



Ministry of Environment

IGES

Institute for Global
Environmental Strategies

**INTEGRATED CAPACITY STRENGTHENING FOR THE
CLEAN DEVELOPMENT MECHANISM**

**CDM Baseline Construction for
the Phnom Penh Electricity Grid**

November 2005

Ministry of the Environment, Japan
1-2-2, Kasumigaseki, Chiyoda-ku,
Tokyo, 100-8975 Japan
Telephone: +81-(0)3-5521-8330 Fax: +81-(0)3-3580-1382

Institute for Global Environmental Strategies (IGES)
2108-11 Kamiyamaguchi, Hayama, Kanagawa 240-0115, Japan
Telephone: +81-(0)46-855-3700 Fax: +81-(0)46-855-3709
<http://www.iges.or.jp>

Ministry of Environment, Cambodia
#48, Samdech Preah Sihanouk, Chamkarmon, Phnom Penh, Kingdom of Cambodia
Telephone/Fax: +855-23-218-370
<http://www.camclimate.org.kh>

Copyright © 2005 by Ministry of the Environment, Japan
Electronic edition published 2006

All rights reserved. Inquiries regarding this publication's copyright should be addressed to IGES in writing. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the Ministry of the Environment, Japan through IGES.

This report was made as a part of the Integrated Capacity Strengthening for Clean Development Mechanism/Joint Implementation (ICS-CDM/JI) programme and published by the Institute for Global Environmental Strategies.

While the contents of this report is believed to be true and accurate at the time of publication, neither the authors nor publisher can accept any legal responsibility or liability for any errors or omissions that may have occurred.

Copyedited by Timothy Skye

Acknowledgements

This report was developed by the Institute for Global Environmental Strategies (IGES) under the Integrated Capacity Strengthening for the Clean Development Mechanism and Joint Implementation (ICS-CDM/JI) programme.

We would like to express our sincere gratitude to the Ministry of the Environment, Japan, for its invaluable support in making this project a reality.

The realisation of this report could not have been accomplished without the extensive support of the Cambodian Climate Change Office under Cambodia's Ministry of Environment.

Mr. Keisuke Iyadomi, IGES country officer for Cambodia, took the main responsibility for the editing as well as the contents, under the supervision of Mr. Shinichi Iioka, IGES CDM programme manager. Mr. Sum Thy, the chief of the Cambodian Climate Change Office, Cambodia's Ministry of Environment prepared the main manuscript by compiling the results for the calculation of the combined margin for the Phnom Penh Electricity Grid. Mr. Yuji Mizuno, senior consultant of Pacific Consultants Co., Ltd., assisted in compiling data and editing this report.

We would like to thank Dr. Chulasa Praing, deputy director of the Corporate Planning & Project Department under the Électricité du Cambodge, and Mr. Piseth Chun, chief of planning, MIS and Tariff Office of Corporate Planning & Project Department under the Électricité du Cambodge for providing Phnom Penh Electricity Grid data for this project.

IGES would like to extend special thanks to Dr. Tin Ponlok of Cambodia's Ministry of Environment and their colleagues at the Cambodian Climate Change Office for their extensive support in making this report truly practical and up to date. Dr. Kayo Ikeda, Mr. Jun Ichihara, Mr. Kazuhisa Koakutsu and Ms. Sakae Seki of IGES provided broad support throughout the project's implementation.

Table of Contents

	Page
1. Introduction	1
2. Current Status of Electricity Generation in Phnom Penh	2
3. CDM Baseline Construction for the Phnom Penh Electricity Grid	5
Appendices	9
References	12

1. Introduction

The Integrated Capacity Strengthening for the Clean Development Mechanism (ICS-CDM) is a Japanese CDM capacity-building project for CDM host countries, under the auspices of the Ministry of the Environment, Japan. ICS-CDM is conducting several CDM-related capacity-building activities in south Asian target countries including Cambodia. The objectives of the ICS-CDM are to provide information and raise awareness on the CDM in both the public and private sectors, to support the institutional framework, to train human resources to operationalise CDM projects and to support the CDM project's identification, development and implementation activities.

To achieve the project's objectives, the ICS-CDM has been implementing several activities in Cambodia in collaboration with the Cambodian Ministry of Environment since the project was launched in late 2003. The ICS-CDM team during its past activities identified the necessity to provide publicly available data for developing the baselines of CDM projects. Some CDM project developers in Cambodia face difficulty in estimating more accurately the amount of Certified Emission Reductions (CERs) generated from their own projects, which is crucial for them to conduct CDM project activity in general. By establishing publicly available baseline data, either CDM project developers or the public in general can utilise this information to set up a credible baseline so that they will project more accurately the Greenhouse Gas (GHG) emission reduction and generation of CERs from planning projects.

In this regard the ICS-CDM, in cooperation with Cambodia Designated National Authority, decided to conduct a CDM baseline construction for the Phnom Penh Electricity Grid in FY 2005. The ICS-CDM held an expert consultation meeting for this activity, inviting Électricité du Cambodge, a public power company in Cambodia. The preliminary results of this activity are summarised in this report.

2. Current Status of Electricity Generation in Phnom Penh

In Phnom Penh as of 2004, the total installed generation was 129.9 MW, of which 57 MW is owned by independent power producers (IPPs). Électricité du Cambodge (EDC) owns three diesel power plants: C3, C5, and C6, and one thermal power plant (C2), while the IPPs operate three power plants: CUPL (IPP1), Jupiter (IPP2) and Cetic Hydropower (IPP3).

The capacity of these power plants is described below:

- Kirirom Hydropower is operated by the China Electric Power Technology Import & Export Corporation (CETIC) (IPP3). The company obtained permission to rebuild the project which was recommissioned in May 2002 with a capacity of 12 MW and an upgraded 115kV transmission line to Phnom Penh. The project generated about 29.1 GWh, 40.5 GWh and 27 GWh in 2002, 2003 and 2004, respectively.
- The Jupiter (IPP2) power plant is located on the site of the EDC C1 power station in the Tuol Sangkae Commune in the Ruessei Kaev district. This 26.4 MW power plant was commissioned in 2000 using diesel. In 2002, 2003 and 2004, the electrical output of the plant was 79.3 GWh, 116.1 GWh, and 143.3 GWh, respectively.
- The Cambodia Utilities Pty Ltd. (CUPL) (IPP1) is comprised of seven 5-MW generators operating on heavy fuel oil (HFO). This plant was commissioned in 1996/97 and is located at the Chak Angrae Leu commune in the Mean Chey district. This plant serves as a major energy supplier for the Phnom Penh area. The electricity output generated in 2002, 2003 and 2004 was 248.3 GWh, 247.1 GWh and 243.6 GWh respectively.
- The C6 power station is adjacent to C5 and is comprised of three generator sets which were recently converted from heavy fuel oil to diesel oil. The total installed capacity of the plant is 18.6 MW. It was commissioned in 1996. The plant generated electricity of 52.5 GWh, 63.7 GWh and 76.8 GWh in 2002, 2003 and 2004 respectively.

- The C3 power station is located in the Boeng Tumpun commune, Mean Chey district, with an installed capacity of 15.4 MW. The electricity is being generated from diesel generators and the electrical output was 21.9 GWh, 29.9 GWh and 47.6 GWh in 2002, 2003 and 2004 respectively.
- The C5 power station has two 5-MW diesel generators with a total installed capacity of 13 MW. The plant was granted by Japan and commissioned in 1995 and in 1996 respectively. The electrical output of the plant was 13.9 GWh, 20.9 GWh and 34.2 GWh in 2002, 2003 and 2004 respectively.
- The C2 power station is being operated by the EDC. It is the oldest plant and was commissioned in 1967. It is comprised of three steam turbines run on heavy fuel oil. The capacity of the plant is 18 MW with the electrical output of 40.4 GWh, 32.4 GWh and 73 GWh in 2002, 2003 and 2004 respectively.

Table 1: Electrical output from each power plant connected to the Phnom Penh grid

Name of Power Plant and Generation Sources	Year commissioned	Capacity (MW)	Electrical output (MWh/year)				
			2000	2001	2002	2003	2004
CITEC Kirirom (Hydro)	2002	12	-	-	29,100	40,500	27,000
C1 Jupiter	2000	26.4	13,200	91,200	79,300	116,100	143,300
CUPL	1996	37.1	208,300	244,500	248,300	247,100	243,600
C6	1996	18.6	60,200	48,800	52,500	63,700	76,800
C3	1995	15.4	20,100	16,400	21,900	29,900	47,600
C5	1995	13	25,800	12,500	13,900	20,900	34,200
C2	1967	18	61,700	25,600	40,400	32,400	73,000

Source: Chalasa P *et al.* 2004.

Table 2: Fuel consumption of each fossil power plant connected to the grid (ton/year)

Power plants	Fuel type	Fuel consumption (t/year)				
		2000	2001	2002	2003	2004
C1 Jupiter	Diesel	2,862	19,694	17,533	26,391	31,903
CUPL	Heavy Fuel Oil	49,592	58,206	59,809	60,015	59,948
C6	Diesel	13,923	11,607	12,482	16,328	18,277
C3	Diesel	4,642	3,593	4,765	6,508	10,596
C5	Diesel	5,490	2,670	2,960	4,443	7,474
C2	Diesel	24,929	10,493	17,512	22,228	32,554

Source: Chalasa P *et al.* 2004.

3. CDM Baseline Construction for the Phnom Penh Electricity Grid

The rules specified in I.D. Type I (Renewable Energy Project) of the UNFCCC indicate that “the baseline is the kWh produced by the renewable generating unit multiplied by an emission coefficient (measured in kg CO₂ eq./kWh) calculated in the transparent and conservative manner that follows:

(a) The average of the “approximate operating margin” and the “build margin,” where:

(i) The “approximate operating margin” is the weighted average emissions (in kg CO₂ eq./kWh) of all generating sources serving the system, excluding hydro, geothermal, wind, low-cost biomass, nuclear and solar generation;

(ii) The “build margin” is the weighted average emissions (in kg CO₂ eq./kWh) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of the most recent 20% of existing plants, or, the five most recent plants;

OR,

(b) The weighted average emissions (in kg CO₂ eq./kWh) of the current generation mix.”

For this study, the operating margin (OM) is derived in two steps:

Step 1: The estimation of annual CO₂ emissions from each type of fuel consumed by each power plant using the 1996 IPCC Guidelines for National Greenhouse Gas Inventory. The following formula is used for estimating the emissions:

$$E(tCO_2/year) = \sum Fuel\ consumption\ (TJ) \times (Carbon\ Emission\ Factor \times - Carbon\ stored) \times Fraction\ of\ Carbon\ Oxidised \times 44/12$$

Step 2: The estimation of annual CO₂ emissions based on electrical output (kWh)

$$OM(tCO_2/MWh) = \frac{\sum_j E_j}{\sum_j K_j}$$

Where:

E_j is CO₂ emission from fuel j (tonnes/year).

K_j is electrical generation from fuel j.

Build margin (BM) is calculated based on the formula below:

$$BM(tCO_2/MWh) = \frac{\sum_1^m e_j G_j}{\sum_1^m G_j} = \frac{e_1 G_1 + e_2 G_2 + \dots + e_m G_m}{G_1 + G_2 + \dots + G_m}$$

Where:

G_j : the generation (MWh) from unit j

e_j : the emission rate (in t CO₂/MWh) for unit j

j : individual plants included among the selected representative set of plants

Table 3: CO₂ emissions from power plants (in t-CO₂)

Plant	2000	2001	2002	2003	2004
C1 Jupiter	9,093	62,572	55,706	83,850	101,362
CUPL	152,656	179,174	184,107	184,743	184,537
C6	44,236	36,877	39,659	51,879	58,071
C3	14,749	11,416	15,140	20,678	33,666
C5	17,442	8,482	9,406	14,117	23,745
C2	79,204	33,340	55,638	70,623	103,432
Total emissions	317,381	331,860	359,656	425,890	504,814

Table 4: Calculation of the operating margin (in t-CO₂/MWh)

Plant	2000	2001	2002	2003	2004
C1 Jupiter	0.689	0.686	0.702	0.722	0.707
CUPL	0.733	0.733	0.741	0.748	0.758
C6	0.735	0.756	0.755	0.814	0.756
C3	0.734	0.696	0.691	0.692	0.707
C5	0.676	0.679	0.677	0.675	0.694
C2	1.284	1.302	1.377	2.180	1.417
Total emissions			0.788	0.835	0.816
OM (t-CO₂ /MWh)					0.813

Note: OM is the average of the emissions for 2002, 2003, and 2004.

Table 5: Calculation of the build margin for 2004

Power Plant	Year of operation	Fuel Type	Electricity Generation (MWh/y)	Actual CO ₂ Emissions (t-CO ₂)
1. CITEC Kirirom (Hydro)	2002	Hydro	27,000	
2. C1 Jupiter	2000	Diesel	143,300	101,362.39
3. CUPL	1996	Residual Fuel Oil	243,600	184,536.91
4. C6	1996	Diesel	76,800	58,071.24
5. C5	1995	Diesel	34,200	23,745.24
Total			524,900	367,715.78
BM (t-CO₂ /MWh)				0.701

+

When the normal scale CDM is connected to a grid, the emission factor can be calculated based on the combined margin. The combined margin is an average of the OM and the BM ($\frac{1}{2}$ OM + $\frac{1}{2}$ BM). Based on Tables 4 and 5, the emission factor for the normal scale renewable CDM project supplying power to the grid is shown below:

Normal scale CDM baseline connected to a grid = $\frac{1}{2}$ OM + $\frac{1}{2}$ BM = 0.813 + 0.701
= 0.757 t-CO₂ /MWh

Table 6: Summary of the CDM Baseline Construction for the Phnom Penh Electricity Grid

Operating margin from 2002-2004 (t-CO₂/MWh)	0.813
Build margin (t-CO₂/kWh)	0.701
Normal scale CDM connected to a grid = Combined margin (t-CO₂/MWh)	0.757
Weighted average for small scale CDM Project (SSC) (t-CO₂/MWh)	0.782

Appendices

Table 7: Worksheet for the estimation of CO₂ emissions from Power Plants in Phnom Penh in 2002

Worksheet		CO ₂ emissions from Power Plants in Phnom Penh in 2002					
		STEP 1		STEP 2		STEP 3	
Name of Power Plant		A	B	C	D	E	G
	Fuel Type	Electricity generation (MWh/y)	Fuel Consumption (kt)	Conversion Factor (TJ/kt)	Fuel Consumption (TJ)	Carbon Emission Factor (t C/TJ)	Carbon Content (t C)
					D=(BxC)		G=(DxE)
C1 Jupiter	Diesel	79,300	17.53	43.3	759.70	20.20	15,346.04
CUPL	Residual Fuel Oil	248,300	59.81	40.2	2,403.70	21.10	50,718.15
C6	Diesel	52,500	12.48	43.3	540.86	20.20	10,925.33
C3	Diesel	21,900	4.77	43.3	206.48	20.20	4,170.82
C5	Diesel	13,900	2.96	43.3	128.27	20.20	2,591.14
C2	Diesel	40,400	17.51	43.3	758.78	20.20	15,327.40
Total consumption		456,300	115.0611				

		STEP 4		STEP 5		STEP 6	
Name of Power Plant		H	I	J	K	L	N
	Fraction of Carbon Stored	Carbon Stored (Gg C)	Net Carbon Emissions (Gg C)	Fraction of Carbon Oxidised	Actual Carbon Emissions	Actual CO ₂ Emissions (t-CO ₂)	CO ₂ Emission/MWh (tCO ₂ /MWh)
		I=(GxH)	J=(G-I)		L=(JxK)	N=(Lx[44/12])	M=(N/A)
C1 Jupiter	0.00	0.00	15,346.04	0.99	15,192.58	55,706.12	0.702
CUPL	0.00	0.00	50,718.15	0.99	50,210.96	184,106.87	0.741
C6	0.00	0.00	10,925.33	0.99	10,816.08	39,658.96	0.755
C3	0.00	0.00	4,170.82	0.99	4,129.11	15,140.07	0.691
C5	0.00	0.00	2,591.14	0.99	2,565.23	9,405.83	0.677
C2	0.00	0.00	15,327.40	0.99	15,174.12	55,638.45	1.377
Total emissions						359,656.29	0.788

Table 8: Estimation of CO₂ emissions from Power Plants in Phnom Penh in 2003

Worksheet		CO ₂ emissions from Power Plants in Phnom Penh in 2003					
		STEP 1		STEP 2		STEP 3	
Name of Power Plant	Fuel Type	A	B	C	D	E	G
		Electricity generation (kWh/y)	Fuel Consumption (kt)	Conversion Factor (TJ/kt)	Fuel Consumption (TJ)	Carbon Emission Factor (t C/TJ)	Carbon Content (t C)
					$D=(B \times C)$		$G=(D \times E)$
C1 Jupiter	Diesel	116,100	26.39	43.3	1,143.52	20.20	23,099.15
CUPL	Residual Fuel Oil	247,100	60.02	40.2	2,412.00	21.10	50,893.26
C6	Diesel	63,700	16.33	43.3	707.51	20.20	14,291.69
C3	Diesel	29,900	6.51	43.3	282.00	20.20	5,696.41
C5	Diesel	20,900	4.44	43.3	192.53	20.20	3,889.07
C2	Diesel	32,400	22.23	43.3	963.14	20.20	19,455.41
Total consumption		510,100	135.9139				

		STEP 4		STEP 5		STEP 6	
Name of Power Plant	H	I	J	K	L	N	M
	Fraction of Carbon Stored	Carbon Stored (Gg C)	Net Carbon Emissions (Gg C)	Fraction of Carbon Oxidised	Actual Carbon Emissions	Actual CO ₂ Emissions (t-CO ₂)	CO ₂ Emission/MWh (tCO ₂ /MWh)
		$I=(G \times H)$	$J=(G-I)$		$L=(J \times K)$	$N=(L \times [44/12])$	$M=(N/A)$
C1 Jupiter	0.00	0.00	23,099.15	0.99	22,868.15	83,849.896	0.722
CUPL	0.00	0.00	50,893.26	0.99	50,384.33	184,742.534	0.748
C6	0.00	0.00	14,291.69	0.99	14,148.78	51,878.847	0.814
C3	0.00	0.00	5,696.41	0.99	5,639.44	20,677.954	0.692
C5	0.00	0.00	3,889.07	0.99	3,850.18	14,117.322	0.675
C2	0.00	0.00	19,455.41	0.99	19,260.86	70,623.148	2.180
Total emissions						425,889.702	0.835

Table 9: Estimation of CO₂ emissions from Power Plants in Phnom Penh in 2004

Worksheet		CO ₂ emissions from Power Plants in Phnom Penh in 2004					
		STEP 1		STEP 2	STEP 3		
Name of Power Plant	Fuel Type	A	B	C	D	E	G
		Electricity generation (kWh/y)	Fuel Consumption (kt)	Conversion Factor (TJ/kt)	Fuel Consumption (TJ)	Carbon Emission Factor (t C/TJ)	Carbon Content (t C)
					$D=(B \times C)$		$G=(D \times E)$
C1 Jupiter	Diesel	143,300	31.90	43.3	1,382.35	20.20	27,923.52
CUPL	Residual Fuel Oil	243,600	59.95	40.2	2,409.32	21.10	50,836.61
C6	Diesel	76,800	18.28	43.3	791.96	20.20	15,997.59
C3	Diesel	47,600	10.60	43.3	459.12	20.20	9,274.32
C5	Diesel	34,200	7.47	43.3	323.83	20.20	6,541.39
C2	Diesel	73,000	32.55	43.3	1,410.58	20.20	28,493.76
Total consumption		618,500	160.7525				

		STEP 4		STEP 5		STEP 6	
Name of Power Plant	H	I	J	K	L	N	M
	Fraction of Carbon Stored	Carbon Stored (Gg C)	Net Carbon Emissions (Gg C)	Fraction of Carbon Oxidised	Actual Carbon Emissions	Actual CO ₂ Emissions (t-CO ₂)	CO ₂ Emission/MWh (tCO ₂ /MWh)
		$I=(G \times H)$	$J=(G-I)$		$L=(J \times K)$	$N=(L \times [44/12])$	$M=(N/A)$
C1 Jupiter	0.00	0.00	27,923.52	0.99	27,644.29	101,362.391	0.707
CUPL	0.00	0.00	50,836.61	0.99	50,328.25	184,536.906	0.758
C6	0.00	0.00	15,997.59	0.99	15,837.61	58,071.240	0.756
C3	0.00	0.00	9,274.32	0.99	9,181.58	33,665.776	0.707
C5	0.00	0.00	6,541.39	0.99	6,475.97	23,745.238	0.694
C2	0.00	0.00	28,493.76	0.99	28,208.82	103,432.347	1.417
Total emissions						504,813.898	0.816

References:

Chalasa P and C. Piseth. 2004. *Statistical Hand Book 1995-2004*. "Electric Utility in Cambodia." Électricité du Cambodge (EdC). Phnom Penh, Cambodia.

Minh Tuyen, T. and A Michaelowa. 2004. *CDM baseline construction for Vietnam national electricity grid*. HWWA discussion paper 295. Hamburg Institute of International Economics. Germany.

Intergovernmental Panel on Climate Change (IPCC). 1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Institute for Global Environmental Strategies IGES, Japan.

United Nations Framework Convention on Climate Change (UNFCCC). 2004. Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories, Appendix B1 of the simplified modalities and procedures for small-scale CDM project activities, Bonn.

United Nations Framework Convention on Climate Change (UNFCCC). 2004. Approved baseline methodology AM0005.
<http://cdm.unfccc.int/UserManagement/FileStorage/AM0005.pdf>