

**CO₂ Baseline Database
for the Indian Power Sector
User Guide**

Version 3.0

December 2007

**Government of India
Ministry of Power
Central Electricity Authority
Sewa Bhawan, R.K.Puram,
New Delhi-66**

Revision History of the Database

Version No.	Date of Publication	Main Revisions Compared to Previous Version
1.0 Draft for Stakeholder Consultation	4 th October 2006	–
1.0	November 2006	<ul style="list-style-type: none"> - Added data on 10 stations which had been in exclusion worksheet of draft database - Adjusted values to latest IPCC Guidance (IPCC 2006 Guidelines for National Greenhouse Gas Inventories) where IPCC defaults are used
1.1	December 2006	<ul style="list-style-type: none"> - Adjusted fuel emission factor of lignite to be in line with Initial National Communication figures
2.0	June 2007	<ul style="list-style-type: none"> - Added data for FY 2005-06, including new stations and units commissioned during 2005-06 <p>Retroactive changes to data for FY 2000-01 to 2004-05:</p> <ul style="list-style-type: none"> - Introduced differentiated default heat rates for open- vs. combined-cycle stations (gas- and diesel-fired; only applicable where fuel consumption was not provided by station) - Refined approximation of unit-level generation where not provided by station, by taking into account day of commissioning (for build margin) - Revised fuel consumption for some stations where data became available
3.0	December 2007	<ul style="list-style-type: none"> - Added data for FY 2006-07, including new stations and units commissioned during 2006-07 - Adapted calculations and User Guide to ensure consistency with new CDM methodologies: ACM0002 Version 07, and Tool to Calculate the Emission Factor for an Electricity System (Version 01, EB 35 Annex 12)

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Foreword

The Clean Development Mechanism (CDM) gives an opportunity to developing countries in achieving their sustainable development objective, besides providing opportunity to introduce new and efficient technologies.

India has high potential for CDM projects, particularly in the Power Sector. With large resources of technical power we can develop innovative CDM projects in energy efficiency and conservation including R&M schemes for power generation and adopt new and renewable technologies.

The last version of CO₂ Baseline Database for the Indian Power Sector (Version 2.0) containing data for the year 2005-06 was published in June 2007. The Baseline Database has benefited all prospective CDM project developers to estimate the amount of Certified Emission Reduction (CERs). This publication is the version 3 of the CO₂ Baseline Database for Indian Power Sector containing data for the year 2006-07.

With the efforts taken by Government of India ,Ministry of Power, the average CO₂ emission rate has declined from 0.85 t CO₂/ MWh in the year 2002-03 to 0.80 t CO₂/MWh in the year 2006-07. All efforts are being made to improve the efficiency of power generation, transmission and distribution.

The team of CEA officers headed by Shri D.S..Arora, Chief Engineer (Conservation and Efficiency Division) has done a commendable job under the able guidance of Shri V.S. Verma, Member (Planning), CEA. We are thankful to Dr A. Kaupp, Smt. Pamposh Bhat, Director, GTZ, Climate Change Unit, Mr Urs Brodmann and Dr Axel Michaelowa, GTZ-CDM-India consultants, who provided guidance and gave useful input to the team of CEA engineers.

New Delhi
December 2007

(Rakesh Nath)
Chairperson

Preface

Developing countries like India do not fall in the Annex I category of the Kyoto Protocol but India has a strong commitment to reduce its emissions of greenhouse gases and mitigate climate change. Ministry of Power has accorded high priority to the CDM projects in the power sector. The number of Indian CDM projects registered with the CDM Executive Board is a good indication to India's commitment towards protection of the Global Environment. Till date, 289 Indian projects have been registered with the Executive Board. Host country approval to more than 650 projects has also been accorded by National CDM Authority established under the Ministry of Environment and Forest.

CEA undertook the study relating to the baseline data for the Power sector in the country with a view to obtaining uniformity of approach in the country towards a common objective. Detailed information was collected from all power generating stations. The database has been updated for the year 2006-07 and is proposed to be updated on annual basis. The user guide has been prepared to enable project developers to use these baseline emission data effectively for CDM benefits. The emission factors have been calculated based on the new tool **"Tool to calculate the emission factors for an electricity system"** published by CDM Executive Board "

The baseline emission database is useful not only to power sector projects but to all the industrial projects which are improving the efficiency of the process thus saving electricity. Indian industries have taken a lead in development of large number of CDM projects though of smaller size. The development of the baseline database would encourage project developers to pose large CDM projects in hydro power generation, Renovation and Modernisation, adoption of super critical technologies in power generation etc. In fact, many CDM projects have been registered based on the emission factors published by Central Electricity Authority.

I appreciate the efforts put in by all the officers of Central Electricity Authority and GTZ-CDM-India in bringing up the updated data for the year 2005-06. This is a unique effort made by our country for the first time in the world.

I am confident, that baseline carbon dioxide emissions, developed by CEA would provide direction to help industry to come up with new CDM project concepts to further consolidate and reinforce our effort to save the global environment.

New Delhi
December 2007

(V.S. Verma)
Member (Planning)

Acknowledgement

India has the distinction of maximum number of registered CDM projects by the CDM Executive Board and I am confident that more and more CDM projects would be got registered in future. Various CDM projects had been facing the difficulties in establishing the baseline emissions for calculating authentic Carbon Emission Reductions (CERs). Accordingly, Central Electricity Authority took the initiative to publish the Carbon di-oxide baseline database for the Indian Power Sector to assist CDM project developers for speedy approval of their CDM projects.

The present publication is the result of the trust Ministry of Power, Government of India, posed in Central Electricity Authority and entrusting us with the responsibility of establishing the Baseline carbon dioxide emissions from the Indian power sector. I am thankful to Shri Anil Razdan, Secretary (Power) and Shri Anil Kumar, Additional Secretary, Ministry of Power who provided whole hearted support and encouragement in developing of Baseline database.

I am grateful to Shri Rakesh Nath, Chairperson, CEA and Shri V.S. Verma, Member(Planning), CEA for enlightening us with their valuable views and guidance all along in developing the Baseline carbon dioxide emissions.

I sincerely thank Dr A. Kaupp, Manager, IGEN, the CDM-India consultants Mr Urs Brodmann and Mr Benjamin stocker of Factor Consulting, Dr Axel Michaelowa of Perspectives Climate Change and Ms Pamposh Bhat, GTZ- Climate Change Unit for providing their expert views in establishing the baseline emissions.

Central Electricity Authority extends its grateful thanks to all the power sector utilities/organizations and their officers for active co-operation and support rendered by them in timely furnishing the requisite data to bring out this updated document.

I acknowledge with deep appreciation, the hard work and efforts put in by Shri Praveen Gupta, Deputy Director and other officers of Conservation and Efficiency Division, CEA in compilation of data and evolving the Baseline carbon dioxide emissions from the power sector. I also thank officers of Thermal, GO&D and Hydro wings of CEA for their contribution in completing this study and providing necessary data and its validation.

All efforts have been made to project the latest data on energy generation to keep high integrity of the Baseline. Any omission in this could be due to oversight of the undersigned. Suggestion from the project developers and consultants are welcome to avoid such omissions in future.

New Delhi
December 2007

(D.S. Arora)
Chief Engineer (C&E)

Message

The Kyoto Protocol's Clean Development Mechanism is expected to result in emission reductions equivalent to over 2 billion tonnes of CO₂ to the end of 2012. CDM will bring in investments in developing projects that reduce Greenhouse Gases. CDM project implementers earn certified emission reduction units which are bought by countries with emission reduction commitments under the Kyoto protocol. CDM in India can lead the way to a low carbon economy.

The Indo German Energy Programme, a technical cooperation of the Governments of India and Germany jointly implemented by GZZ together with partners Central Electricity Authority and the Bureau of Energy Efficiency under the Ministry of Power has undertaken the task of Carbon market development in India since 2003. We have together achieved many landmarks one among which is "Development of the Baseline Data for CDM Projects in the Power Sector". This valuable tool for CDM project developers reduces transaction costs and increases accuracy and consistency of emission reduction calculations.

This baseline was presented to the public as an outstanding example of a national effort to support CDM project developers at the UNFCCC 12th Conference of Parties in Nairobi 2006. We congratulate our partner in the initiative Central Electricity Authority Officials and Personnel as well as our international consultants for their tireless efforts and commitment the cause.

Dr. Albrecht Kaupp
Manager
Indo German Energy Programme

Pamposh Bhat
Director
GTZ- Climate Change Unit

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Summary

Since the emergence of the Kyoto Protocol and its Clean Development Mechanism (CDM), energy projects lowering the carbon intensity of the electricity grid can generate additional revenues from carbon credits. Methodologies approved by the CDM Executive Board have to be applied to determine the resulting emission reductions, using the “baseline” CO₂ emission factor of the relevant geographical area.

In order to facilitate adoption of authentic baseline emissions data and also to ensure uniformity in the calculations of CO₂ emission reductions by CDM project developers, Central Electricity Authority (CEA), in cooperation with GTZ CDM-India, has compiled a database containing the necessary data on CO₂ emissions for all grid-connected power stations in India. The database currently covers the seven fiscal years 2000-01 to 2006-07. CEA intends to update the database at the end of each financial year.

The Indian electricity system is divided into five regional grids, viz. Northern, Eastern, Western, Southern, and North-Eastern. Each grid covers several states. As the regional grids are interconnected, there is inter-state and inter-regional exchange. A small power exchange also takes place with the neighbouring countries Bhutan and Nepal. For each of the five regions, the main emission factors are calculated in accordance with the relevant CDM methodologies.

The prevailing baseline emissions based on the data for the Fiscal Year 2006-07 is shown in Table S-1. The calculations are based on generation, fuel consumption and fuel quality data obtained from the power stations. Typical standard data were used only for a few stations where information was not available from the station. Inter-regional and cross-border electricity transfers were also taken into account for calculating the CO₂ emission baseline.

Table S-1: Weighted average emission factor, simple operating margin (OM), build margin (BM) and combined margin (CM) of all Indian regional grids for FY 2006-07 (inter-regional and cross-border electricity transfers included), in tCO₂/MWh

	Average	OM	BM	CM
North	0.74	1.00	0.63	0.81
East	1.00	1.09	0.93	1.01
South	0.72	1.00	0.71	0.85
West	0.86	0.99	0.59	0.79
North-East	0.40	0.70	0.23	0.46
India	0.80	1.01	0.68	0.84

Average is the average emission of all stations in the grid, weighted by net generation.

OM is the average emission from all stations excluding the low cost/must run sources.

BM is the average emission of the 20% (by net generation) most recent capacity addition in the grid.

CM is a weighted average of the OM and BM (here weighted 50 : 50).

1 Background and Objective

Purpose of the CO₂ Database

The Clean Development Mechanism (CDM) under the Kyoto Protocol to United Nations Framework Convention on Climate Change (UNFCCC) provides an opportunity for the Indian power sector to earn revenue through the reduction of greenhouse gas emissions (GHG), particularly carbon dioxide (CO₂). India has tremendous potential for CDM projects. Power generation based on higher efficiency technologies such as supercritical technology, integrated gasification combined cycle, and renovation and modernisation of old thermal power plants, co-generation along with renewable energy sources are some of potential candidates for CDM in the power sector. Energy efficiency and conservation projects also present themselves as eligible CDM projects, as these would also result in energy savings and displace associated CO₂ emissions which otherwise would be produced by grid-connected power stations.

CDM appears to be a promising mechanism but many implementation issues are yet to be addressed like fixing of baseline etc. A need was, therefore, felt to work out an acceptable and realistic baseline of CO₂ emissions for the various regions of the country to enable the prospective project developers to pose their projects for approval by the CDM Executive Board. Central Electricity Authority (CEA), accordingly took up in cooperation with GTZ CDM-India, to compile a database for all grid-connected power stations in India. The purpose of the database is to establish authentic and consistent quantification of the CO₂ emission baseline which can be readily used by CDM project developers in the Indian power sector. This would enhance the acceptability of Indian projects and would also expedite the clearance/approval process. India is the first country in the world to have ventured to take up the complex task of developing such an official baseline for the power sector as a whole.

The baseline emissions for all the five regional grids are given in Section 5 (Results) of this User Guide. The complete updated CO₂ Database (Microsoft Excel File) and this User Guide along with all previous versions are available on the website of Central Electricity Authority: www.cea.nic.in.

The purpose of this User Guide is to provide a ready reference to the underlying calculations and assumptions used in the CO₂ database and to summarise the key results.

Official Status of the Database

The database is an official publication of the Government of India for the purpose of CDM baselines. It is based on the most recent data available to the Central Electricity Authority.

Consistency of the Database with CDM Methodologies

Under the CDM, emission reductions must be quantified using an approved methodology. Key examples of such methodologies include AMS-I.D and ACM0002 for grid-connected power generation from renewable sources in small and large- scale projects, respectively. The latest versions of all approved CDM methodologies are available at the official CDM website, <http://cdm.unfccc.int>.

In October 2007, the CDM Executive Board adopted a methodological tool to facilitate the calculation of baseline emission factors for electricity grids.¹ This Tool is set to become the main reference for CDM methodologies involving baseline emission factors for power grids. In particular, ACM0002 was subsequently revised and in its latest Version 07 refers to the Tool with respect to the methodological details of the baseline emission factor calculation.

The CO₂ Database is designed to be consistent with the Tool and thus Version 07 of ACM0002. In comparison with the previous versions of the database, this required only one minor modification, in the calculation of CO₂ emissions from imported electricity (see Section 4.4). Moreover, the delineation into regional grids was reviewed, but found to be consistent with the respective criteria provided in the Tool (see next section for details).

Indian Power Sector: Installed Capacity and Regional Grids

As a result of the impressive growth attained by the Indian Power Sector, the installed capacity has grown from mere 1,713 MW in 1950 to 138251.63 MW as on 30.11.2007, consisting of 89275.84 MW Thermal, 34680.76 MW Hydro and 4120 MW Nuclear. Region-wise details of installed capacity is shown in Table 1.

Table 1: *Region wise installed capacity (MW) as on 30.11.2007.*

Region	Hydro	Thermal				Nuclear	Renew.	Total
		Coal	Gas	Diesel	Total			
Northern	12671.15	18,327.50	3,433.19	14.99	21,775.68	1,180.00	1220.18	36847.01
Western	7198.50	23502.50	6600.72	17.48	30120.70	1,840.00	2670.34	41829.54
Southern	10646.18	16182.50	3,586.30	939.32	20,708.12	1100.00	5899.33	38353.63
Eastern	3048.93	15149.88	190.00	17.20	15357.08	0.00	227.81	18633.82
N.Eastern	1,116.00	330.00	771.50	142.74	1,244.24	0.00	146.01	2506.25
Islands	0	0.00	0.00	70.02	70.02	0.00	11.36	81.38
All India	34,680.76	73492.38	14581.71	1201.75	89275.84	4120.00	10175.03	138251.63

Note: These capacities are not identical with those listed in the Excel database, because the database currently covers only the years up to 31.3.2007

¹ Tool to calculate the emission factor for an electricity system (Version 01), adopted by EB 35 (Annex 12). See <http://cdm.unfccc.int>

It is evident from Table 1 that the installed capacity is predominantly coal based and therefore, is a major source of carbon dioxide emissions in India. Hence, there exists scope for reducing the CO₂ emissions in the country by way of fuel substitution, increased use of renewable energy sources, and also by improving the thermal efficiency of power generation.

The Indian power system is divided into five independent regional grids, namely Northern, Eastern, Western, Southern, and North-Eastern. Each grid covers several states (see Table 2). Power generation and supply within the regional grid is managed by Regional Load Dispatch Centre (RLDC). The Regional Power Committees (RPCs) provide a common platform for discussion and solution to the regional problems relating to the grid.

Each state in a regional grid meets their demand with their own generation facilities and also with allocation from power plants owned by the central sector such as NTPC and NHPC etc. Specific quotas are allocated to each state from the central sector power plants. Depending on the demand and generation, there are electricity exports and imports between states in the regional grid. Moreover, there are also electricity transfers between regional grids, and small exchanges in the form of cross-border imports and exports (e.g. from Bhutan). Recently, the Indian regional grids have started to work in synchronous mode, i.e. at same frequency.

Table 2: Geographical scope of the five regional electricity grids

Northern	Western	Southern	Eastern	North-Eastern
Chandigarh	Chhattisgarh	Andhra Pradesh	Bihar	Arunachal Pradesh
Delhi	Gujarat	Karnataka	Jharkhand	Assam
Haryana	Daman & Diu	Kerala	Orissa	Manipur
Himachal Pradesh	Dadar & Nagar Haveli	Tamil Nadu	West Bengal	Meghalaya
Jammu & Kashmir	Madhya Pradesh	Pondicherry	Sikkim	Mizoram
Punjab	Maharashtra	Lakshadweep	Andaman-Nicobar	Nagaland
Rajasthan	Goa			Tripura
Uttar Pradesh				
Uttarakhand				

For the purposes of the CDM, the delineation of the electricity grid is a key step in the calculation of a grid emission factor. The current methodological guidance² given by the CDM Executive Board implies that a grid is characterized by the absence of *significant transmission constraints*, and provides the following possible criteria for determining the existence of such constraints:

² Tool to calculate the emission factor for an electricity system (Version 01), adopted by EB 35 (Annex 12). See <http://cdm.unfccc.int>

- In case of electricity systems with spot markets for electricity: there are differences in electricity prices (without transmission and distribution costs) of more than 5% between the systems during 60% or more of the hours of the year.
- The transmission line is operated at 90% or more of its rated capacity during 90% or more of the hours of the year.

Due to the absence of well-established spot markets, the first criterion is currently not applicable in the Indian context. Similarly, a transmission line fulfilling the second criterion would be an exception. Nevertheless, CEA has decided to maintain the division into five regional grids for the purpose of this database. The main reason is that electricity continues to be produced and consumed largely within the same region, as is evidenced by the relatively small volume of net transfers between the regions. Consequently, it is appropriate to assume that also the impacts of CDM projects will be confined to the regional grid in which it is located.

2 How to Use the Database

Structure of the Database

Emission reductions from CDM projects in the power sector are calculated based on the net electricity generated by the project, and the difference between the emission factors (in tCO₂/MWh) of the baseline and the project activity. The baseline emission factor reflects the carbon intensity of the displaced amount of grid electricity. This baseline emission factor can be derived from the data provided in the CO₂ Database.

Specifically, the database contains the following elements:

- Worksheet “Data” provides the net generation and the absolute and specific CO₂ emissions of each grid-connected power station (see Section 3 for exceptions). It also indicates which stations and units have been included in the operating margin and build margin, respectively.
- Worksheet “Results” provides the most commonly used aggregate emission factors. These are calculated from the station data in accordance with the approved consolidated methodology ACM0002 (Version 07). The emission factors are explained in more detail in the next section.
- Worksheet “Abbreviations” explains the abbreviations used in the “Data” worksheet.
- Worksheet “Assumptions” shows the assumptions that were used for the calculation of the CO₂ emissions at station and unit level, to the extent required.
- Worksheet “Electricity Transfers” shows the inter-regional and cross-border power transfers.

Different Types of Emission Factors

The CDM methodologies which have been approved to date by the CDM Executive Board distinguish a range of different emission factors. In the Indian context, the following four are most relevant, and were therefore calculated for each regional grid based on the underlying station data:

- **Weighted average:**
The weighted average emission factor describes the average CO₂ emitted per unit of electricity generated in the grid. It is calculated by dividing the absolute CO₂ emissions of all power stations in the region by the region’s total net generation. Net generation from so-called low-cost/must-run sources (hydro and nuclear) is included in the denominator.
- **Simple operating margin (OM):**
The operating margin describes the average CO₂ intensity of the existing stations in the grid which are most likely to reduce their output if a CDM project supplies electricity to the grid (or reduces consumption of grid electricity). “Simple” denotes one out of four possible

variants listed in ACM0002 for calculating the operating margin.³ The simple operating margin is the weighted average emissions rate of all generation sources in the region *except* so-called low-cost or must-run sources. In India, hydro and nuclear stations qualify as low-cost / must-run sources and are excluded. The operating margin, therefore, can be calculated by dividing the region's total CO₂ emissions by the net generation of all thermal stations. In other words, it represents the weighted average emissions rate of all thermal stations in the regional grid.

- **Build margin (BM):**

The build margin reflects the average CO₂ intensity of newly built power stations that will be (partially) replaced by a CDM project. In accordance with ACM0002, the build margin is calculated in this database as the average emissions intensity of the 20% most recent capacity additions in the grid based on net generation. Depending on the region, the build margin covers units commissioned in the last five to ten years.

- **Combined margin (CM):**

The combined margin is a weighted average of the simple operating margin and the build margin. By default, both margins have equal weights (50%). However, CDM project developers may choose to argue for different weights. In particular, for intermittent and non-dispatchable generation types such as wind and solar photovoltaic, ACM0002 allows to weigh the operating margin and build margin at 75% and 25%, respectively (see ACM0002, Version 06). However, the combined margins shown in the database are calculated based on equal weights.

In line with the *Tool for calculation of the emission factor for an electricity grid*, if a station is registered as a CDM activity, it is excluded from the build margin but not from the operating margin.⁴

³ The two variants "Simple adjusted operating margin" and "Dispatch data analysis operating margin" cannot currently be applied in India due to lack of necessary data.

⁴ See EB 35 (Annex 12), pp.5 and 13.

3 Scope of Database

The database includes all grid-connected power stations having an installed capacity above 5 MW in case of hydro and above 10 MW for other plant types. The data covers power stations of both public utilities and independent power producers (IPPs).

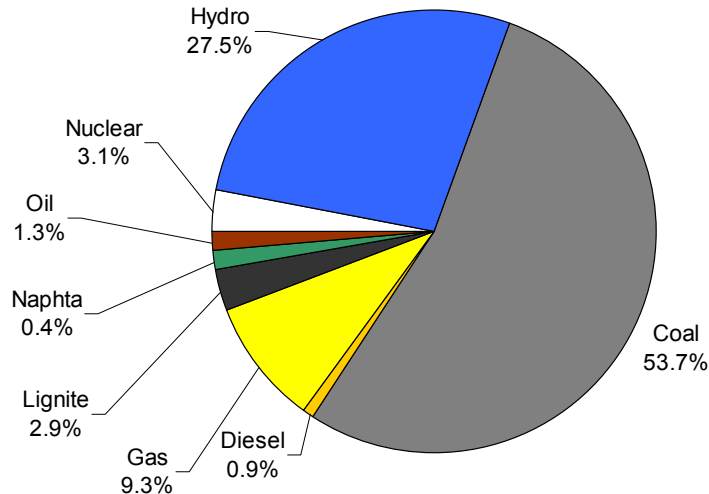


Figure 1: Breakdown of generation capacity covered by the database. The total corresponds to 124,486 MW as on 31.03.2007.

The following power stations are currently not accounted for in the database:

- Stations or units installed in Andaman and Nicobar Islands and Lakshadweep.
- Captive power stations:
As on 31 March 2007, the installed capacity and electricity generation from captive stations were 24,680.70 MW. The generation of these stations in 2006-07 was 76,845.50 GWh, equalling 10.32% of total generation in India.
- Non-conventional renewable energy stations:
These include power generation from wind, biomass, solar photovoltaic, and hydro below 5 MW capacity. The installed, grid-connected capacity of these sources was approx. 10,175 MW as on 31. 12. 2007.⁵
- Small decentralised generation sets.

⁵ Annual Report 2005-2006, Ministry of Non-Conventional Energy Sources

4 Data and Calculation Approach

This section gives an overview on the base data, annual data as well as the approaches used to calculate station-level and unit-level CO₂ emissions.

4.1 Base Data

The following base data parameters were collected for all the stations listed in the CO₂ database:

- **SNo:**
The Station Numbers start at 1 in each regional grid. The numbering has been introduced for unambiguous referral to each station and to allow for the insertion of additional station in a region without having to change the numbers of other regions. All units of a station have the same station number. Numbers may change in future database versions.
- **Station Name**
Name of the power station
- **Unit Number:**
The units of a station are numbered serially starting with 1. Stations are attributed with unit number 0 for the purpose of calculations.
- **Commissioning Date:**
The commissioning date is provided for each unit. Commissioning dates are important for the determination of the build margin.
- **Capacity:**
Capacity data is based on declared rated capacities in MW for each unit as of 31st March 2007.
- **Region:**
Regional grid to which the station is connected to. The table below gives the codes for the different regions used in the database:

Table 3: Codes of regional grids used in the database

Name of the Region	Code
Northern Region	NR
Eastern Region	ER
Western Region	WR
Southern Region	SR
North-Eastern Region	NER

- **State:**
State where the power station is located.

- **Sector:**
This denotes whether the station is operated by the central sector, the state authorities, or the private sector.
- **System:**
A list of the systems including abbreviations and full names is provided in Appendix A.
- **Type:**
Indicates the type of the station, viz. thermal, nuclear, hydro.
- **Fuel:**
Fuel 1 and Fuel 2 indicates the main fuels used for power generation at each station. For example, in coal based stations, Coal is indicated as Fuel 1 and Oil as Fuel 2.

4.2 Annual Data

The annual data columns in the database provide the following: net generation in GWh of the station, absolute carbon dioxide emissions in metric tonnes, and specific carbon dioxide emissions in tCO₂/MWh, for the Fiscal Years 2000-01 to 2006-07. In addition, there are columns to indicate whether the station is included in the operating margin in the respective year, and an additional column indicating which units are included in the build margin. If a unit is part of a registered CDM activity, it is excluded from the build margin, and the CDM registration number is indicated in the respective column.

CEA has compiled the CO₂ Database for the Fiscal Years (FY)⁶ 2000-01 to 2006-07 based upon generation, fuel consumption and fuel gross calorific value (GCV) data furnished by each power station. In cases where the station could not provide reliable data for all the relevant parameters, assumptions were made as described below. Further details on the assumptions made are provided in Appendix B.

Assumptions at Station Level

At the station level, the following assumptions were made where the relevant data could not be provided by a station:

Net generation:

For hydro stations, only gross generation was available, but not net generation data. Instead, the CEA standard value for auxiliary power consumption in hydro units (0.5%) was applied to derive the net generation from the gross generation data reported by the stations. Likewise, CEA standard values for auxiliary power consumption had to be applied for some of the gas- and diesel-fired thermal stations.

⁶ FY: 1 April – 31 March

Gross Calorific Value (GCV):

Default values were used for some thermal stations where station-specific GCVs were not available.

Assumptions at Unit Level

At unit level, the following assumptions were made for those units falling into the build margin (i.e. the most recently built units comprising 20% of net generation):

Gross generation:

For some stations, gross generation data were not available at unit level. Instead, the plant load factor of the respective station was used to derive the gross generation of the units. For units commissioned after the start of the relevant fiscal year, the gross generation was further adjusted pro rata the number of days since commissioning.

Net generation:

Net generation data is generally not measured at unit level. Two distinct approaches were applied to estimate net generation.

1. The auxiliary consumption (in % of gross generation) of the unit was assumed to be equal to that of the respective stations in the following cases:

- i. All units of a station fall into the build margin; or
- ii. All units of a station have the same installed capacity; or
- iii. The units in the station have different capacities but do not differ with respect the applicable standard auxiliary consumption.

2. In all other cases, standard values for auxiliary consumption adopted by CEA were applied.

Fuel consumption and GCV:

Fuel consumption and GCV are generally not measured at unit level. Instead, the specific CO₂ emissions of the relevant units were directly calculated based on heat rates. See Section 4.3 for details.

4.3 Calculation of CO₂ Emissions

Calculation Approach – Station Level

CO₂ emissions of thermal stations were calculated using the formula below:

$$AbsCO_2(station)_y = \sum_{i=1}^2 FuelCon_{i,y} \times GCV_{i,y} \times EF_i \times Oxid_i \quad (1)$$

Where:

AbsCO_{2,y} Absolute CO₂ emission of the station in the given fiscal year ‘y’

FuelCon_{i,y} Amount of fuel of type i consumed in the fiscal year ‘y’

GCV_{i,y} Gross calorific value of the fuel i in the fiscal year ‘y’

EF_i CO₂ emission factor of the fuel i based on GCV

Oxid_i Oxidation factor of the fuel I

The emission- and oxidation factors used in the CO₂ database are provided in Appendix B.

The emission factors for coal and lignite are based on the values provided in India’s Initial National Communication under the UNFCCC (Ministry of Environment & Forests, 2004). The emission factor for coal is supported by the results of an analysis of approx. 120 coal samples collected from different Indian coal fields. Since the values in the National Communication are based on the NCV (Net Calorific Value), they were converted to GCV basis using a formula also furnished in the National Communication. For other fuels, default emission factors from IPCC 2006 Guidelines⁷ (also based on the respective fuel’s NCV) were taken and converted to GCV basis using IEA default conversion factors.

The oxidation factor for coal and lignite were derived from an analysis performed with data on the unburnt carbon content in the ash from various Indian coal-fired power stations. The value of 98% is consistent with the default value provided in the IPCC 1996 Guidelines.⁸ For all other fuels, default values provided in the more recent IPCC 2006 Guidelines were used.

Specific CO₂ emissions of stations (*SpecCO₂(station)_y*) were computed by dividing the absolute emissions (*AbsCO₂(station)_y*) estimated above by the station’s net generation (*NetGen(station)_y*).

$$SpecCO_2(station)_y = \frac{AbsCO_2(station)_y}{NetGen(station)_y} \quad (2)$$

⁷ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Table 2.2

⁸ IPCC 1996 Revised Guidelines for National Greenhouse Gas Inventories, Volume 3 (Reference Manual), p.1.13

Calculation Approach – Unit Level

Unit-level CO₂ emissions were only calculated for units falling in the build margin.

The absolute CO₂ emissions of thermal units ($AbsCO_2(unit)_y$) were derived by multiplying the specific emissions ($SpecCO_2(unit)_y$) with the net generation of each unit ($NetGen(unit)_y$), where net generation was obtained as described in section 4.2:

$$AbsCO_2(unit)_y = SpecCO_2(unit)_y \times NetGen (unit)_y \quad (3)$$

A unit was assumed to have the same specific emissions as the corresponding station in the following three cases:

- i. If all units of a station fall into the build margin;
- ii. If all units of a station have the same installed capacity;
- iii. If the default specific emissions for the respective station type is higher than the corresponding station's specific emissions, and the concerned unit is capacity-wise among the largest of the station.

For over 90% of all thermal units in the build margin 2006-07, one of these cases applied. In the remaining cases, the specific emissions of the units were derived from conservative standard heat rate values, defined as the design heat rate plus 5% (see Appendix B).

4.4 Adjustment for Inter-Regional and Cross-Border Electricity Transfers

The weighted average emission factors and operating margins of each region were adjusted for inter-regional and cross-border electricity imports and exports, in line with the methodology ACM0002 and the *Tool to calculate the emission factor for an electricity system*:

- The relevant amounts of electricity imported and exported are listed in the database worksheet "Transfers";
- The CO₂ emissions associated with these imports were quantified based on the simple operating margin of the exporting grid.⁹ was used to quantify the CO₂ emissions associated with imports;

⁹ This corresponds to Approach c) listed in the Tool to calculate the emission factor of an electricity grid (Version 01, p.4). In the previous versions of the database, the emissions had been calculated based on either the combined margin or the weighted average emission factor of the exporting grid, depending on the share of imports in the importing region's total electricity supply.

4.5 Conservativeness

The need to ensure conservativeness of calculations in situations of uncertainty is a fundamental principle in the CDM. Assumptions are conservative if they tend to reduce the number of emission reductions being credited to a CDM project activity. The following approaches and assumptions contribute to the conservativeness of the database:

- The quality of station-level data was ensured through extensive plausibility testing and interaction with the station operators.
- In cases of data gaps at station level, standard data from CEA was used. For example, standard auxiliary power consumption was assumed for a number of gas-fired stations. Comparison with monitored values shows that these standard values are rather conservative, i.e. they lead to a somewhat lower heat rate and hence lower emissions than observed in many stations.
- Where required, the emission factors of thermal units were also derived from standard CEA values (design heat rate plus 5%). Again, these values are conservative (i.e. relatively low) compared to the heat rates observed in practice. See Section 4.3 for details on the build margin calculation.
- The fuel emission factors and oxidation factors used are generally consistent with IPCC defaults. For coal, the emission factor provided in India's Initial National Communication was used (95.8 t CO₂/TJ on NCV basis), being somewhat lower than the IPCC default for sub-bituminous coal (96.1 t CO₂/TJ).¹⁰

¹⁰ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Table 2.2

5 Results

Worksheet "Results" in the database provides the net generation and CO₂ emissions data and the resulting emission factors for the five regional grids in FY 2000-01 to FY 2006-07. The emission factors are also reproduced in Appendix C. The values are rounded off at two decimals. See database file for additional decimals.

5.1 Results for Fiscal Year 2006-07

Table 5 indicates the development of total emissions by region over the years covered by the database. The total emissions of India increased on average by 3.8% per year.

Table 4: Total emissions from the power sector by region for the FY 2000-01 to 2006-07

Absolute Emissions Total (tCO₂)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North	97'866'565	102'743'113	106'808'582	109'996'544	112'212'597	120'102'148	129'554'682
East	58'026'488	61'427'499	66'593'200	75'512'010	83'956'860	92'517'515	96'360'317
South	89'019'263	92'178'116	105'239'700	108'123'211	105'603'624	101'760'966	109'251'806
West	135'192'153	141'597'621	148'557'341	144'127'175	157'781'065	153'933'199	157'722'686
North-East	2'207'396	2'159'969	2'285'724	2'462'796	2'468'463	2'532'819	2'645'856
India	382'311'864	400'106'317	429'484'546	440'221'736	462'022'608	470'846'647	495'535'347

Table 5 shows the emission factors for FY 2006-07 excluding inter-regional and cross-border power transfers, whereas Table 6 shows the emission factors for the same year including these power transfers.

Table 5: Weighted average emission factor, simple operating margin (OM), build margin (BM) and combined margin (CM) of all regional grids for FY 2006-07 (not adjusted for inter-regional and cross-country electricity transfers), in tCO₂/MWh

	Average	OM	BM	CM
North	0.72	0.99	0.63	0.81
East	1.03	1.13	0.93	1.03
South	0.72	1.00	0.71	0.85
West	0.85	0.99	0.59	0.79
North-East	0.39	0.69	0.23	0.46
India	0.80	1.01	0.68	0.85

Table 6: *Weighted average emission factor, simple operating margin (OM), build margin (BM) and combined margin (CM) of all regional grids for FY 2006-07 (adjusted for inter-regional and cross-country electricity transfers), in tCO₂/MWh*

	Average	OM	BM	CM
North	0.74	1.00	0.63	0.81
East	1.00	1.09	0.93	1.01
South	0.72	1.00	0.71	0.85
West	0.86	0.99	0.59	0.79
North-East	0.40	0.70	0.23	0.46
India	0.80	1.01	0.68	0.84

The observed variations in the emission factors between the different regional grids originate from the differing availability and use of coal, gas and hydro resources. Stations fired with other fossil fuels such as diesel as well as nuclear stations play a less significant role.

A comparison of Table 5 and Table 6 shows that electricity transfers between regions did not have a significant influence on the emission factors in 2006-07.

Table 7 shows the weighted average specific emissions for fossil fuel-fired power stations in the five regional grids. Inter-regional variations arise chiefly from differences in station age and build (installed capacity and conversion technology). The substantially higher emission factor of gas stations in the North-Eastern Region (0.69 tCO₂/MWh) compared to other regions (0.44-0.49 tCO₂/MWh) can be explained with the dominance of open-cycle gas stations in the North-Eastern grid. However, due to the relatively low absolute generation level in this region, the influence on the country average value is small.

Table 7: *Weighted average specific emissions for fossil fuel-fired stations in FY 2006-07, in tCO₂/MWh..*

Weighted average specific emissions fuel wise in 2006-07 (tCO₂/MWh)						
	Coal	Disl	Gas	Lign	Napt	Oil
North	1.09	-	0.44	-	-	-
East	1.13	-	-	-	-	-
South	1.01	0.62	0.49	1.43	0.66	0.61
West	1.10	-	0.45	1.36	0.61	0.82
North-East	-	0.64	0.69	-	-	-
India	1.09	0.62	0.47	1.42	0.61	0.77

Note:

Stations for which assumptions had to be made are included in this analysis (see Section 4 for details).

5.2 Developments over Time

Figure 2 illustrates the development of the import-adjusted operating margins over the period from FY 2000-01 to FY 2006-07. The variations between the years are generally quite small, and largely driven by variations in annual electricity transfers between the regions (see Appendix C for details).

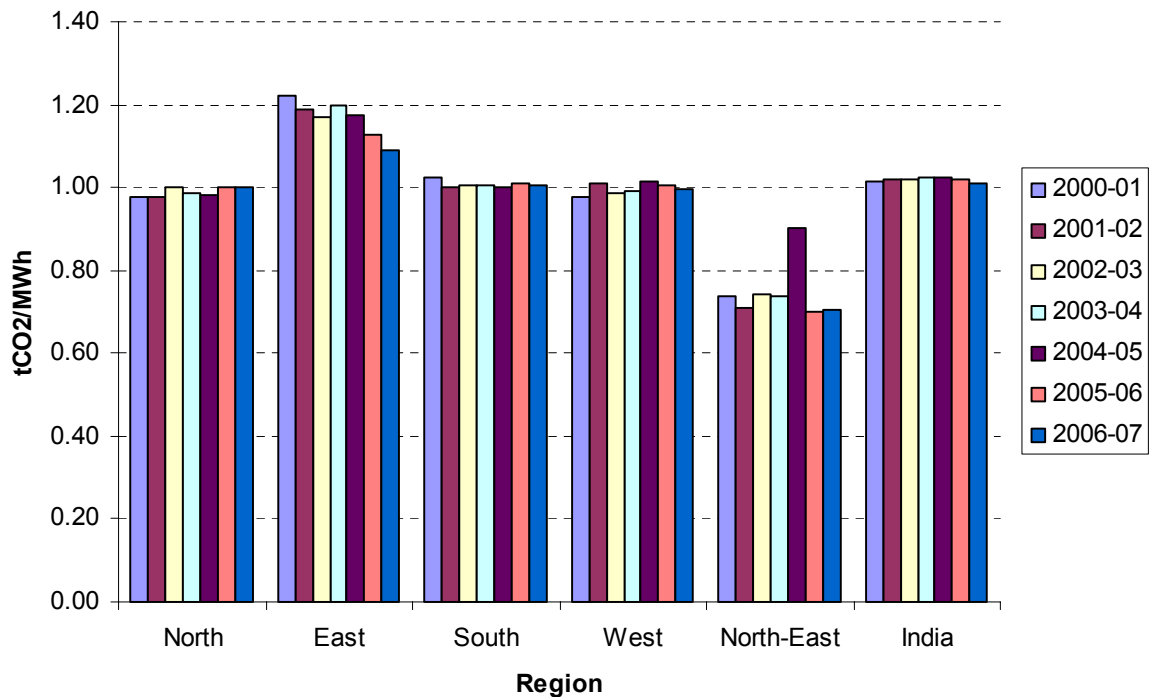


Figure 2: Development of the operating margin (adjusted for electricity transfers) for India's regional grids over the period 2000-01 to 2006-07.

Figure 3 shows the build margins for the three Fiscal Years 2004-05 to 2006-07. Significant changes compared to the previous year are observed for some regions. These can be explained by variations in the respective shares of coal, hydro and other generation types among the units falling into the build margin, as shown in Figure 4. It should be noted that due to the definition stipulated by the CDM rules, the build margin can react sensitively to a few large units being added to the grid in a given year. Consequently, the changes observed here need not necessarily point to longer-term trends.

The build margins for the four years prior to 2004-05 (i.e., 2000-01 – 2003-04) could not be calculated for practical reasons. The combined margins for these years were determined based on the respective operating margins for each year and the build margin for 2004-05.

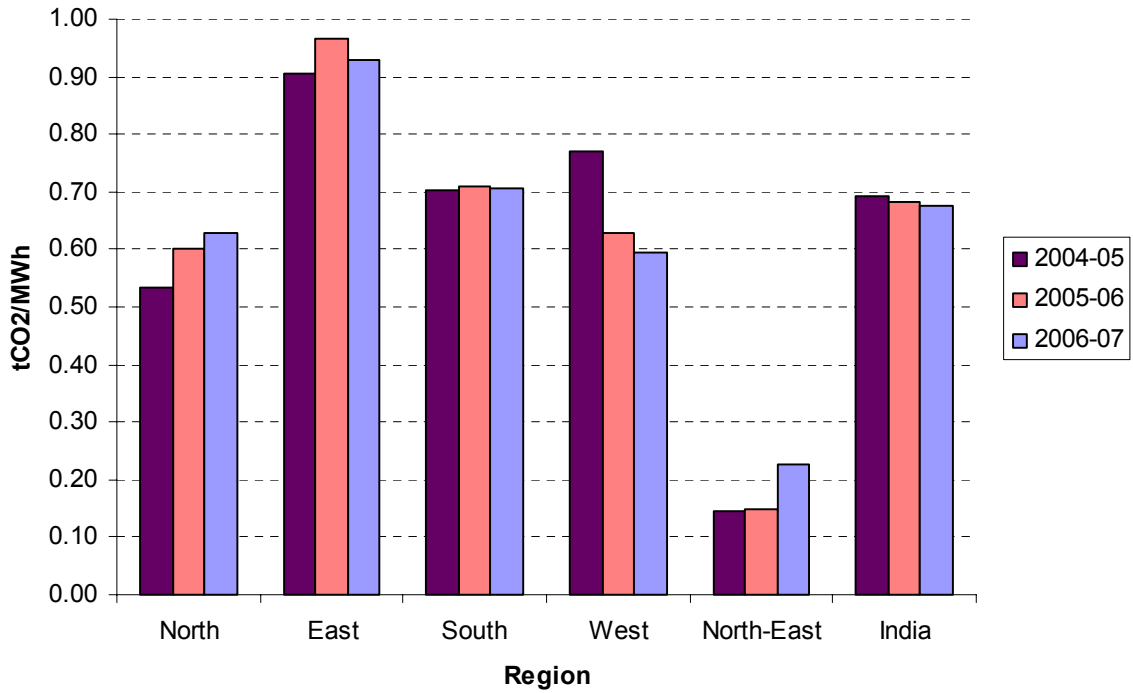


Figure 3: Development of the build margins for India's regional grids for FY 2004-05 and 2006-07.

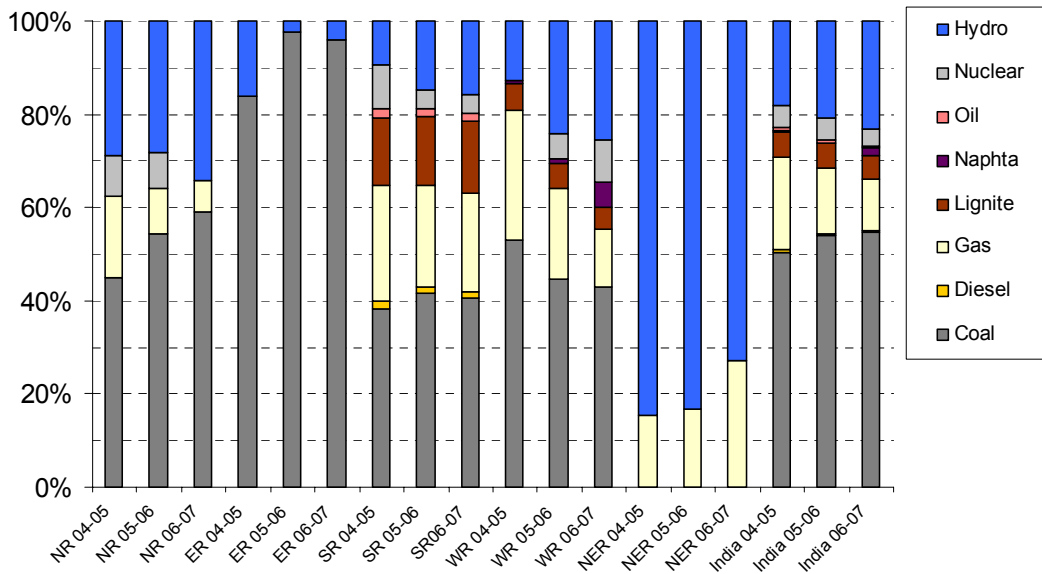


Figure 4: Breakdown of the build margin (comparison of FY 2004-05 and 2006-07) by station and fuel type for all regional grids (shares based on net generation)

Figure 5 shows the trends in the import-adjusted combined margins in the period 2000-01 – 2006-07. The most prominent variations are due to the changes in the build margins between 2004-05 and 2006-07. For India as a whole, the combined margin remained nearly constant.

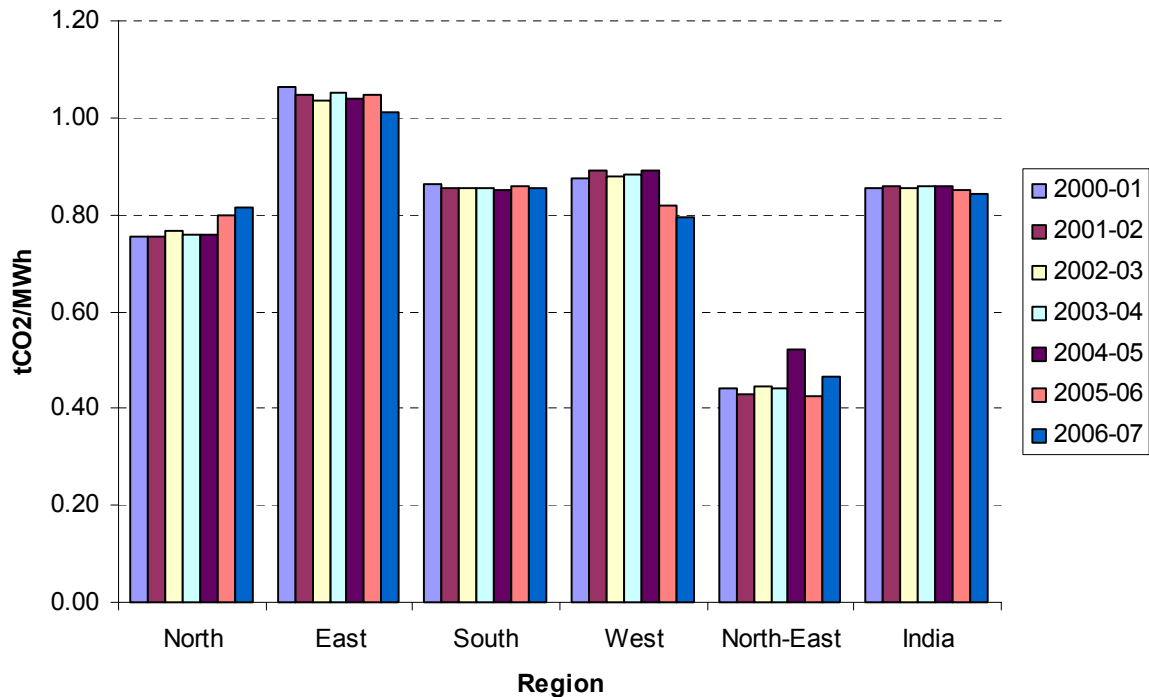


Figure 5: Development of the combined margin (adjusted for electricity transfers) for India's regional grids over the period 2000-01 to 2006-07.

5.3 Changes compared to Previous Database Versions

In comparison with the previous version of the Database (Version 2.0), this version includes some small changes which affect the emission factors for the past Fiscal Years 2000-01 to 2005-06:

- South: Build margin for 2004-5 has slightly decreased due to revision of commissioning dates of some units;
- All regions: Slight changes of different margins due to adoption of a new calculation approach for import-adjusted emission factors, in line with the latest version of ACM0002 and the new *Tool for calculation of the emission factor for an electricity system* (see Sections 1 and 4.4).

6 User Examples

This section provides two illustrative examples of how the CO₂ Database can be applied. The examples are based on hypothetical renewable energy projects that differ in size and supply different regional grids.

Project A is a grid-connected 5 MW small hydropower station located in the State of Assam (North-Eastern Region). The station will be commissioned in 2009. Annual net generation is projected at approx. 17'500 MWh.

- The project qualifies as a small-scale CDM activity since its capacity is below the 15 MW threshold. Hence it will use the latest version of CDM methodology AMS-I.D for grid-connected power generation from renewable energy sources.
- Methodology AMS-I.D gives two options for determining the baseline emission factor: Either the weighted average emissions, or the combined margin of the regional grid. In this example, it is assumed that the promoters choose the weighted average option. In addition, it is assumed that the promoters choose to adjust the weighted average emission factor for electricity imports, despite the fact that this is not mandatory under AMS-I.D.
- In the PDD, the expected emission reductions achieved by the hydro station are projected based on the expected annual generation, and the import-adjusted weighted average emission factor for the North-Eastern Grid in the most recent year for which data is available (2006-07). The corresponding value is 0.40 t CO₂/MWh. Hence the absolute emission reductions are projected at $0.40 * 17'500 = 7'000$ t CO₂/yr. The emission reductions are equal to the baseline emissions, since the project does not result in greenhouse gas emissions of its own.
- In accordance with AMS-I.D, the promoters will determine the *actual* baseline emission factor *ex post*. The actual emission reductions will then be calculated in each year of the crediting period based on the observed net generation and the weighted average emission factor for the respective year.¹¹ The latter would be published annually by CEA.

Project B is a 100 MW grid-connected wind farm located in the State of Tamil Nadu (Southern Region). The project will be commissioned in 2009. Average net supplies to the grid are projected at 312,500 MWh per year.

- The project exceeds the 15 MW threshold and thus qualifies as a large-scale CDM activity. Hence it is eligible to use the latest version of methodology ACM0002 for grid-connected power generation from renewable energy sources.
- Under ACM0002, the combined margin approach is mandatory. In addition, inter-regional power transfers (imports and exports) must be taken into account.

¹¹ The emission factor of the previous year may be used instead. See request for clarification AM_CLA_0038 (<http://cdm.unfccc.int/methodologies/PAMethodologies/Clarifications/index.html>).

- In contrast to the first example, the promoters decide to fix the baseline emission factor *ex ante*. That is, the baseline emission factor is determined based on the most recent data available, and remains fixed for the duration of the crediting period. The actual emission reductions will be calculated in each year based on the observed net generation and the pre-defined baseline emission factor.
- For this *ex ante*-option, the methodology ACM0002 requires that the operating margin is calculated as the average of the three most recent years (here 2004-05 – 2006-07). The operating margin to be applied thus works out to 1.00 t CO₂/MWh.
- Since wind is an intermittent energy source, the promoter is allowed to assign a weight of 75% to the operating margin, and 25% to the build margin. The resulting combined margin is 0.93 t CO₂/MWh (75% x 1.00 + 25% x 0.71 for the fiscal year 2006-07). This value is used for projecting the emission reductions in the PDD as well as for calculating the actual emission reductions.

The two CDM project activities are summarised in Table 8 below.

Table 8: Illustration on how to use the CO₂ Database for calculating the emission reductions of CDM projects

	Project A	Project B
Project Info		
Type:	Hydro station	Wind park
Size:	5 MW (small-scale according to CDM criteria)	100 MW (large-scale according to CDM criteria)
Projected Generation (net):	17'500 MWh /yr	312'500 MWh /yr
Commissioning year:	2009	2009
Year of CDM registration:	2008	2008
Region:	North East	South
CDM methodology:	AMS-I.D / Version 13	ACM0002 / Version 07
Baseline Emission Factor Calculation		
Calculation method:	Weighted average	Combined margin
Data vintage for projection of emission reductions:	2006-07 (most recent available at time of PDD validation)	For OM: 2004-05, 2005-06, 2006-07 (most recent 3 years available at time of PDD validation) For BM: 2006-07
Data vintage for verification of emission reductions:	Actual year of generation, i.e. 2006-07, 2006-07 etc. (emission factor fixed <i>ex post</i>)	Same as for projection (emission factor fixed <i>ex ante</i>)
Accounting of imports:	Not mandatory, but done	Mandatory
Weights for combined margin:	Operating margin: 50% Build margin: 50%	Operating margin: 75% Build margin: 25% (default for intermittent sources)
Emission Reduction Calculations		
Values in tCO ₂ /MWh:	0.40 Weighted average	1.00 Operating margin 0.71 Build margin 0.93 Combined margin
Projected emission reductions:	7000 t CO ₂ per year	290'625 t CO ₂ per year
Actual emission reductions:	Monitored net generation x monitored weighted average	Monitored net generation x fixed combined margin

7 Updating Procedure

The CO₂ Database will be updated annually by CEA and made available on its website: www.cea.nic.in . Previous versions will be archived by CEA and the main changes relative to previous database versions will be documented.

8 Further Information

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Appendix A – Systems in India’s Regional Grids

In alphabetical order

Abbreviation	Full name
ABAN	ABAN Power Company
APGCL	Assam Power Generation Corporation Limited
APGENCO	Andhra Pradesh Power Generation Co Ltd
ASEB	Assam State Electricity Board
BBMB	Bhakra Beas Management Board
BSEB	Bihar State Electricity Board
CESC	Calcutta Electric Supply Company Limited
CSEB	Chattisgarh State Electricity Board
DPL	Durgapur projects Limited
DVC	Damodar Valley Corporation
GIPCL	Gujarat Industrial Power Corporation Limited
GMDCL	Gujarat Mineral Development Corporation Limited
GMR Energy	GMR Energy
GPEC	Gujarat Paguthan Energy Corporation Pvt. Limited
GSECL	Gujarat State Electricity Corporation Limited
GTE Corp	GTE Corporation
GVK Ind.	GVK Power & Infrastructure Limited
HEGL	HEG Limited
HPGCL	Haryana Power Generation Corporation
HPSEB	Himachal Pradesh State Electricity Board
INDSIL	Indsil Electros melt Ltd
IPGPCL	Indrapratha Power Generation Co Ltd
JINDAL	JSW Energy Limited
JKEB	Jammu & Kashmir Electricity Board

Continuation

Abbreviation	Full name
JPHPL	Jai Prakash Hydro Power Limited
JSEB	Jharkand State Electricity Board
KPCL	Karnataka Power Corporation Limited
KSEB	Kerala State Electricity Board
LVS Power	LVS Power Limited
MaduraiP	Madurai Power Corporation Limited
MAHAGENCO	Maharashtra State Power Generation Company Ltd
MAPS	Madras Atomic Power Station
MALANA	Malana Power Corporation Ltd
MPDC	Manipur Power Development Corporation
MEGEB	Meghalaya State Electricity Board
MPGPCL	Madhya Pradesh Power Generating Co. Ltd.
NAPS	Narora Atomic Power Station
NCTPP	National Capital Thermal Power Plant
NEEPCO	North Eastern Electric Power Corporation Ltd
NHDC	Narmada Hydro Electric Development Corporation
NHPC	National Hydro Electric Corporation
NLC	Neyvelli Lignite Corporation Ltd
NPC	Nuclear Power Corporation of India Ltd.
NTPC	NTPC Ltd
OHPC	Orissa Hydro Power Corporation
OPGC	Orissa Power Generation Corporation
PPCL	Pondichery Power Corporation Limited

Continuation

Abbreviation	Full name
PPNPG	PPN Power Generating Company Pvt. Limited
PSEB	Punjab State Electricity Board
RAPS	Rajasthan Atomic Power Station
RATANAGIRI	Ratnagiri Gas & power Pvt Ltd
REL	Reliance Energy Ltd
RPG	RP Goenka Group
RRVUNL	Rajasthan Rajya Vidyut Utpadan Nigam
Samalpatti	Samalpatti Power Company Limited
SJVNL	Sutluj Jal Vidyut Nigam Ltd
SPECT. IND	Spectrum Power Generation Limited
SSVNL	Sardar Sorovar Vidyut Nigam Limited
STPS	Super Thermal Power Station
Tata MAH	Tata Power Company Limited
Tata PCL	Tata Power Company Limited
THDC	Tehri Hydroelectric Development Corporation
TNEB	Tamilnadu Electricity Board
TVNL	Tenughat Vidyut Nigam Limited
UPHPC	Uttar Pradesh Hydro Power Corporation Limited
UPRVUNL	Uttar Pradesh Rajya Vidyut Utpadan Nigam
VVNL	Visvesarya Vidyut Nigam Ltd
WBPDC	West Bengal Power Development Corporation Ltd
WBSEB	West Bengal State Electricity Board

Appendix B – Assumptions for CO₂ Emission Calculations

Fuel Emission Factors (EF) (Source: Coal/Lignite - Initial National Communication, Gas/Oil/Diesel/Naphta - IPCC 2006, Corex - own assumption)

	Unit	Coal	Lignite	Gas	Oil	Diesel	Naphta	Corex
EF based on NCV	gCO ₂ /MJ	95.8	106.2	56.1	77.4	74.1	73.3	0.0
Delta GCV NCV	%	3.6%	3.6%	10%	5%	5%	5%	n/a
EF based on GCV	gCO ₂ /MJ	92.5	102.5	51.0	73.7	70.6	69.8	0.0
Oxidation Factor	-	0.98	0.98	1.00	1.00	1.00	1.00	n/a
Fuel Emission Factor	gCO ₂ /MJ	90.6	100.5	51.0	73.7	70.6	69.8	0.0

n/a = not applicable (i.e. no assumptions were needed)

Assumptions at Station Level (only where data was not provided by station)

	Unit	Coal	Lignite	Gas-CC	Gas-OC	Oil	Diesel-Eng	Diesel-OC	Naphta	Hydro	Nuclear
Auxiliary Power Consumption	%	8.0	10.0	3.0	1.0	3.5	3.5	1.0	3.5	0.5	10.5
Gross Heat Rate	kcal /kWh (gross)	2'500	2'713	2'013	3'150	2'117	1'975	3'213	2'117	n/a	n/a
Net Heat Rate	kcal /kWh (net)	2'717	3'014	2'075	3'182	2'193	2'047	3'330	2'193	n/a	n/a
Specific Oil Consumption	ml /kWh (gross)	2.0	3.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GCV	kcal /kg (or m3)	3755	n/a	8'800	n/a	10'100	10'500	10'500	11'300	n/a	n/a
Density	t /1,000 lt	n/a	n/a	n/a	n/a	0.95	0.83	0.83	0.70	n/a	n/a
Specific CO ₂ emissions	tCO ₂ /MWh	1.04	1.28	0.44	0.68	0.68	0.60	0.98	0.64	n/a	n/a

n/a = not applicable (i.e. no assumptions were needed)

Assumptions at Unit Level (by capacity; only for units in the BM, where data was not provided by station)

Coal	Unit	67.5 MW	120 MW	200-250 MW	500 MW
Gross Heat Rate	kcal /kWh	2'750	2'500	2'500	2'425
Auxiliary Power Consumption	%	12.0	9.0	9.0	7.5
Net Heat Rate	kcal /kWh	3'125	2'747	2'747	2'622
Specific Oil Consumption	ml /kWh	2.0	3.0	2.0	2.0
Specific CO ₂ Emissions	tCO ₂ /MWh	1.19	1.05	1.05	1.00
Lignite	Unit	75 MW	125 MW	210/250 MW	
Gross Heat Rate	kcal /kWh	2'750	2'560	2'713	
Auxiliary Power Consumption	%	12.0	12.0	10.0	
Net Heat Rate	kcal /kWh	3'125	2'909	3'014	
Specific Oil Consumption	ml /kWh	3.0	3.0	3.0	
Specific CO ₂ Emissions	tCO ₂ /MWh	1.32	1.23	1.28	
Gas	Unit	0-49.9 MW	50-99.9 MW	>100 MW	
Gross Heat Rate	kcal /kWh	1'950	1'910	1'970	
Auxiliary Power Consumption	%	3.0	3.0	3.0	
Net Heat Rate	kcal /kWh	2'010	1'969	2'031	
Specific CO ₂ Emissions	tCO ₂ /MWh	0.43	0.42	0.43	
Diesel	Unit	0.1-1 MW	1-3 MW	3-10 MW	>10 MW
Gross Heat Rate	kcal /kWh	2'350	2'250	2'100	1'975
Auxiliary Power Consumption	%	3.5	3.5	3.5	3.5
Net Heat Rate	kcal /kWh	2'435	2'332	2'176	2'047
Specific CO ₂ Emissions	tCO ₂ /MWh	0.72	0.69	0.64	0.60
Naphta	Unit	All sizes			
Increment to Gas Heat Rate	%	2%			
Gross Heat Rate	kcal /kWh	2'117			
Auxiliary Power Consumption	%	3.5			
Net Heat Rate	kcal /kWh	2'193			
Specific CO ₂ Emissions	tCO ₂ /MWh	0.64			

Combined Margin

	Unit	
Weight OM	%	50%
Weight BM	%	50%

Conversion Factors

	Unit	
Energy	kJ /kcal	4.1868
	MJ /kWh	3.6

Oil

Specific Emission	gCO ₂ /ml	2.96
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Appendix C – Grid Emission Factors

Note: Values are rounded off at two decimals here. See Database (Excel File, Worksheet "Results") for additional decimals.

Table A: Values for all regional grids for FY 2000-01 until FY 2006-07, excluding inter-regional and cross-border electricity transfers.

Weighted Average Emission Rate (tCO₂/MWh) (excl. Imports)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North	0.72	0.73	0.74	0.71	0.71	0.71	0.72
East	1.09	1.06	1.11	1.10	1.08	1.08	1.03
South	0.73	0.75	0.82	0.84	0.78	0.74	0.72
West	0.90	0.92	0.90	0.90	0.92	0.87	0.85
North-East	0.42	0.41	0.40	0.43	0.32	0.33	0.39
India	0.82	0.83	0.85	0.85	0.84	0.82	0.80

Simple Operating Margin (tCO₂/MWh) (excl. Imports)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North	0.98	0.98	1.00	0.99	0.97	0.99	0.99
East	1.22	1.22	1.20	1.23	1.20	1.16	1.13
South	1.02	1.00	1.01	1.00	1.00	1.01	1.00
West	0.98	1.01	0.98	0.99	1.01	0.99	0.99
North-East	0.74	0.71	0.74	0.74	0.71	0.70	0.69
India	1.02	1.02	1.02	1.03	1.03	1.02	1.01

Build Margin (tCO₂/MWh) (excl. Imports)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North					0.53	0.60	0.63
East					0.90	0.97	0.93
South					0.70	0.71	0.71
West					0.77	0.63	0.59
North-East					0.15	0.15	0.23
India					0.69	0.68	0.68

Combined Margin (tCO₂/MWh) (excl. Imports)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North	0.76	0.76	0.77	0.76	0.75	0.80	0.81
East	1.06	1.06	1.05	1.07	1.05	1.06	1.03
South	0.86	0.85	0.86	0.85	0.85	0.86	0.85
West	0.87	0.89	0.88	0.88	0.89	0.81	0.79
North-East	0.44	0.43	0.44	0.44	0.43	0.42	0.46
India	0.86	0.86	0.86	0.86	0.86	0.85	0.85

Table B: Values for all regional grids for FY 2000-01 until FY 2006-07, including inter-regional and cross-border electricity transfers.

Weighted Average Emission Rate (tCO₂/MWh) (incl. Imports)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North	0.72	0.73	0.74	0.71	0.72	0.73	0.74
East	1.06	1.03	1.09	1.08	1.05	1.05	1.00
South	0.74	0.75	0.82	0.84	0.79	0.74	0.72
West	0.90	0.92	0.90	0.90	0.92	0.89	0.86
North-East	0.42	0.41	0.40	0.43	0.52	0.33	0.40
India	0.82	0.83	0.85	0.85	0.84	0.81	0.80

Simple Operating Margin (tCO₂/MWh) (incl. Imports)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North	0.98	0.98	1.00	0.99	0.98	1.00	1.00
East	1.22	1.19	1.17	1.20	1.17	1.13	1.09
South	1.02	1.00	1.01	1.00	1.00	1.01	1.00
West	0.98	1.01	0.99	0.99	1.01	1.00	0.99
North-East	0.74	0.71	0.74	0.74	0.90	0.70	0.70
India	1.01	1.02	1.02	1.02	1.02	1.02	1.01

Build Margin (tCO₂/MWh) (not adjusted for imports)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North					0.53	0.60	0.63
East					0.90	0.97	0.93
South					0.70	0.71	0.71
West					0.77	0.63	0.59
North-East					0.15	0.15	0.23
India					0.69	0.68	0.68

Combined Margin in tCO₂/MWh (incl. Imports)							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North	0.76	0.76	0.77	0.76	0.76	0.80	0.81
East	1.06	1.05	1.04	1.05	1.04	1.05	1.01
South	0.86	0.85	0.86	0.85	0.85	0.86	0.85
West	0.87	0.89	0.88	0.88	0.89	0.82	0.79
North-East	0.44	0.43	0.44	0.44	0.52	0.42	0.46
India	0.85	0.86	0.86	0.86	0.86	0.85	0.84

Appendix D – Summary of Methodology ACM0002 / Version 07

Download ACM0002 at: <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>

ACM0002 is a consolidated CDM methodology for grid-connected power generation from renewable energy sources. It covers grid-connected renewable power generation project activities that involve electricity capacity additions. Examples of eligible project types include run-of-river hydro power plants, and hydro power projects with existing reservoirs where the volume of the reservoir is not increased; wind energy; geothermal energy; solar energy; and wave and tidal energy.

The methodology requires the calculation of the baseline emission factor following the combined margin (CM) approach. The combined margin consist of a weighted average of:

- Operating margin (OM);
- Build margin (BM).

The relative weights used to determine the combined margin are by default the same, i.e. 50%. Alternative weights can be used for intermittent power sources.

There are four options to calculate the operating margin, depending on local conditions:

- *Simple operating margin*. This is the preferred approach for India, except potentially in regions with a very high share of hydro power (North-Eastern Region).
- The other three approaches are: (i) *simple adjusted operating margin*; (ii) *dispatch data analysis*; and (iii) *average operating margin*.

The build margin is the generation-weighted average emission factor of the most recent power plants, consisting of the larger of (i) the five power plants that have been built most recently; or (ii) the capacity additions that represent 20% of the system generation that have been built most recently. In India, the latter approach generally yields the larger sample and hence must be followed. CDM projects must be excluded from the build margin, as long as the build margin does not contain generation units older than 10 years.

The operating margin must be adjusted for electricity transfers (imports) from connected electricity systems (other states/regions, other countries) to the project electricity system. Generally, no such adjustments are required for the build margin.

The actual emission reductions achieved by a CDM project are calculated based on the monitored electricity production in each year, and the combined margin (baseline emission factor). The combined margin is initially calculated from the most recent data available at the time of PDD submission. It can then either remain fixed for the duration of the project's crediting period (*ex-ante approach*), or be updated annually (*ex-post approach*). The two approaches have different requirements in terms of data vintage.

Appendix E – Abbreviations

In alphabetical order

Abbreviation	Full Name
ACM0002	Approved Consolidated Methodology by CDM Executive Board for grid connected large scale renewable project
AMS-1.D	Approved Methodology for small scale grid connected renewable projects
BM	Build margin
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CER	Certified Emission Reduction
CM	Combined margin
CO ₂	Carbon Dioxide
FY	Financial Year
GCV	Gross Calorific Value
GHG	Greenhouse Gases
GWH	Gigawatt Hour
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
MW	Megawatt
OM	Operating margin
PDD	Project Design Document
RLDC	Regional Load Dispatch Centre
RPC	Regional Power Committee
UNFCCC	United Nations Framework Convention on Climate Change