CO_2 Baseline Database for the Indian Power Sector

User Guide

Version 2.0

June 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	4th October 2006	–
1.0	November 2006	- 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	- Adjusted fuel emission factor of lignite to be in line with Initial National Communication figures
2.0	June 2007	- Added data for FY 2005-06, including new stations and units commissioned during 2005-06 **Retroactive changes to data for FY 2000-01 to 2004-05:** - 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

Expert Team Contributing to the Database

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Foreword

The Clean Development Mechanism (CDM) gives an opportunity to developing countries in achieving their sustainable development objective. Besides providing an additional opportunity to introduce new and efficient technologies and also benefit from selling Carbon Credits to developed countries.

India has high potential for CDM projects, particularly in the Power Sector. The Baseline Carbon Dioxide Emissions from Power Sector have been worked out by CEA based on detailed authenticated information obtained from all the operating Power Stations in the country. India with large resources of technical power has potential to develop innovative CDM projects in Energy Efficiency and Conservation in addition to projects in power generation through R & M schemes and adoption of new and renewable technologies. The present capacity utilisation of renewable energy is very low and to increase the utilisation factors of such electricity generation plants would be attractive schemes for CDM benefits. The Baseline would benefit all prospective CDM project developers to estimate the amount of Certified Emission Reduction (CERs) from any CDM project activity.

The team of CEA Officers headed by Shri R.C.Nakul, Chief Engineer (Conservation and Efficiency Division) has done a commendable job under the able guidance of Shri V.S. Verma, Member (Planning), CEA. The work has been updated as a result of series of interaction with the Power Station Authorities, the Officers of GTZ namely, Dr A. Kaupp, Smt. Pamposh Bhat, Director, GTZ- Climate Change Unit and review of the whole data by Mr Urs Brodmann and Dr Axel Michaelowa, GTZ-CDM-India consultants, who also provided feedback and guidance to the team of engineers working on the job.

The baseline information is dynamic in nature and data will have to be updated every year based on the new generating capacity added in the country. This Version 2.0 of the database represents the first update of this kind. It incorporates the data for the Fiscal Year 2005-06, thereby extending the scope of the database to six years (2000-01 – 2005-06).

I am confident that this Baseline Carbon Dioxide Emissions Database is fulfilling the expectations of all the stakeholders who are involved in the development of CDM projects in India and help reduce transaction costs and mitigate the risk of non delivery of CERs over long period.

New Delhi
June 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, 248 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 2005-06 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 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.

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
June 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 get 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 Rodrigo Weiss 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 through me 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, Dy 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
June 2007

(R.C.Nakul)
Chief Engineer (C&E)

Message

The Kyoto Protocol's Clean Development Mechanism is expected to result in emission reductions equivalent to 1.8 billion tonnes of CO2 to the end of 2012. CDM will bring in investments in developing projects that reduces 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" CO_2 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 CO_2 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 CO_2 emissions for all grid-connected power stations in India. The database currently covers the six fiscal years 2000-01 to 2005-06. 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 like 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 2005-06 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 2005-06 (inter-regional and cross-border electricity transfers included), in tCO_2/MWh

	Average	OM	BM	CM
North	0.72	0.99	0.60	0.80
East	1.05	1.13	0.97	1.05
South	0.74	1.01	0.71	0.86
West	0.88	0.99	0.63	0.81
North-East	0.33	0.70	0.15	0.42
India	0.81	1.02	0.68	0.85

Average is the average emissions of all stations in the grid

OM is the average emission from all the 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 CO_2 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 (CO_2). 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 CO_2 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 CO_2 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 CO_2 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.

Project developers wishing to benefit from the CDM must use an approved methodology to quantify their emission reductions. 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.

The baseline emissions for all the five regional grids are given in Section 5 (Results) of this user guide. The complete updated CO_2 Database (Microsoft Excel File) and this User Guide along with all the previous versions is 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 CO_2 database and 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.

Indian Power Sector

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 132,329 MW as on 31.03.2007, consisting of 86,015 MW Thermal, 34,654 MW Hydro and 3,900 MW Nuclear. Region-wise details of installed capacity are shown in Table 1.

Table 1: Region wise installed capacity (MW) as on 31.3.2007.
Note: These capacities are not identical with those listed in the Excel database, because the database currently covers only the years up to 31.3.2006

Region	Hydro	Thermal				Nuclear	Renew.	Total
		Coal	Gas	Diesel	Total			
Northern	13,000.38	18,027.50	3,323.19	14.99	21,365.68	1,180.00	813.37	36,359.43
Western	6,918.83	22,441.50	5,820.72	17.48	28,279.70	1,840.00	1,874.76	38,913.29
Southern	11,011.71	16,172.50	3,586.30	939.32	20,698.12	880.00	4,971.55	37,561.38
Eastern	2,496.53	14,149.88	190.00	17.20	14,357.08	0.00	46.76	16,900.37
N.Eastern	1,221.07	330.00	771.50	142.74	1,244.24	0.00	48.91	2,514.22
Islands	5.25	0.00	0.00	70.02	70.02	0.00	5.25	80.52
All India	**34,653.77**	**71,121.38**	**13,691.71**	**1,201.75**	**86,014.84**	**3,900.00**	**7,760.60**	**132,329.21**

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 CO_2 emissions from 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. 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				
Uttaranchal				

For the purpose of calculating the emission reductions achieved by any CDM project, the CDM Executive Board requires that the "project electricity system is defined by the spatial extent of the power plants that can be dispatched without significant transmission constraints".[1] This implies that the grid emission factors are most appropriately calculated at the level of the five regional grids.

[1] Approved consolidated baseline methodology ACM0002 / Version 06

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 t CO_2/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 CO_2 Database.

Specifically, the database contains the following elements:

- Worksheet "Data" provides the net generation and the absolute and specific CO_2 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 06). 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 CO_2 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 CO_2 emitted per unit of electricity generated in the grid. It is calculated by dividing the absolute CO_2 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 CO_2 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.[2] The simple operating margin is obtained by dividing the region's total CO_2 emissions by the net generation of the stations serving the region *excluding* low-cost/must-run sources. In other words, the total emissions are divided by the total net generation of all thermal power stations. Hydro and nuclear qualify as low-cost/must-run sources, and their net generation is therefore excluded from the denominator.

- **Build margin (BM):**
  The build margin reflects the average CO_2 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 chose 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.

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[2] 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.

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).

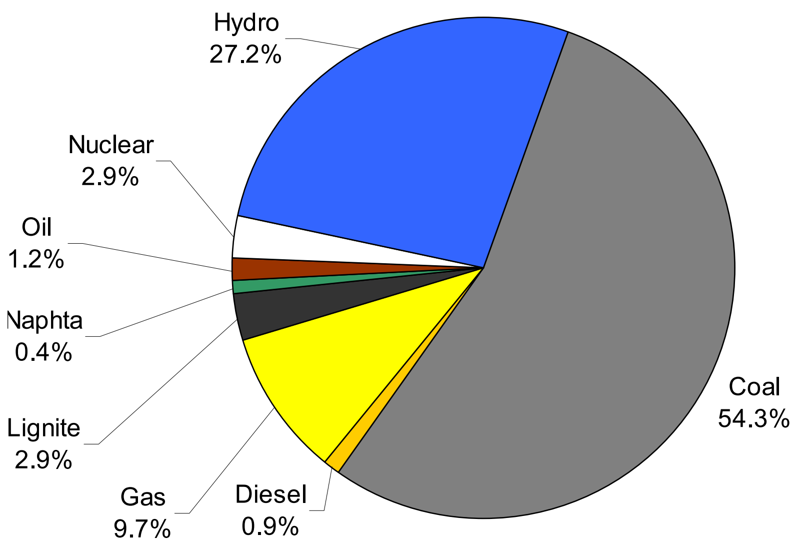

Figure 1: Breakdown of generation capacity covered by the database. The total corresponds to 117,680 MW as on 31.03.2006.

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 2006, the installed capacity and electricity generation from captive stations were 21,468.21 MW and 73,639.7 GWh, respectively, which is approx. 12% 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. 10,253 MW as on 31 12 2007.[3]
- Small decentralised generation sets.

In the future, stations registered as CDM activities may have to be excluded for the duration of their crediting period, to avoid an unjustified “negative feedback” to subsequent CDM project activities.

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 CO_2 emissions.

4.1 Base Data

The following base data parameters were collected for all the stations listed in the CO_2 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 2006.
- 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.

[3] Ministry of Non-Conventional Energy Sources

- Sector:
  This denotes whether the stations 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 tCO_2/MWh, for the Fiscal Years 2000-01 to 2005-06. 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.

CEA has compiled the CO_2 Database for the Fiscal Years (FY)[4] 2000-01 to 2005-06 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.

Gross Calorific Value (GCV):
Default values were used for some thermal stations where station-specific GCVs were not available.

4 FY: 1 April – 31 March

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. (i) In cases where all units of a station fall into the build margin or where all units of a station have the same installed capacity, the auxiliary consumption (in % of gross generation) of the units was assumed to be equal to that of the respective station. (ii) 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 CO_2 emissions of the relevant units were directly calculated based on heat rates. See Section 4.3 for details.

4.3 Calculation of CO_2 Emissions

Calculation Approach – Station Level

CO_2 emissions of thermal stations were calculated using the formula below:

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

Where:

$AbsCO_{2,y}$	Absolute CO_2 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	CO_2 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 CO_2 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 Guidelines[5] (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.[6] For all other fuels, default values provided in the more recent IPCC 2006 Guidelines were used.

Specific CO_2 emissions of stations (*$SpecCO_2(station)_y$*) were computed by dividing the absolute emissions (*$AbsCO_2(station)_y$*) estimated above by the station's net generation (*$NetGen(station)_y$*).

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

Calculation Approach – Unit Level

Unit-level CO_2 emissions were only calculated for units falling in the build margin.

The absolute CO_2 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 0.0.0:

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

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 2005-06, 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).

5 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Table 2.2

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

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

The weighted average emission factors and operating margins of each region where adjusted for inter-regional and cross-border electricity imports and exports, in line with the methodology ACM0002:

- The relevant amounts of electricity import and export are listed in the database worksheet “Transfers”;
- For the North-Eastern Grid, approach d) of ACM0002 Version 06 (p.4, weighted average emissions of exporting grid) was used to quantify the CO_2 emissions associated with imports;
- For all other regional grids, approach c) of the same methodology was used (combined margin of the exporting grids).

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 CO_2/TJ on NCV basis), being somewhat lower than the IPCC default for sub-bituminous coal (96.1 t CO_2/TJ).[7]

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

5 Results

Worksheet "Results" in the database gives the various emission factors calculated for all the five regional grids for FY 2000-01 to FY 2005-06. The same data 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 2005-06

Table 4 shows the emission factors for FY 2005-06 excluding inter-regional and cross-border power transfers, whereas Table 5 shows the emission factors for the same year including these power transfers.

Table 4: Weighted average emission factor, simple operating margin (OM), build margin (BM) and combined margin (CM) of all regional grids for FY 2005-06 (not adjusted for inter-regional and cross-country electricity transfers), in tCO_2/MWh

	Average	OM	BM	CM
North	0.71	0.99	0.60	0.80
East	1.08	1.16	0.97	1.06
South	0.74	1.01	0.71	0.86
West	0.87	0.99	0.63	0.81
North-East	0.33	0.70	0.15	0.42
India	0.82	1.02	0.68	0.85

Table 5: Weighted average emission factor, simple operating margin (OM), build margin (BM) and combined margin (CM) of all regional grids for FY 2005-06 (adjusted for inter-regional and cross-country electricity transfers), in tCO2/MWh

	Average	OM	BM	CM
North	0.72	0.99	0.60	0.80
East	1.05	1.13	0.97	1.05
South	0.74	1.01	0.71	0.86
West	0.88	0.99	0.63	0.81
North-East	0.33	0.70	0.15	0.42
India	0.81	1.02	0.68	0.85

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 4 and Table 5 shows that electricity transfers between regions did not have a significant influence on the emission factors in 2005-06.

Table 6 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 (0.66 tCO_2/MWh) compared to other regions (0.45-0.46 tCO_2/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 6: Weighted average specific emissions for fossil fuel-fired stations in FY 2005-06, in tCO_2-MWh.
Note: Stations for which assumptions had to be made are included in this analysis (see Section 4 for details).

	Coal	Disl	Gas	Lign	Napt	Oil
North	1.10	0.98	0.44	-	-	-
East	1.16	-	-	-	-	-
South	1.00	0.60	0.47	1.44	0.79	0.64
West	1.11	-	0.45	1.32	0.62	0.81
North-East	-	-	0.70	-	-	-
India	1.10	0.61	0.47	1.43	0.65	0.79

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 2005-06. 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).

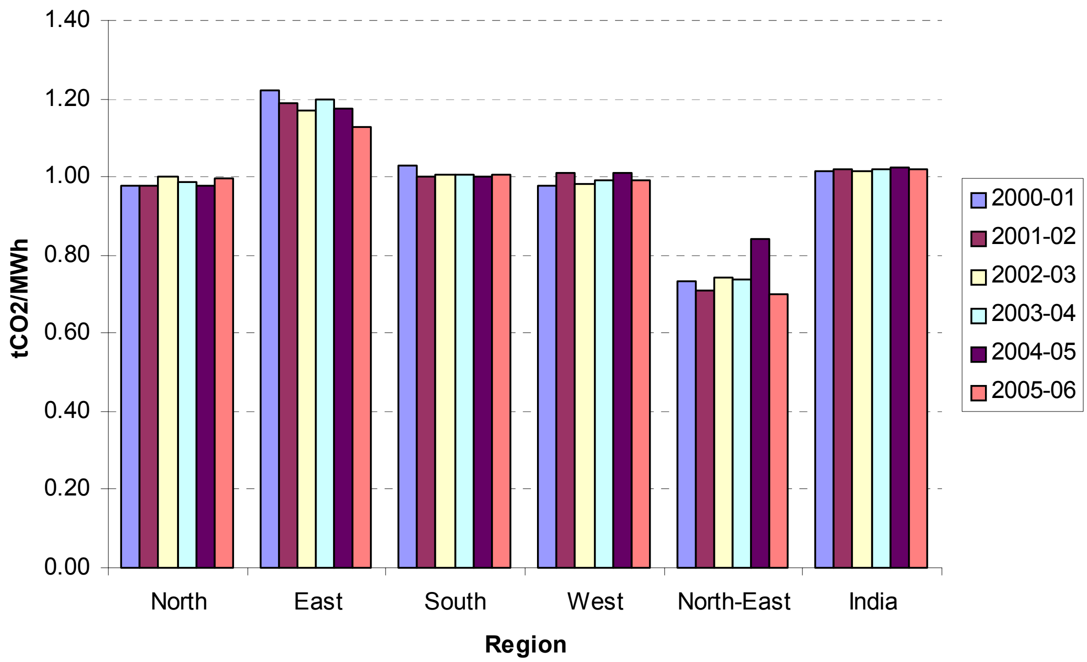

Figure 2: Development of the operating margin (adjusted for electricity transfers) for India's regional grids over the period 2000-01 to 2005-06.

Figure 3 shows the build margins for the Fiscal Years 2004-05 and 2005-06. Significant changes compared to the previous year are observed for some regions (especially Northern, Eastern and Western). 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. This simplification is considered acceptable because the variations in the build margin will tend to cancel out over the years, and because the retrospective build margins are only relevant for a small number of early CDM projects. In the future, the build margins will be updated annually along with the operating margins for each region.

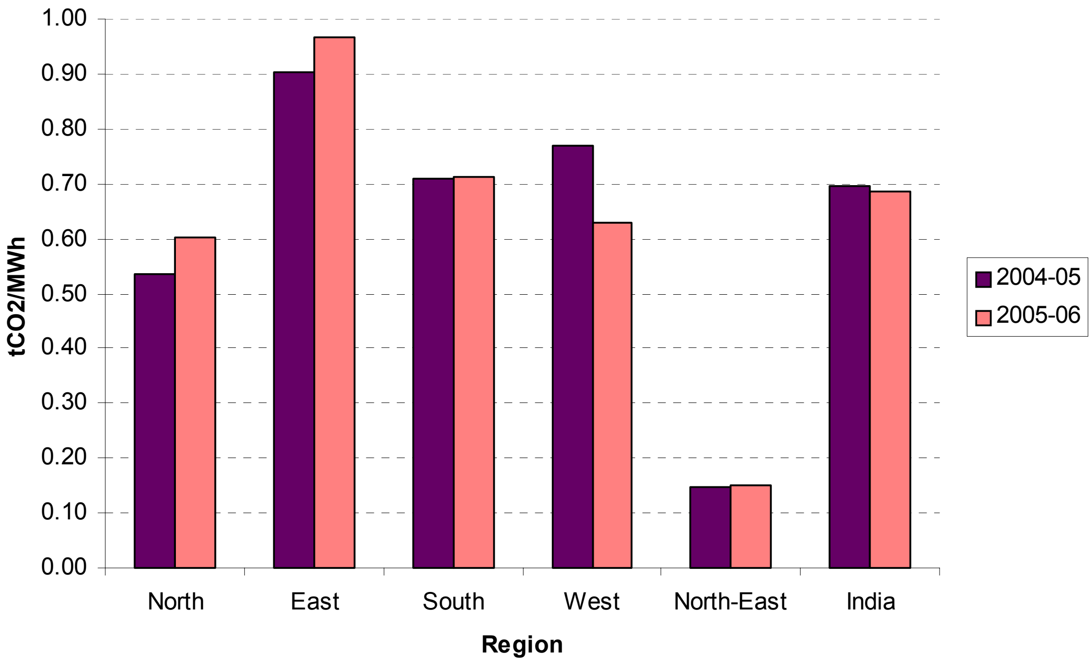

Figure 3: *Development of the build margins for India's regional grids for FY 2004-05 and 2005-06.*

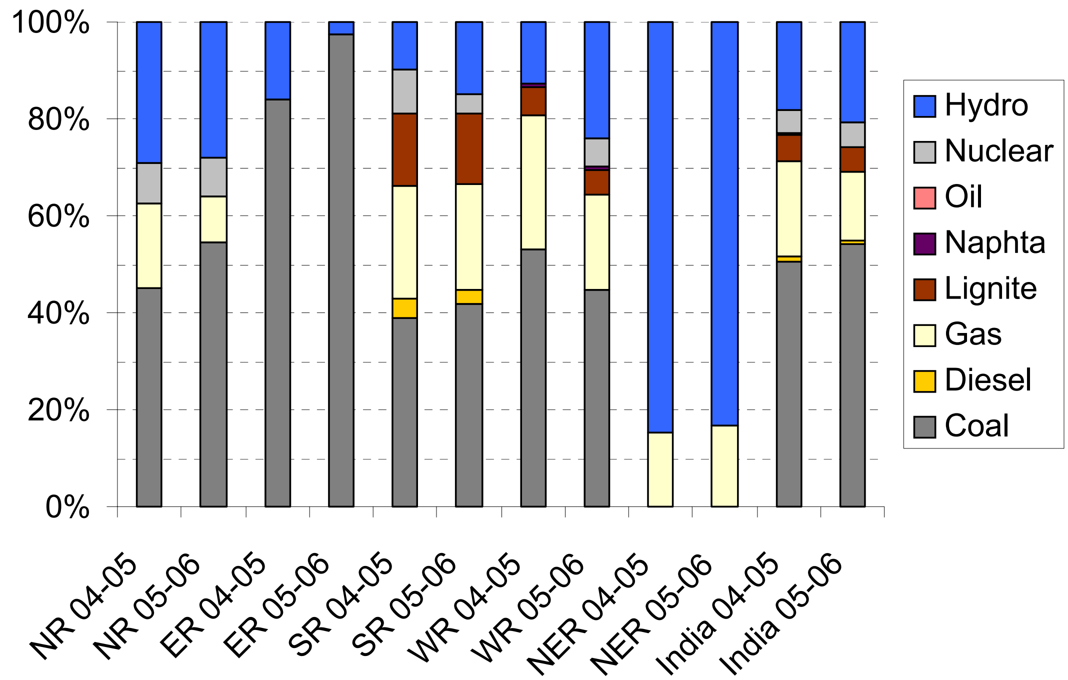

Figure 4: *Breakdown of the build margin (comparison of FY 2004-05 and 2005-06) by station and fuel type for all regional grids (shares based on net generation)*

Figure 5 shows the trends in the import-adjusted combined margins in the period 2000-01 – 2005-06. The most prominent variations are due to the changes in the build margins between 20004-05 and 2005-06. For India as a whole, the combined margin remained nearly constant.

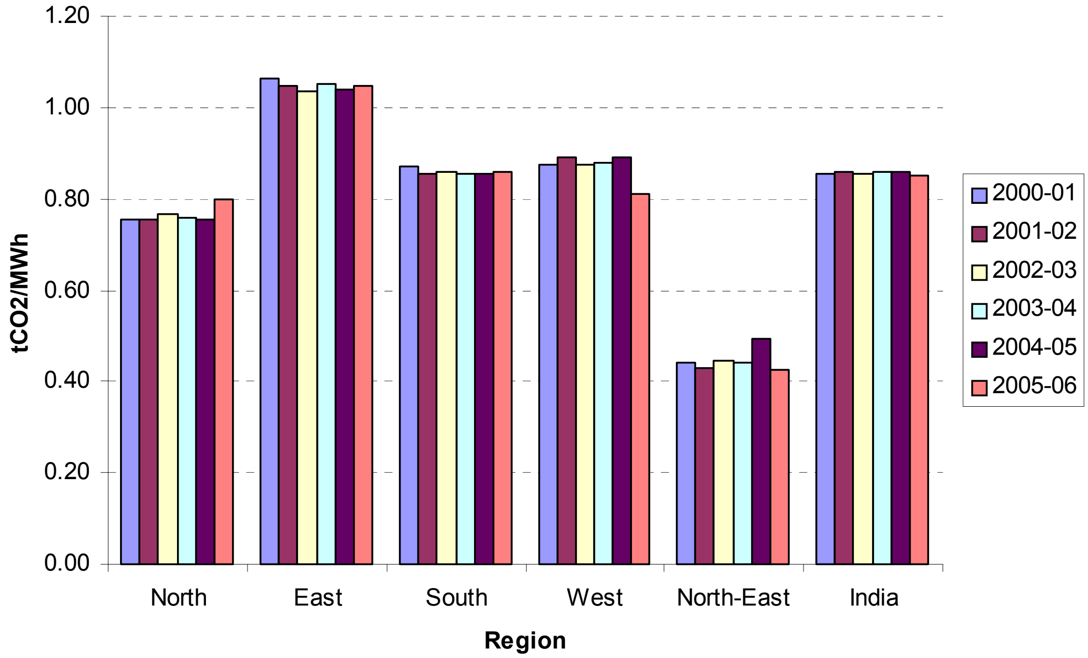

Figure 5: Development of the combined margin (adjusted for electricity transfers) for India's regional grids over the period 2000-01 to 2005-06.

5.3 Changes compared to Previous Database Versions

In comparison with the previous version of the Database (Version 1.1), this version includes some small changes, which affect the emission factors for the Fiscal Years 2000-01 to 2004-05. The most notable of these changes are summarized below.

- North-East: The operating margins and the build margin 2004-05 increased slightly in comparison with Version 1.1. The reason is that actual fuel consumption data became available for some stations.
- South: The operating margins and build margin decreased slightly for some years. Again the main reason is that actual fuel consumption became available for some stations.
- West: The build margin 2004-05 decreased slightly due to some changes in the composition.

6 User Examples

This section provides two illustrative examples of how the CO_2 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 2008. 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 (2005-06). The corresponding value is 0.33 t CO_2/MWh. Hence the absolute emission reductions are projected at 0.33 * 17’500 = 5’775 t CO_2/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.[8] 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 2008. 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.

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[8] 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 2003-04 – 2005-06). The operating margin to be applied thus works out to 1.00 t CO_2/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 CO_2/MWh (75% x 1.00 + 25% x 0.71 for the fiscal year 2005-06. 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 7 below.

Table 7: Illustration on how to use the CO_2 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:	2008	2008
Year of CDM registration:	2007	2007
Region:	North East	South
CDM methodology:	AMS-I.D / Version 11	ACM0002 / Version 06
Baseline Emission Factor Calculation		
Calculation method:	Weighted average	Combined margin
Data vintage for projection of emission reductions:	2005-06 (most recent available at time of PDD validation)	For OM: 2003-04, 2004-05, 2005-06 (most recent 3 years available at time of PDD validation) For BM: 2005-06
Data vintage for verification of emission reductions:	Actual year of generation, i.e. 2005-06, 2006-07 etc. (emission factor fixed *ex post*)	Same as for projection (emission factor fixed *ex ante*)
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 f. intermittent sources)
Emission Reduction Calculations		
Values in tCO_2/MWh:	0.33 Weighted average	1.00 Operating margin 0.71 Build margin 0.93 Combined margin
Projected emission reductions:	5'775 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

In CDM, emission reductions achieved by projects are often quantified on a yearly basis based on observed performance of the project and the electricity grid. To enable this approach, the CO_2 Database will be updated annually by CEA 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
APGCL	Assam Power Generation Corporation Limited
APGENCO	Andhra Pradesh Power Generation Co Ltd
ASEB	Assam State Electricity Board
BBMB	Bhakra Beas Management Board
BSEB	BSEB Limited
CESC	Calcutta Electric Supply Company
CSEB	Chattisgarh State Electricity Board
DPL	Durgapur projects Limited
DVC	Damodar Valley Corporation
GIPCL	Gujarat Industrial Power Corporation Ltd
GMDCL	Gujrat Mineral Development Corporation Limited
GMR Energ	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 Limited
HPSEB	Himachal Pradesh State Electricity Board
INDSIL	Indsil Electrosmelt Ltd
IPGPCL	Indrapratha Prastha Power Generators Co Ltd
JINDAL	JSW Energy Limited
JKEB	Jammu & Kashmir Electricity Board
JPHPL	Jai Prakash Hydro Power Limited

Continuation

Abbreviation	Full name
JSEB	Jharkand State Electricity Board
KPCL	Karnataka Power Corporation Limited
KEB	Kerala State Electricity Board
KSEB	Kerala State Electricity Board
LVS Power	LVS Power Limited
MaduraiP	Madurai Power Corporation Limited
MAHAGENCO	Maharastra 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.
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
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 Saorovar 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
USEB	Uttaranchal State Electricity Board
VVNL	Visvesarya Vidyut Nigam Ltd
WBPDC	West Bengal Power Development Corporation Ltd
WBSEB	West Bengal State Electricity Board

Appendix B – Assumptions for CO_2 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	gCO2 /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	gCO2 /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	gCO2 /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	3150	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)	3'755	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 CO2 emissions	tCO2 /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	2.0	2.0	2.0
Specific CO2 Emissions	tCO2 /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 CO2 Emissions	tCO2 /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 CO2 Emissions	tCO2 /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 CO2 Emissions	tCO2 /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 CO2 Emissions	tCO2 /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	gCO2 /ml	2.96

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 2005-06, 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
North	0.72	0.73	0.74	0.71	0.71	0.71
East	1.09	1.06	1.11	1.10	1.08	1.08
South	0.73	0.75	0.82	0.84	0.78	0.74
West	0.90	0.92	0.90	0.90	0.92	0.87
North-East	0.42	0.41	0.40	0.43	0.32	0.33
India	0.82	0.83	0.85	0.85	0.84	0.82

Simple Operating Margin (tCO2/MWh) (excl. Imports)

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
North	0.98	0.98	1.00	0.99	0.97	0.99
East	1.22	1.22	1.20	1.23	1.20	1.16
South	1.02	1.00	1.01	1.00	1.00	1.01
West	0.98	1.01	0.98	0.99	1.01	0.99
North-East	0.73	0.71	0.74	0.74	0.71	0.70
India	1.02	1.02	1.02	1.03	1.03	1.02

Build Margin (tCO2/MWh) (excl. Imports)

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
North					0.53	0.60
East					0.90	0.97
South					0.71	0.71
West					0.77	0.63
North-East					0.15	0.15
India					0.70	0.68

Combined Margin (tCO2/MWh) (excl. Imports)

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
North	0.76	0.76	0.77	0.76	0.75	0.80
East	1.06	1.06	1.05	1.07	1.05	1.06
South	0.87	0.85	0.86	0.86	0.85	0.86
West	0.87	0.89	0.88	0.88	0.89	0.81
North-East	0.44	0.43	0.44	0.44	0.43	0.42
India	0.86	0.86	0.86	0.86	0.86	0.85

Table B: Values for all regional grids for FY 2000-01 until FY 2005-06, 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
North	0.72	0.73	0.74	0.71	0.72	0.72
East	1.09	1.03	1.09	1.08	1.05	1.05
South	0.74	0.75	0.82	0.84	0.78	0.74
West	0.90	0.92	0.90	0.90	0.92	0.88
North-East	0.42	0.41	0.40	0.43	0.48	0.33
India	0.82	0.83	0.85	0.85	0.84	0.81

Simple Operating Margin (tCO2/MWh) (incl. Imports)

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
North	0.98	0.98	1.00	0.99	0.98	0.99
East	1.22	1.19	1.17	1.20	1.17	1.13
South	1.03	1.00	1.01	1.00	1.00	1.01
West	0.98	1.01	0.98	0.99	1.01	0.99
North-East	0.73	0.71	0.74	0.74	0.84	0.70
India	1.01	1.02	1.02	1.02	1.02	1.02

Build Margin (tCO2/MWh) (not adjusted for imports)

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
North					0.53	0.60
East					0.90	0.97
South					0.71	0.71
West					0.77	0.63
North-East					0.15	0.15
India					0.70	0.68

Combined Margin in tCO2/MWh (incl. Imports)

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
North	0.76	0.76	0.77	0.76	0.75	0.80
East	1.06	1.05	1.04	1.05	1.04	1.05
South	0.87	0.85	0.86	0.86	0.85	0.86
West	0.87	0.89	0.88	0.88	0.89	0.81
North-East	0.44	0.43	0.44	0.44	0.49	0.42
India	0.85	0.86	0.86	0.86	0.86	0.85

Appendix D – Summary of Methodology ACM0002 / Version 06

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, including:

- Run-of-river hydro power plants, and hydro power projects with existing reservoirs where the volume of the reservoir is not increased;
- Wind sources;
- Geothermal sources;
- Solar sources;
- Wave and tidal sources.

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.

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-I.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