณพลังงานของเชื้อเพลิง (ค่าความร้อนสุทธิ)

ENERGY CONTENT OF FUEL (NET CALORIFIC VALUE)

ประเภท(หน่วย)	กิโล-แคลอรี่ /หน่วย kcal / UNIT	ตันเทียบเท่า น้ำมันดิบ/ ล้านหน่วย toe / 10^6 UNIT	เมกะจูล /หน่วย MJ / UNIT	พันบีทียู /หน่วย 10^3 Btu / UNIT	TYPE(UNIT)
พลังงานเชิงพาณิชย์					COMMERCIAL ENERGY
1. น้ำมันดิบ (ลิตร)	8680	860.00	36.33	34.44	1. CRUDE OIL (litre)
2. คอนเดนเสท (ลิตร)	7900	782.72	33.07	31.35	2. CONDENSATE (litre)
3. ก๊าซธรรมชาติ					3. NATURAL GAS
3.1 ชื้น (ลูกบาศก์ฟุต)	248	24.57	1.04	0.98	3.1 WET (scf.)
3.2 แห้ง (ลูกบาศก์ฟุต)	244	24.18	1.02	0.97	3.2 DRY (scf.)
4. ผลิตภัณฑ์ปิโตรเลียม					4. PETROLEUM PRODUCTS
4.1 ก๊าซปิโตรเลียมเหลว (ลิตร)	6360	630.14	26.62	25.24	4.1 LPG (litre)
4.2 น้ำมันเบนซิน (ลิตร)	7520	745.07	31.48	29.84	4.2 GASOLINE (litre)
4.3 น้ำมันเครื่องบิน (ลิตร)	8250	817.40	34.53	32.74	4.3 JET FUEL (litre)
4.4 น้ำมันก๊าด (ลิตร)	8250	817.40	34.53	32.74	4.4 KEROSENE (litre)
4.5 น้ำมันดีเซล (ลิตร)	8700	861.98	36.42	34.52	4.5 DIESEL (litre)
4.6 น้ำมันเตา (ลิตร)	9500	941.24	39.77	37.70	4.6 FUEL OIL (litre)
4.7 ยางมะตอย (ลิตร)	9840	974.93	41.19	39.05	4.7 BITUMEN (litre)
4.8 ปิโตรเลียมโค๊ก (กก.)	8400	832.26	35.16	33.33	4.8 PETROLEUM COKE (kg)
5. ไฟฟ้า (กิโลวัตต์ชั่วโมง)	860	85.21	3.60	3.41	5. ELECTRICITY (kWh)
6. ไฟฟ้าพลังน้ำ (กิโลวัตต์ชั่วโมง)	2236	221.54	9.36	8.87	6. HYDROELECTRIC (kWh)
7. พลังงานความร้อนใต้พิภพ (กิโลวัตต์ชั่วโมง)	9500	941.24	39.77	37.70	7. GEOTHERMAL (kWh)
8. ถ่านหินนำเข้า (กก.)	6300	624.19	26.37	25.00	8. COAL IMPORT (kg.)
9. ถ่านโค๊ก (กก.)	6600	653.92	27.63	26.19	9. COKE (kg.)
10. แอนทราไซต์ (กก.)	7500	743.09	31.40	29.76	10. ANTHRACITE (kg.)
11. อีเทน (กก.)	11203	1110.05	46.89	44.45	11. ETHANE (kg.)
12. โปรเพน (กก.)	11256	1115.34	47.11	44.67	12. PROPANE (kg.)
13. ลิกไนต์					13. LIGNITE
13.1 ลี้ (กก.)	4400	435.94	18.42	17.46	13.1 LI (kg.)
13.2 กระบี่ (กก.)	2600	257.60	10.88	10.32	13.2 KRABI (kg.)
13.3 แม่เมาะ (กก.)	2500	247.70	10.47	9.92	13.3 MAE MOH (kg.)
13.4 แจ้คอน(กก.)	3610	357.67	15.11	14.32	13.4 CHAE KHON (kg.)
พลังงานใหม่และหมุนเวียน					NEW & RENEWABLE ENERGY
1. ฟืน (กก.)	3820	378.48	15.99	15.16	1. FUEL WOOD (kg.)
2. ถ่าน (กก.)	6900	683.64	28.88	27.38	2. CHARCOAL (kg.)
3. แกลบ (กก.)	3440	340.83	14.40	13.65	3. PADDY HUSK (kg.)
4. กากอ้อย (กก.)	1800	178.34	7.53	7.14	4. BAGASSE (kg.)
5. ขยะ (กก.)	1160	114.93	4.86	4.60	5. GARBAGE (kg.)
6. ขี้เลื่อย(กก.)	2600	257.60	10.88	10.32	6. SAW DUST (kg.)
7. วัสดุเหลือใช้ ทางการเกษตร (กก.)	3030	300.21	12.68	12.02	7. AGRICULTURAL WASTE (kg.)
8. ก๊าซชีวภาพ (ลูกบาศก์เมตร)	5000	495.39	20.93	19.84	8. BIOGAS (m^3)

TABLE 1.4 DEFAULT CO_2 EMISSION FACTORS FOR COMBUSTION [1]						
Fuel type English description		**Default carbon content (kg/GJ)**	**Default carbon oxidation factor**	**Effective CO_2 emission factor (kg/TJ) [2]**		
				Default value [3]	**95% confidence interval**	
		A	**B**	**C=A*B*44/12*1000**	**Lower**	**Upper**
Crude Oil		20.0	1	73 300	71 100	75 500
Orimulsion		21.0	1	77 000	69 300	85 400
Natural Gas Liquids		17.5	1	64 200	58 300	70 400
Gasoline	Motor Gasoline	18.9	1	69 300	67 500	73 000
	Aviation Gasoline	19.1	1	70 000	67 500	73 000
	Jet Gasoline	19.1	1	70 000	67 500	73 000
Jet Kerosene		19.5	1	71 500	69 700	74 400
Other Kerosene		19.6	1	71 900	70 800	73 700
Shale Oil		20.0	1	73 300	67 800	79 200
Gas/Diesel Oil		20.2	1	74 100	72 600	74 800
Residual Fuel Oil		21.1	1	77 400	75 500	78 800
Liquefied Petroleum Gases		17.2	1	63 100	61 600	65 600
Ethane		16.8	1	61 600	56 500	68 600
Naphtha		20.0	1	73 300	69 300	76 300
Bitumen		22.0	1	80 700	73 000	89 900
Lubricants		20.0	1	73 300	71 900	75 200
Petroleum Coke		26.6	1	97 500	82 900	115 000
Refinery Feedstocks		20.0	1	73 300	68 900	76 600
Other Oil	Refinery Gas	15.7	1	57 600	48 200	69 000
	Paraffin Waxes	20.0	1	73 300	72 200	74 400
	White Spirit & SBP	20.0	1	73 300	72 200	74 400
Other Petroleum Products		20.0	1	73 300	72 200	74 400
Anthracite		26.8	1	98 300	94 600	101 000
Coking Coal		25.8	1	94 600	87 300	101 000
Other Bituminous Coal		25.8	1	94 600	89 500	99 700
Sub-Bituminous Coal		26.2	1	96 100	92 800	100 000
Lignite		27.6	1	101 000	90 900	115 000
Oil Shale and Tar Sands		29.1	1	107 000	90 200	125 000
Brown Coal Briquettes		26.6	1	97 500	87 300	109 000
Patent Fuel		26.6	1	97 500	87 300	109 000
Coke	Coke oven coke and lignite Coke	29.2	1	107 000	95 700	119 000
	Gas Coke	29.2	1	107 000	95 700	119 000
Coal Tar		22.0	1	80 700	68 200	95 300
Derived Gases	Gas Works Gas	12.1	1	44 400	37 300	54 100
	Coke Oven Gas	12.1	1	44 400	37 300	54 100
	Blast Furnace Gas [4]	70.8	1	260 000	219 000	308 000
	Oxygen Steel Furnace Gas [5]	49.6	1	182 000	145 000	202 000

TABLE 1.4 (CONTINUED)
DEFAULT CO_2 EMISSION FACTORS FOR COMBUSTION [1]

Fuel type English description		Default carbon content (kg/GJ)	Default carbon oxidation Factor	Effective CO_2 emission factor (kg/TJ) [2]		
				Default value	95% confidence interval	
		A	B	C=A*B*44/12*1000	Lower	Upper
Natural Gas		15.3	1	56 100	54 300	58 300
Municipal Wastes (non-biomass fraction)		25.0	1	91 700	73 300	121 000
Industrial Wastes		39.0	1	143 000	110 000	183 000
Waste Oil		20.0	1	73 300	72 200	74 400
Peat		28.9	1	106 000	100 000	108 000
Solid Biofuels	Wood/Wood Waste	30.5	1	112 000	95 000	132 000
	Sulphite lyes (black liquor)[5]	26.0	1	95 300	80 700	110 000
	Other Primary Solid Biomass	27.3	1	100 000	84 700	117 000
	Charcoal	30.5	1	112 000	95 000	132 000
Liquid Biofuels	Biogasoline	19.3	1	70 800	59 800	84 300
	Biodiesels	19.3	1	70 800	59 800	84 300
	Other Liquid Biofuels	21.7	1	79 600	67 100	95 300
Gas biomass	Landfill Gas	14.9	1	54 600	46 200	66 000
	Sludge Gas	14.9	1	54 600	46 200	66 000
	Other Biogas	14.9	1	54 600	46 200	66 000
Other non-fossil fuels	Municipal Wastes (biomass fraction)	27.3	1	100 000	84 700	117 000

Notes:

[1] The lower and upper limits of the 95 percent confidence intervals, assuming lognormal distributions, fitted to a dataset, based on national inventory reports, IEA data and available national data. A more detailed description is given in section 1.5

[2] TJ = 1000GJ

[3] The emission factor values for BFG includes carbon dioxide originally contained in this gas as well as that formed due to combustion of this gas.

[4] The emission factor values for OSF includes carbon dioxide originally contained in this gas as well as that formed due to combustion of this gas

[5] Includes the biomass-derived CO_2 emitted from the black liquor combustion unit and the biomass-derived CO_2 emitted from the kraft mill lime kiln.

The Ratio of the Low Cost / Must Run (LC/MR) in the last 5 years (2006 – 2010)

Generation type	Unit	Electricity Generation			
		EGAT	IPP	SPP	Total
2010					
Total	GWh	78,517.70	67,775.98	13,897.27	160,190.96
Non LC/MR	GWh	73,185.41	67,775.98	11,642.33	152,603.73
LC/MR	GWh	5,332.30	0.00	2,254.94	7,587.23
% of LC/MR	%				4.74
2009					
Total	GWh	66,488.10	64,840.72	13,971.37	145,300.19
Non LC/MR	GWh	59,541.66	64,840.72	11,811.42	136,193.80
LC/MR	GWh	6,946.44	0.00	2,159.95	9,106.39
% of LC/MR	%				6.27
2008					
Total	GWh	63,719.02	67,420.14	14,092.83	145,232.00
Non LC/MR	GWh	56,791.19	67,420.14	11,904.81	136,116.14
LC/MR	GWh	6,927.83	0.00	2,188.03	9,115.86
% of LC/MR	%				6.28
2007					
Total	GWh	67,704.95	62,233.44	14,426.00	144,364.39
Non LC/MR	GWh	59,765.33	62,233.44	11,982.99	133,981.76
LC/MR	GWh	7,939.62	0.00	2,443.02	10,382.64
% of LC/MR	%				7.19
2006					
Total	GWh	70,409.11	55,360.65	13,652.19	139,421.94
Non LC/MR	GWh	62,480.23	55,360.65	11,619.95	129,460.82
LC/MR	GWh	7,928.88	0.00	2,032.23	9,961.12
% of LC/MR	%				7.14