Rule consistency of grid emission factors published by CDM host country authorities

Zurich, 14 February 2011

Axel Michaelowa

Tel: +41 44 8204 208

michaelowa@perspectives.cc

perspectives GmbH

Klosbachstrasse 2

8031 Zurich, Switzerland

info@perspectives.cc

www.perspectives.cc

The report has been commissioned by CDM Watch[1]

[1] I thank Michael Eschmann and Miriam Schröder for valuable research support and Anja Kollmuss for detailed and insightful comments. I also like to note that Perspectives wrote one of the methodology submissions (NM0217 "Grid-connected supercritical coal-fired power generation") that led to the approval of ACM0013. However, we do not see a conflict of interest as the approved methodology is substantially different from the submission due to the work of the Meth Panel and the UNFCCC Secretariat on the methodology. Moreover, the report does not judge the appropriateness of the methodology, but only whether the calculation of the benchmark used in ACM0013 is done according to the methodology.

Executive summary

For the Clean Development Mechanism (CDM), electricity grid emission factors (grid EFs) directly determine the volume of Certified Emission Reductions (CERs) for all project types that relate to renewable electricity generation or reduction of electricity consumption. The higher the grid EF, the higher the number of CERs a project can generate. Designated National Authorities (DNAs), responsible for approving CDM projects in their respective host countries, have started to provide such grid EFs in order to reduce the time to search for data (and hence transaction costs) for project developers and therefore increase the attractiveness of the respective host country. Almost 20 DNAs publish them on their websites. Grid EFs can be used by all CDM project developers in these countries and thus they no longer have to embark on the costly collection of data themselves. The Indian and Chinese DNAs also publish a benchmark for efficient coal-fired power plants used in the baseline and monitoring methodology ACM0013.

This study examines whether the benchmarks published by DNAs are conforming with the CDM rules and if they are overestimating emission reductions.

The grid EF calculation is based on the combined margin approach, taking into account the following two effects caused by an electricity-related CDM project:

(i) the displacement of power in the grid which is generated by power plants operating on the margin ("operating margin") (e.g. how much less power will be produced by conventional power plants because of the new CDM renewable facility)

(ii) the delay of future power generation capacity additions to the grid ("build margin") (e.g. how many fewer conventional power plants will have to be built).

The rules to calculate the grid EF have changed considerably over time, especially since late 2007 when the UNFCCC secretariat introduced the *Tool to calculate the emission factor for an electricity system* ("Tool"). This Tool defines the data requirements to establish the efficiency of power plants and their fuel use to calculate the "build margin". If such power plant specific efficiency data is not available, conservative default values have to be used. The rules for calculating the benchmark for efficient coal-fired power plants have also been updated, most recently in September 2010.

Because a high grid EF leads to a competitive advantage for project developers, DNAs may have an incentive to publish overly high grid EF values. Yet the current CDM rules do not require that a DNA-published grid EF be validated by an independent third-party auditor (DOEs). In 2010, the CDM Executive Board (CDM EB) rejected a proposal to make such audits mandatory after considerable debate. Thus the grid EF and coal benchmarks do not currently undergo additional scrutiny once published on DNA websites.

Yet an accurate and conservative calculation of the grid EFs, according to the rules specified in the UNFCCC Tool is crucial to safeguard the environmental integrity of the CDM.

In this report, we examine the consistency of the grid EF and the benchmark for efficient coal plants published by the DNAs with the Tool and ACM 0013 by analyzing the data used for the calculations. Important data include the efficiency of recently built power plants used in the calculation of the "build margin", the CO_2 emission factor of the different fossil fuels used and overall fuel use. We find that most of the documents provided by the DNAs do not allow an external observer to judge whether the data has been collected correctly. However, there are clear indications that the grid EFs, as well as the coal power plant benchmarks, have been overestimated both in China and India.

The grid EF reported by China has changed considerably over time. Between 2006 and 2008, the EF increased yet since 2008, the EF has become more conservative, increasing by almost 20%, as China has chosen more conservative default fuel emission factors and has selected a more realistic sample for newly built coal and gas power plants to calculate the build margin. Despite these positive developments, sampling procedures for the build margin remain inconsistent with the Tool. Applying the conservative default values for the build margin (as specified in the Tool) would reduce CER volumes of non-wind renewables and energy efficiency projects by up to 7% for 2007 and 2008 vintages and 1% when applying the current Chinese EFs.

The Chinese DNA does not publish data for the sample group of power plants used to calculate the benchmark efficiencies for super critical coal power plant CDM projects (ACM0013). It is therefore impossible to assess the Chinese figures for ACM0013.

The study has found two significant shortcomings in the India EFs:

- Non-CDM non-hydro renewable power plants are completely omitted in the calculation of the "build margin"; including them would reduce CER volumes by 3% for non-wind projects and 1.5% for wind projects.
- Indian power sector regulation provides an incentive for power plant operators to over-report fuel use; although the extent of this over-reporting is not known, it is reasonable to assume that this could artificially inflate Indian EF by several percentage points.

The study notes positively, that the Indian grid EF report is quite transparent and India is the only country that fully complied with the Tool.

The study concludes that there are serious deficiencies in the current grid EF calculations. Applying the difference between the correct calculation and the published values to the total of electricity-related projects registered in China and India between 2007 and today, we estimate an over-crediting of 11 million pre-2012 CERs, about 2.5% of total CER volume for these projects. To address the shortcomings observed, we recommend:

- Independent validation of grid EF to address many of the shortcoming identified in this study.

- The use of default values for power plant efficiencies for all power plants for which data is not published.
- Inclusion of all non-CDM renewable power plants.
- Revised grid EF should be applied retroactively if the grid EF used is found to be inconsistent with the Tool.

.

Table of Contents

1. The role of grid emission factors and coal power plant benchmarks for the CDM

The Clean Development Mechanism (CDM) is increasingly dominated by projects that relate to the electricity sector as the previously dominating industrial gas projects are starting to get saturated.
Therefore, setting the baseline for electricity-related projects has a growing influence on the CDM. In the early years of the CDM, there were several large-scale methodologies for renewable energy projects with different approaches for calculation of the baseline. They eventually converged into the methodology ACM 0002 "Consolidated methodology for grid-connected electricity generation from renewable sources" which was valid from September 2004 onwards and coined the concept of a grid emission factor (grid EF)[2]. The grid EF calculation is based on the combined margin approach, taking into account the following two effects caused by an electricity-related CDM project:

> (i) Operating margin: the displacement of power in the grid which is generated by fossil fuel power plants (e.g. how much less power will be produced by conventional power plants because of the new CDM renewable facility); for countries with a high share of hydropower, it also includes the "must-run" hydropower plants. To take into account changes in technology and fuel source of newly built plants the build margin looks at the most recent plants covering 20% of total electricity generation.
>
> (ii) Build margin: To take into account changes in technology and fuel source of newly built power plants the build margin looks at the most recently built plants covering 20% of total electricity generation. This is to simulate the avoidance of future power generation capacity additions to the grid due to the CDM project.

The combined margin represents the result of weighting the operating and the build margin. For most project activities a simple average of the operating and build margin is taken. However, for the second (and an eventual third) crediting period the build margin becomes more important (representing 75% of the combined margin). For solar and wind projects the operating margin is more important (75% of the combined margin). This has to do with the intermittent nature of solar and wind power.
When the CDM Executive Board's started to streamline baseline methodologies through the introduction of tools that are applicable as modules within different methodologies, it in October 2007 adopted the "Tool to calculate the emission factor for an electricity system". This tool has since been revised twice. A purely editorial revision was done in late July 2009, while the revision done by EB 50 in October 2009 allows for the inclusion of off-grid power plants in the calculation of the grid EF.
Grid EFs can either be calculated by project developers, which is labour-intensive and costly or the data can be collected by a public agency, preferably the host country's Designated National Authority (DNA) and be published. This has increasingly been done in the past years.
Given that CDM project developers, DNA members as well as credit (CER) buyers have an incentive to overestimate the number of CERs a project can generate, the question is whether the data has

[2] Since 2004, ACM 0002 has been revised 12 times.

been manipulated to increase the grid EF compared to its actual value. This issue is particularly sensitive in the case of the application of the methodology ACM0013 which allows the crediting of the construction of efficient coal power plants. This methodology allows to claim emission reductions from relatively small differences in energy efficiency between the baseline (business-as-usual coal plant) and the CDM project coal power plant. Given that ACM0013 is currently growing to become one of the most popular project types, an inflated EF could lead to significant over-crediting. This study assesses whether

(a) the EF calculations published by the DNAs are performed based on the currently valid version of the Tool/methodology ;

(b) the calculation of the emission factors is transparently and sufficiently documented, as required by the Tool/methodology;

(c) the calculations performed were conducted as required by the underlying methodology;

(d) over-crediting happens due to non-conformity of EF calculations with the Tool.

While de facto DOEs accept grid EFs published by DNAs, formally they need to validate the underlying data. Therefore, the CDM Executive Board (EB) addressed the issue of validation of grid EF published by DNAs in its 54th meeting (CDM EB 2010a) and decided that DNAs may request an auditor (DOE) to validate its grid EFs. At its 58th meeting, the EB again discussed the issue on the basis of a proposal with two options. Option one would allow the project auditors (DOEs) to use a DNA-published grid EF for any validation without having to validate the underlying data; EB members would however still be allowed to raise a review if "he/she considers there to be sufficient grounds to doubt that the calculation of the factor complied with the requirements of the Tool". Option two would require the DNA to ask for EB endorsement of the grid EF, which would require a completeness check by the UNFCCC Secretariat. This proposal led to a heated debate in the EB, with some members opposing any EB interference with the DNA and asking to refer the decision to the COP/MOP. The EB thus deferred the decision to an unspecified future meeting, asking the UNFCCC Secretariat to include an option where DOEs would be able to accept the DNA-published grid EF without further validation.

2. Data requirements for grid EFs and benchmarks

The grid EF calculation requires a set of data that are defined in the Tool and the relevant methodologies. They are summarized in Table 1 (methodological details are provided in Annex I).

Table 1: Relevant data for the calculation of the grid emission factor and the benchmark

Required data	Possible sources
Operating margin, build margin, and benchmark of ACM0013	
Net electricity generated per power plant unit	Utility or government records or official publications
Fossil fuel used per power plant unit	Utility or government records or official publications
Net calorific values (NCVs)	Fuel supplier
	National default values

Required data	Possible sources
	IPCC default values at lower 95% confidence level
CO_2 emission factors per fuel type	Fuel supplier
	National default values
	IPCC default values at lower 95% confidence level
Build margin and benchmark of ACM0013	
Commissioning dates of power plants	Not defined
Efficiency of power plants	Manufacturer's specifications, data from the utility, the dispatch center or official records
Operating margin	
Electricity imports	Not defined

The accuracy and transparency of this data is important as it determines the grid EF. The Tool requires data from the last three years. The geographical extent of the relevant grid is defined by the absence of significant transmission constraints within that grid, i.e. there should not be any blocking of electricity flows due to insufficient capacity of transmission lines that. If such national data is available it it has to be used for the EF calculation. In cases where such data is not available, default plant efficiencies and overall fuel consumption have to be used.

3. Publication of grid emission factors by DNAs

As the grid EF is a classical public good, already early in the CDM history attempts were made to publish a grid EF valid for an entire host country.

DNAs of large host countries with a high replicability of electricity-related projects took the initiative. The Indian DNA calculated an Indian grid EF with the support of the German Technical Cooperation (GTZ) in 2005 and 2006 and published the first version in October 2006. China published first drafts in December 2006 and presented them at a large workshop in March 2007. While Brazil started already in July 2005 to collect data to apply the dispatch analysis in a collaborative effort of the Ministry of Mines and Energy, the Ministry of Science and Technology and the National Electricity Systems Operator, in order to ensure the transparency of the process, the details of the criteria adopted in the application of the methodology in Brazil were widely disseminated on the DNA website and two meetings were held with specialists and parties interested in developing projects in early 2007. This led to an intense discussion about the number of grids in Brazil, with 22 formal submissions from project developers and other stakeholders made to the DNA. Eventually, the DNA decided in April 2008 to publish the grid EF for a single Brazilian grid. For an overview of which DNAs have published grid EFs see Table 2 below.

Table 2: DNAs that publish grid EFs and ACM 0013 benchmarks

Country	Donor	Date of first publication of grid EF	Website
Argentina	Japan	June 2007	http://energia3.mecon.gov.ar/contenidos/verpagina.php?idpagina=2311
Armenia	UNDP	June 2010	http://www.nature-ic.am/res/pdfs/documents/ Baseline%20Study%202009%20English.pdf
Brazil	-	May 2008	http://www.mct.gov.br/index.php/content/view/307492.html
China	UK	December 2006 *ACM 0013: June 2008*	Links in English language: http://cdm.ccchina.gov.cn/english/NewsInfo.asp?NewsId=4905 *(Underlying documents in Chinese language only)*
Ethiopia	Austria	August 2008	http://www.ji-cdm-austria.at/blueline/upload/ Ethiopia_EmissionFactor_FINALREPORT.pdf
Georgia	-	2007	http://cdm.unfccc.int/filestorage/71UAJ4GI623TZPMP05JPSAJW5J7S6T/PDD%20Version%203.pdf?t=RjZ8MTI5NjY3NjY3MS4wMQ==|_SFho127DdcMgLJGpklBmmwnZAk=(Annex of PDD), as DNA website is unavailable)
Ghana	Austria	July 2008	http://www.ji-cdm-austria.at/blueline/upload/ Ghana_EmissionFactor_FINALREPORT.pdf
India	Germany	October 2006 *ACM 0013: October 2008*	http://www.cea.nic.in/planning/c%20and%20e/Government%20of%20India%20website.htm
Indonesia	-	December 2008	http://dna-cdm.menlh.go.id/Downloads/Others/ DJLPE_Grid_Sumatera_JAMALI_2008.pdf *(Indonesian language only)*
Malaysia	-	January 2008	http://cdm.eib.org.my//up_dir/articles1016,article,1270025735,label_CDM_Baseline_2008.pdf
Mongolia	World Bank	November 2010	http://cdm-mongolia.com/index.php?option= com_ content&view=article&id=75&Itemid=105&lang=en
Peru	World Bank	November 2009	http://www.fonamperu.org/general/mdl/documentos/factor.pdf
Rwanda	UNDP	July 2010	http://www.rema.gov.rw/dna/index.php?option=com_docman&task=doc_download&gid=24&Itemid=
Singapore	-	September 2008	http://www.nccc.gov.sg/cdm/InformationOnEmissionFactors.pdf
Swaziland	EU	June 2009	www.rdmu.org/docs/Grid_EF_Report_Final.pdf
Tanzania	UNEP	2008	http://cd4cdm.org/sub-saharan%20Africa/ Tanzania/GridEmissionFactor_Tanzania.xls
Thailand	Denmark	December 2005/ 2009	www.tgo.or.th/download/publication/GEFReport_EN.pdf *2005 version not formally endorsed by DNA*
Uganda	Austria	July 2008	http://www.ji-cdm-austria.at/blueline/upload/ Uganda_Emission_Factor_FINAL_REPORT_3.pdf
Uzbekistan		August 2008	www.mineconomy.uz/cdm/files/BL%20calculation_eng.pdf

Country	Donor	Date of first publication of grid EF	Website
Vietnam	-	December 2009	http://www.noccop.org.vn/Data/vbpq/Airvariable_ldoc_vnHe%20so%20phat%20thai.pdf *(Vietnamese only)*

.

There is a continued drive of donor institutions to support grid EF calculation so other countries are likely to publish their grid EFs.

4. Rule consistency of DNA-published grid emissions factors

Given that China and India have the largest number of CDM projects in the electricity sector and thus an overestimated grid EF would have a large impact we assess their grid EF calculation in detail.

4.1. China

The Chinese grid EF has never been published in English, but only in Chinese (Chinese DNA 2010a, 2009a, 2008a-c, 2007a-c, 2006a-c). Even for Chinese language readers, the documents provide very little underlying information regarding the calculation of the specific parameters which makes it difficult to validate the accuracy and conservativeness of the data and assumptions that the Chinese grid EF is based on. In the following sections we provide further details on the Chinese grid EF.

Build margin

The only parameters shown in the Chinese documents are the power plant efficiency for the build margin calculations, the CO_2 emission factor of each fuel and the oxidization factor. No information is given on the actual power plants and their commissioning dates.
Table **3** shows the changes of these parameters over time

Table 3: Parameters driving the Chinese build margin

Parameter	Coal					Gas					Oil				
Year of publication	**2006**	**2007**	**2008**	**2009**	**2010**	**2006**	**2007**	**2008**	**2009**	**2009**	**2006**	**2007**	**2008**	**2009**	**2010**
Power plant efficiency (%)	36.53	35.82	37.28	38.1	39.08	45.87	47.67	48.81	49.99	51.46	45.87	47.67	48.81	49.99	51.46
CO_2 fuel emission factor (tC/TJ)	25.8	25.8	25.8	23.81	23.81	15.3	15.3	15.3	14.81	14.81	21.1	21.1	21.1	20.59	20.59
Oxidization factor (%)	98	100	100	100	100	99.5	100	100	100	100	99	100	100	100	100
CO_2 (g/kWh)	913.6	950.8	913.5	824.9	804.2	438.1	423.7	413.8	391	379.9	601.1	584.3	570.6	543.7	528.2

Change of parameter reducing (green) or increasing (red) the build margin.
Sources: Chinese DNA (2006c, 2007c, 2008c, 2009c, 2010c)

The parameters have changed considerably over time, becoming less conservative in 2007, while increasing conservativeness substantially in 2009 due to the change of the fuel emission factor to the more conservative lower level of the 95% confidence interval of the IPCC default fuel emission factor. According to the Chinese DNA, the efficiency of new coal plants is established as follows: "According

to the Statistics of Newly Built Heat Power Plant in the 11th 5 years' plan by the State Electricity Regulatory Commission, 21% of single coal power plant units built in 2000-2005 had a capacity >600 MW, 60% a capacity of 300 MW and the rest <300 MW. According to the statistics of the China Electricity Council for 2006, the total capacity of newly built medium and large coal power plants was 94 GW, with 64 600-MW units covering 40%. The calculation uses the weighted average of the best 30 units in terms of coal consumption to approximate the technology of optimum commercial efficiency. The coal consumption of these 600 MW units is 329.94 gce/kWh, i.e. an efficiency of 37.28%" (Chinese DNA 2008c, p. 3 quoted in full, own translation) This efficiency calculation is ***not consistent*** with the Tool which requires the use of plant-specific data for all plants in the build margin, not just a sample. Given the absence of plant-specific data for the entire set of plants in the build margin, the – more conservative - default values prescribed by the Tool of 39% for subcritical and 45% for supercritical plants would have to be used. If the Chinese DNA calculated the efficiencies for the entire set of newly built coal power plants, the build margin would be less conservative than the current one derived from the sample.
It is interesting to note that already in 2008 the validator Japan Consulting Institute (JCI) commented in its validation report on a Chinese hydropower project (UNFCCC project no. 1605), that super-critical coal fired power plants are being constructed on a commercial basis in China including Guangdong Province. JCI therefore questioned whether the efficiency of 35.82% published by the Chinese DNA in 2007 did reflect the actual efficiency of the best technology commercially available at that time (Japan Consulting Institute 2008). The project developer thus changed the efficiency of the baseline coal power plants in the build margin to 38.44% in his baseline calculation. Interestingly, the efficiency of coal plants in the build margin data published in 2009 still remained lower at 38.1% and only exceeded this value in 2010, see Table 3.

Table 4 shows how the number of plants used in the calculation of this efficiency benchmark has changed between 2004 and 2008.

Table 4: 600 MW units, supercritical units and the coal efficiency benchmark for 2004-2007

	2004	2005	2006	2007	2008
Total coal capacity built (GW)	34	54	94	83.6	65.8
of which 600 MW units	6.6	9	38.4	47.4	42.2
# of 600 MW units	11	15	64	79	68
# of units in benchmark	11	14	30	30	30
# of 1000 MW supercritical units	0	0	0	4	4

Sources: Chinese DNA (2006c, 2007c, 2008c, 2009c, 2010c).
The total coal capacity built in 2008 is no longer provided in the Chinese DNA document (2010c); our data is from World Nuclear Association (2011).

Due to the selection of the best plants for the sample, the stringency of the benchmark increases over time, as the share of benchmarked plants in the total cohort of 600 MW plants decreases. Since

2007, four 1000 MW coal plants have come online, yet these plants are not included in the grid EF calculations. This omission likely leads to a higher grid EF since these plants are significantly more efficient than 600 MW size plants.

For gas power plants, the Chinese DNA consistently refers to combined cycle turbines of the type General Electric 9 E, with a size of 200 MW for the calculation of the efficiency of gas plants (for the resulting efficiencies see Table 3). Their efficiency is considerably worse that the default value of 60% listed in the Tool. The efficiency used for oil power plants (see Table 3), on the other hand, is higher than the default value in the Tool (46%).

Operating margin

The Chinese documents describing the calculation of the operating margin do not provide data for fuel use on a power plant-specific basis; they only list fuel use data for entire power grids. Therefore, total fuel use for the power sector in each grid is multiplied by the fuel emission factor, the CO_2 emission factor of each fuel, the oxidization factor and the net calorific value **(**NCV) and divided by the total net electricity generation. While the NCV has remained constant over time, the other parameters have changed in the same way as for the build margin calculation, see Table 3. (Chinese DNA, 2006b, 2007b, 2008b, 2009b). Thus, we had an increase from 2006-7 and a decrease from 2008-9, as shown in
Table **5**.[3]

Table 5: Operating margin emission factors (g CO_2/kWh) in relevant Chinese grids

	Oct. 2006	**Aug. 2007**	**Dec. 2008**	**July 2009**	**Dec. 2010**
Northern Grid	1058.5	1120.8	1116.9	1006.9	991.4
Northeastern Grid	1198.3	1240.4	1256.1	1129.3	1110.9
Northwestern Grid	1032.9	1125.7	1122.5	1024.6	994.7
Eastern Grid	941.1	942.1	954.0	882.5	859.2
Central Grid	1252.6	1289.9	1278.3	1125.5	1087.1
Southern Grid	985.3	1011.9	1060.8	998.7	976.2

Sources: Chinese DNA (2006a, 2007a, 2008a, 2009a, 2010a).

[3] Further changes which had only a small impact on reducing the build margin were the reduction of carbon emission factors of coke from 29.5 tc/TJ in Chinese DNA (2006b) to 25.8 tc/TJ in Chinese DNA (2007b), coke oven gas and other coke gas from 13 tc/TJ in Chinese DNA (2006b) to 12.1 tc/TJ in Chinese DNA (2007b), as well as dry gas from refinery, which fell from 18.2 tc/TJ in Chinese DNA (2007b) to 15.7 tc/TJ in Chinese DNA (2008b). However, the reduction of the coke emissions factor was reversed in Chinese DNA (2008b). The NCV of other petroleum products” increased from 38.369 MJ/t in Chinese DNA (2008b) to 41.816 in Chinese DNA (2009b).

Throughout this period, supercritical plants with an emission factor of around 860g CO_2/kWh have been increasing their share of new coal power plants in China. According to IEA (2008), in 2006, 20% of thermal plant additions – i.e. close to 20 GW - were supercritical and in 2007, 100 GW of new supercritical plants were on the order books. Thus, we would have expected the operating margin to have fallen continuously over the period.

Combined margin

The combined margin represents the result of averaging the operating and the build margin. Table 6 shows how the combined margin Chinese grid EF has changed over time.

Table 6: Combined margin emission factors (g CO_2/kWh) of Chinese grids

	Oct 2006	Aug. 2007	Dec 2008	July 2009	Dec. 2010	*Total change*
Northern Grid	982.6	939.7	992.8	893.6	870.5	*-11.5 %*
Northeastern Grid	1004.6	1051.8	1031.5	926.8	909.8	*-9.4%*
Eastern Grid	864.0	867.1	888.8	782.6	769.1	*-11.0%*
Central Grid	944.5	974.6	973.5	852.9	770.7	*-18.4%*
Northwestern Grid	841.0	849.8	871.2	834.0	841.3	*+0%*
Southern Grid	778.4	843.4	871.2	788.0	713.4	*-8.3%*

Overall evaluation

While the Chinese grid EF has become much more conservative in the last three years, it still suffers from rule inconsistencies due to the absence of power-plant specific efficiency and fuel use data. In section 5 below we will assess to what extent this has led to an overestimate of the grid EF and thus to over-crediting.

4.2. India

The Indian grid EF has originally been calculated in 2005 by a team of engineers from the Central Electricity Authority (CEA) and the Swiss CDM consultancy Factor AG (now First Climate). It has been updated five times in an annual rhythm and changes have been reported in a transparent fashion (Central Electricity Authority of India 2009). For example, the 2008 revision included a new delineation of regional grids due to full integration of all regional grids except the Southern grid from August 2006. Moreover, the most conservative IPCC-based fuel emission default factors at the low end of the 95% confidence interval were used. Given the very detailed background documentation in CEA (2009), we can assess the different issues of data coverage and quality which leads to a different structure than in the Chinese case, where deficiencies in the underlying data could not be assessed.

Coverage of power plants

According to CEA (2009), the database includes all grid-connected power stations having an installed capacity above 3 MW in case of hydro and above 10 MW for other plant types, totalling 134.4 GW. It does neither include 24.7 GW of grid-connected captive power plants, which were responsible for 12.1% of total power generation in India, nor 13.2 GW of wind, biomass, solar photovoltaic, and hydro below 3 MW capacity, for which generation figures are not available.

Grid-connected captive power plants are a special feature of India. They are attractive due to high electricity tariffs for industrial consumers and the high probability of blackouts. On average, they are small and inefficient: Most are fired by coal or oil, some by natural gas. The shortage of natural gas does not allow a substitution of coal and oil. Therefore, the emission factor of Indian captive power plants is likely to be similar to the operating margin and substantially above the build margin. Their omission is thus leading to an ***underestimate of the build margin***.

In contrast, the exclusion of non-CDM renewable power plants leads to an ***overestimate of the build margin***. According to UNEP Riso Centre (2011), in late 2010 9.7 GW of Indian non-hydro renewables – 7 GW of which is wind and 2.6 GW biomass - were registered CDM projects or under validation, while projects of 2.8 GW (1.3 GW wind and 1.5 GW biomass) had been rejected or terminated validation, mostly due to lacking additionality. Using standard assumptions on plant load factors (25% for wind and 75% for biomass), this means that the 2.8 GW non-CDM renewable plants in the build margin generated 13.3 TWh, i.e. 10% of the total build margin electricity generation. The ***build margin is thus overestimated by 10%***, which translates into 60 g CO_2/kWh, or 30 g CO_2/kWh for the combined margin if calculated 50-50, and for wind projects 15 g CO_2/kWh.

Default values in case of data gaps

For some power plant types and multi-unit plants, instead of actually measuring certain parameters, default values were used as follows (CEA 2009):

- For hydro plants, the CEA standard value for auxiliary power consumption in hydro units (0.5%) is applied. This is conservative, as in reality auxiliary consumption can be significantly higher.
- For some of the gas- and diesel-fired thermal plants, CEA standard values for auxiliary power consumption had to be applied. Comparison with monitored values shows that these standard values lead to a somewhat lower heat rate and hence lower emissions than actually occurring. This calculation is thus also conservative.
- Default values, i.e. the standard heat rate + 5%, were used for some thermal plants where station-specific gross calorific values (GCVs) are not available. This is also conservative as the standard heat rate
- Many power plants in India consist of a number of units commissioned at different dates. Fuel consumption and GCV are however generally not measured at unit level. To nevertheless

allow calculation of the build margin on the basis of each unit the following default values are used, based on statutory performance rates (see Table 7 and Table 8). Table 8 shows that the efficiency for the largest units is lower than for medium sized plants. Given that normally, larger power plant sizes are more efficient than smaller ones, the decrease of efficiency for the largest categories is surprising. Otherwise, the calculation seems to be realistic.

Table 7: Assumptions regarding coal units for build margin calculation in India

Parameter	67.5 MW	120 MW	200-250 MW	300 MW	500 MW
Gross heat rate (kcal/kWh)	2750	2500	2500	2350	2425
Auxiliary power consumption (%)	12	9	9	9	7.5
Net heat rate (kcal/kWh)	3125	2747	2747	2582	2622
Specific oil consumption (ml/kWh)	2	2	2	2	2
CO_2 (g/kWh)	1190	1050	1050	980	1000

Source: CEA (2009), p. 39

Table 8: Assumptions regarding lignite units for build margin calculation in India

Parameter	75 MW	125 MW	210/250 MW
Gross heat rate (kcal/kWh)	2750	2560	2713
Auxiliary power consumption (%)	12	12	10
Net heat rate (kcal/kWh)	3125	2909	3014
Specific oil consumption (ml/kWh)	3	3	3
CO_2 (g/kWh)	1320	1230	1280

Source: CEA (2009), p. 39

- For some power plants, gross generation data were not available at unit level. Therefore the plant load factor of the full power plant was used to derive the gross generation of the units. This seems to be a neutral approach.
- Auxiliary consumption is generally not measured at unit level, and CEA thus used two distinct approaches (CEA 2009, p. 10): The auxiliary consumption per unit was assumed to be equal to that of the entire plant if all units fall into the build margin or all units have the same installed capacity, or they do not differ with respect to the applicable standard auxiliary consumption. This covers over 85% of all thermal units in the build margin (CEA 2009, p. 11). In all other cases, the design heat rate plus 5% was used as standard. This approach is mildly conservative.

Generic data quality issues

According to Brodmann (2010), when the Indian grid EFs were initially calculated 5-10% of thermal power plants did not provide data of sufficient quality. These plants had to be reevaluated for subsequent versions of the grid EF. Currently less than 5% of the power plants do not deliver sufficient data.

Interestingly, the CEA received complaints by project developers that the grid EF was too conservative. The main issue raised were differences of the CO_2 emissions factor of coal. As the CEA has measurements of the NCV of all typical Indian coal varieties - 120 coal samples were collected from different Indian coal fields (CEA 2009, p. 10) -, its data are robust. Initially, problems arose regarding the NCV of oil, which is used as an auxiliary fuel by all coal power plants. Here, some mistakes arose as some power plant operators did not differentiate between kilogrammes and litres. From 2008-9 thus an average NCV was used.

Overall evaluation

The main challenge of the Indian grid EF -which is of an entirely political nature and cannot be rectified by the grid EF calculation exercise as such - is the ***underlying fuel use data***. As the Indian power sector is still highly regulated, power plants have to reduce power tariffs if they reduce their power generation costs. Therefore, plant operators resort to overreporting of fuel use to increase their profitability. According to experts in the Indian electricity sector, this leads to an underestimate of thermal power plant efficiencies by several percentage points. Unfortunately, no scientific study of this phenomenon is available. Often, overreporting of fuel use is hidden by referring to poor quality coal, high ambient temperatures and limited water supplies that do contribute to lower efficiency (see e.g. IEA Coal Industry Advisory Board 2010, p. 60).

Apart from this issue and the lack of renewable power plant coverage, the Indian calculations itself seem to be in line with the versions of the methodologies valid at the point of publication. They are a ***model of transparency***, and the described problems could only be detected because the calculation and sources are described in detail.

4.3. Other countries

For the countries other than India and China, we provide a short summary of the most relevant observations regarding concistency of their grid EF calculation approach with the Tool, followed by a table listing the sources for the underlying data (see Table 9).

Armenia

The document (Ministry of Nature Protection of the Republic of Armenia 2010) provides all sources for the values. It is however somewhat intransparent as only a pdf.-file and no spreadsheet file is available. The document states that imports are included in the calculation. However, it is unclear whether this has been done, as it rather seems that imports have just been listed. However, the default fuel emissions factor is taken from the IPCC inventory guidelines of 2000 which is clearly inconsistent with the Tool that requires the 2006 value.

Argentina

The calculation of Argentina's grid emission factor is consistent with the Tool. However, the source for the grid data is not indicated.

Brazil

Brazil does not publish any information on the data used for the calculation and just refers to the grid operator. Even if hourly data for dispatched data is available, there is no detailed information on the calculation of these values.

Ethiopia

The calculation (Energy Changes 2008a) is consistent with the Tool. However, sources for NCV and fuel emission factors are not available. The same values are taken for all plants, but are probably aggregated domestic values and not IPCC default values.

Ghana

Ghana has faced big energy supply problems in the early 2000s and installed emergency plants. The build margin is calculated on the basis of these emergency plants only, some of which stopped operating two years later (2009). These plants may not adequately represent the actual grid emissions and might overrepresent emission from capacity addition in the future. The sources for fuel emission factors are not available (Energy Changes 2008b).

Georgia

While the calculation in Ministry of Environment Protection and Natural Resources of Georgia (2007) is consistent with the version of ACM 0002 valid prior to introduction of the Tool, it is now outdated.

Indonesia

Indonesia has only published emission factors without the underlying calculation.

Malaysia

The document (PTM 2008) contains only emission factors and provides limited additional information. For example load curves are shown and some sources are mentioned. However, more detailed information is not available. The operating margin has not been calculated on the base of a generation-weighted average and is therefore not consistent with the Tool.

Mongolia

Fuel consumption is measured in tons coal equivalent, which hides the actual NCV used. Moreover, sources are not available.

Peru

Peru has only published emission factors without underlying calculations. However, some sources and assumptions are listed.

Rwanda

The grid EF calculation lists import and exports but does not take them into account for calculation of operating margin. The operating margin is calculated with simple instead of generation-weighted average of the last three years.

Singapore

Singapore has only published emission factors without underlying calculations.

Swaziland

The file (GFA Consulting 2009) only contains final results of the grid emission factor calculations. No information is provided about NCV and fuel emission factor sources. The Tool has been adjusted to national circumstances (85% imports) and the document proposes four different grid emission factors.

Thailand

The calculation is fully consistent with the Tool.

Tanzania

The calculation does not provide information about imports.

Uganda

For the simple-adjusted operating margin hourly load data are only available for two years instead of three. Sources for fuel emission factors are not available. The simple operating margin is calculated as simple average and not generation-weighted average (Energy Changes 2008c).

Uzbekistan

The calculation is in line with the Tool. However, the source for the fuel emission factor is not indicated.

Vietnam

The calculation for the Vietnamese grid seems comprehensive. However, it is only available in Vietnamese and no detailed information about the conformity of the calculation can be provided.

Table 9: Availability of information for countries with detailed calculation

	Source for grid data	Info on electricity imports	Fuel emission factor and NCV values
Armenia	PSRC of RA	Yes	Default/own values
Argentina	Not available	Yes	2nd National Communication
Ethiopia	EEPCO	Yes	Source not clear
Georgia	Ministry of Energy	Yes	Own values
Ghana	Not available	Yes	Source not clear
India	CEA	Yes	Own values
Malaysia	EC, SESB, SEB	No	Not available
Mongolia	Not available	Yes	Source not clear
Rwanda	Rwanda Electricity Corp.	Yes	Not available
Swaziland	Not available	Yes	Not available
Tanzania	TANESCO	No	Default values
Thailand	EGAT	Yes	Default/own values
Uganda	Not available	Yes	Source not clear
Uzbekistan	Uzbekenergo	Yes	Source not clear

Countries without detailed information or language other than Spanish and English:
Brazil, China, Indonesia, Peru, Singapore, Vietnam

5. Rule consistency of DNA-published coal power plant benchmarks (ACM0013)

5.1. China

The Chinese DNA (2008d, 2009d, 2010b) has published the coal power plant benchmark three times. The document does not provide a list of the power plants used and only publishes the benchmark for three classes of power plant units – 600 MW, 660 MW and 1000 MW (see Table 10). It is thus not possible to judge the realism of the underlying data. 2009 values have decreased markedly (by about 10%) due to the use of the lower end of the 95% confidence interval for the IPCC fuel default factors. A comparison with the build margin values quoted in Table 3 suggests a consistent approach.

Table 10: Coal power plant benchmark according to ACM 0013 in China

Grid name	1000 MW			660 MW				600 MW	
	2006	2008	2009	2006	2008	2009	2006	2008	2009
Northern grid	878.4	857.8	783.8	878.4	873.2	806.5	NA	880.6	807.5
Northeastern grid	NA	NA	794.4	NA	881.1	796.8	NA	NA	796.8
Eastern grid	858	832.7	761.3	866.2	848.1	782.5	NA	853	784.5
Central grid	870.3	854.7	796.3	855.1	859.8	796.3	NA	865.5	804.4
Northwestern grid	NA	NA	824.4	NA	905.7	831.1	NA	904.1	832.5
Southern grid	NA	876.9	800.8	NA	877.4	800.8	NA	879.8	805.4

Sources: Chinese DNA (2010b, 2009d, 2008d)

5.2. India

CEA (2009, p. 29) calculates the efficiency of the standard baseline 500 MW coal power plant on the basis of a Gross Heat Rate as 2450 kcal/kWh and an auxiliary power consumption of 7% as specified by the Central Electricity Regulatory Commission norms, as 32.6%. For domestic coal, a baseline emission factor of 1000 g CO_2/kWh is derived, for imported coal 987 g CO_2/kWh.

For the calculation of the benchmark sample group coal power plant unit sizes above 330 MW up to 990 MW are selected, giving 13 units of 500 MW (CEA 2009, p. 32). For the two best performers of this sample, an emissions factor of 944 g CO_2/kWh is calculated. This value is consistent with the calculations of the grid EF.

5.3. Other countries

No other countries have published an ACM 0013 benchmark.

5.4. Conclusions

The benchmarks for ACM0013 suffer from similar data issues as the calculation of the grid EF; there does not seem to be a particular case for overestimation.

6. Impact of a conservative default calculation of grid emission factors on CER volumes

The Tool has specified conservative default power plant efficiencies in case power-plant specific values are not available. This decision was made to provide an incentive for good data collection, and to prevent over-crediting. We illustrate the effect of the use of the default efficiencies on China's grid EF and estimate the volume of over-crediting due to the non-application of the default values. Applying the default of 39% for standard coal and 45% for supercritical coal units, as well as 60% for gas power plants, the emission factor for build margin coal power plants in China would have developed as shown in Table 11[4]:

Table 11: Power plant efficiency increase due to use of default power plant values for China and resulting reductions of the build margin according to vintage

Year of publication	**2007**	**2008**	**2009**	**2010**
Difference in efficiency of coal power plants (%)	3.2	1.7	1.2	0.7
Difference in efficiency of gas power plants (%)	12.3	11.2	10	8.5
Differential of coal power plant emission factor (g CO2/kWh)	80	43	25	15
Differential of gas power plant emission factor (g CO2/kWh)	98	90	70	60
Total differential in build margin (g CO2/kWh)	80	44	26	16

Notes: In 2009, the average default build margin efficiency for coal power plants is 39.3% (4.8% of new capacity in 2007 was supercritical and thus used 45% as default efficiency). This value increased to 39.8% in 2010 (6.1% of new capacity in 2008 was supercritical). We assume a 2% share of natural gas in power generation of build margin plants[5].

Depending on the region, CER volumes for hydro and energy efficiency projects submitted for validation after the publication of the Tool would thus have been reduced by 3-7% in 2007, 2-4% in 2008, 1-2% in 2009 and less than 1% in 2010. A calculation of the volumes of over-crediting gives about 5.1 million CERs[6]. For wind and solar projects, the reduction of CER volumes is lower due to the 25% weight of the build margin. 1.25 million pre-2013 CERs would be overissued for wind[7].

For India, exclusion of the renewable projects leads to an over-crediting reaching 4.1 million for standard renewables and energy efficiency projects[8] and 0.7 million for wind and solar[9].

---

[4] For China, before the change in the fuel emission factor in 2009, an increase of 1% of efficiency would have led to a reduction in the emissions factor for build margin coal power plants by 25 g CO_2/kWh. After the change, the reduction would still have been 21 g CO_2/kWh. For gas power plants 1% efficiency increase would lead to a decrease of 8 and 7 g CO_2/kWh, respectively.

[5] As the Chinese documents (Chinese DNA 2006c-2010c) do not provide differentiated data for installed capacity of coal and gas power plants, it is not possible to calculate the exact result for the build margin of each grid.

[6] 59 million from projects in 2008 times 5%, 17 million from projects in 2009 times 3% and 109 million from projects in 2010 times 1.5%.

[7] 24 million from projects in 2008 times 2.5%, 17 million from projects in 2009 times 1.5% and 58 million from projects in 2010 times 0.75%.

[8] 96 million from registered and 21 million from projects under validation, times 3.5%

7. Summary and policy recommendations for the CDM EB

The detailed analysis of grid EF published by DNAs shows substantial inconsistencies with the current version of the "Tool to calculate the emission factor for an electricity system". Moreover, the data used for the benchmark of ACM0013 is not always clear. No published report gives enough information to be able to state that a country fulfils all the requirements. The following inconsistencies are notable:

- Lack of data used for calculation of power plant efficiencies or incomplete data. For example, the Chinese sample of coal power plants used for the build margin is clearly inconsistent with the "Tool". Likewise, the Chinese DNA does not publish the list of coal power plants and their data used to calculate the benchmark of ACM 0013.
- Lack of coverage of certain power plant technologies, as the non-CDM renewable power plants in the Indian case
- Unclear quality of fuel use and NCV data used
- Coverage of imports

To guarantee a conservative calculation of grid EF, the EB should require:

- Use of default power plant efficiencies for all power plants for which data are not published
- Use of a default emission factor of zero and a default plant load factor for non-CDM renewable power plants
- Validation of fuel use and NCV data
- Retroactive application of a revised grid EF if the grid EF used is found to be inconsistent with the "Tool"/methodology in force when the project was submitted for registration
- Publication of all underlying information in English, as this is the official CDM language

[9] 29 million from registered and 11 million from projects under validation, times 1.75%.

8. References

Brodmann, Urs (2010): Personal communication, November 1

CDM EB (2010b):Draft procedures for the consideration of validation reports of emission factors for electricity systems, EB 58 Annotated Agenda Annex 4

CDM EB (2010a): Report of the 54th meeting of the CDM EB, download at https://cdm.unfccc.int/UserManagement/FileStorage/JFZ3XEVTQP4S2AH5OMD8RL19WBU60Y

Central Electricity Authority of India (2009): CO_2 Baseline Database for the Indian Power Sector User Guide. Version 5.0 November 2009, New Delhi

Chinese DNA (2010c): 附件2：中国电网基准线BM计算过程 (China's grid baseline BM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2551.doc

Chinese DNA (2010b): 2010中国低碳技术化石燃料并网发电项目区域电网基准线排放因子 (China's Regional Grid Baseline Emission Factors 2010 for "new grid connected fossil fuel fired power plants using a less GHG intensive technology projects"), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2537.pdf

Chinese DNA (2010a): 2010 中国区域电网基准线排放因子 (2010 Baseline Emission Factors for Regional Power Grids in China), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2552.pdf

Chinese DNA (2009d) 关于公布2009 年中国低碳技术化石燃料并网发电项目区域电网基准线排放因子的公告 (China's Regional Grid Baseline Emission Factors 2009 for "new grid connected fossil fuel fired power plants using a less GHG intensive technology projects") download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2330.pdf

Chinese DNA (2009c): 附件2：中国电网基准线BM计算过程 (China's grid baseline BM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2332.doc

Chinese DNA (2009b): 附件1：中国电网基准线OM计算过程 (China's grid baseline OM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2331.xls

Chinese DNA (2009a): 关于公布2009年中国区域电网基准线排放因子的公告 (China's Regional Grid Baseline Emission Factors 2009), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2413.pdf

Chinese DNA (2008d): 2008 中国低碳技术化石燃料并网发电项目区域电网基准线排放因子 (China's Regional Grid Baseline Emission Factors 2010 for "new grid connected fossil fuel fired power plants using a less GHG intensive technology projects")download at cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File1829.pdf

Chinese DNA (2008c): 附件2：中国电网基准线BM计算过程(China's grid baseline BM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2107.pdf

Chinese DNA (2008b): 附件1：中国电网基准线OM计算过程(China's grid baseline OM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File1879.pdf

Chinese DNA (2008a): 2008中国区域电网基准线排放因子, (China's Regional Grid Baseline Emission Factors 2008) download at: http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File2106.pdf

Chinese DNA (2007c): 附件2：中国电网基准线BM计算过程(China's grid baseline BM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File1365.pdf

Chinese DNA (2007b): 附件1：中国电网基准线OM计算过程(China's grid baseline OM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File1358.xls

Chinese DNA (2007a): 2007中国区域电网基准线排放因子 (China's Grid Baseline Emission Factors Calculation Result 2007), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/File1364.pdf

Chinese DNA (2006c):, 附件2：中国电网基准线BM计算过程(China's grid baseline BM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/2006/20061215144747182.pdf

Chinese DNA (2006b): 附件1：中国电网基准线OM计算过程(China's grid baseline OM calculation progress), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/2006/20061215144641643.xls

Chinese DNA (2006a): 中国电网基准线排放因子 (China's Grid Baseline Emission Factors Calculation Result), download at http://cdm.ccchina.gov.cn/WebSite/CDM/UpFile/2006/20061215144550669.pdf

Energy Changes (2008a): Calculation of the Combined margin emission factor of Ethiopia's electric power system according the UNFCCC Methodological tool "Tool to calculate the emission factor for an electricity system", Vienna

Energy Changes (2008b): Calculation of the Combined margin emission factor of Ghana's electric power system according the UNFCCC Methodological tool "Tool to calculate the emission factor for an electricity system", Vienna

Energy Changes (2008c): Calculation of the Grid Emission Factor (GEF) of the electricity grid in Uganda according to the "Tool to calculate the emission factor for an electricity system", Vienna

ERM (2005): Study on Electricity Sector Baselines in Thailand, Bangkok

GFA Consulting (2009): Swaziland grid emission factor assessment, Mbabane

Hinchiranan, Sukamon (2009): The estimation of emission factor for an electricity system in Thailand 2007, Bangkok

IEA (2008): World Energy Outlook 2008, Paris

IEA Coal Industry Advisory Board (2010): Power Generation from Coal. Measuring and Reporting Efficiency Performance and CO_2 Emissions, Paris

Japan Consulting Institute (2008): Validation report of Shaba 24MW Hydropower Project in Yunnan Province, China, 2 April 2008

Ministry of Environment Protection and Natural Resources of Georgia (2007): Baseline Emission Factor for the Electricity System of Georgia (Recommended for the CDM projects), Tbilisi

Ministry of Nature Protection of the Republic of Armenia (2010): Calculation of Grid (Baseline) Emission Factor for the Electricity System of the Republic of Armenia for the year 2009, Erewan

Ministry of Science and Technology of Brazil, Interministerial Commission on Global Climate Change (2008): Clarification note, Brasilia

PTM (2008): Study on Grid Connected Electricity Baselines in Malaysia Year: 2005, Kuala Lumpur

UNEP Riso Centre (2011): CDM pipeline, download at www.cdmpipeline.org

World Nuclear Association (2011): Nuclear Power in China, download at http://www.world-nuclear.org/info/inf63.html

Annex I: Data requirements for calculation of the grid emission factor and ACM0013

Tool to calculate the emission factor for an electricity system

Before any data can be collected, the ***relevant grid*** (called "project electricity system" in CDM jargon) needs to be defined. It can be linked to other grids ("connected electricity systems") through lines with transmission constraints. The grid definition can be formally published by the host country DNA ("delineated"). There are no formal requirements for this delineation, whereas the definition of the grid by a project developer has to follow formal criteria regarding utilisation rates of transmission lines and price differentials, as a grid needs to allow power plant dispatch without ***significant transmission constraints***.

The following data are required for the calculation of the grid EF under the tool:

- Fossil fuel used in each power plant serving the grid (in volumes or mass units)
- Net calorific values (NCV) of each fuel type used
    - Values from fuel suppliers
    - National or regional default values documented in regional or national energy statistics / energy balances
    - IPCC default values at the lower 95% confidence interval

  Gross calorific value (GCV) can also be used but then need to be applied also for the CO_2 emission factor calculation.
- CO_2 emission factors for each fuel type used
    - Values from fuel suppliers
    - National or regional default values documented in regional or national energy statistics / energy balances
    - IPCC default values at the lower 95% confidence interval
- Net electricity generation of each plant serving the grid
- Electricity imports
    - From grids within the host country; for these operating margins can be calculated
    - From grids outside of the host country
- Commissioning dates of power plant units

If no fuel use data are available for each power plant, it is sufficient to know the fuel type, provided the efficiency of each plant serving the grid is known. The efficiency is determined as follows:

- Documented manufacturer's specifications if the efficiency of the plant is not significantly increased through retrofits or rehabilitations
- Data from the utility, the dispatch center or official records "if it can be deemed reliable". The tool requires project developers to provide provide appropriate justification if the values are "significantly lower" than the default value provided by the Tool
- Default values provided by the Tool. These default values are very conservative (see Table A-1).

Table A-1: Default power plant efficiencies

Fuel	Technology	before 2000	after 2000
Coal	Subcritical	37%	39%
Coal	Supercritical	-	45%
Coal	Ultra-supercritical	-	50%
Coal	IGCC	-	50%
Coal	FBS	35.50%	-
Coal	CFBS	36.50%	40%
Coal	PFBS	-	41.50%
Oil	Steam turbine	37.50%	39%
Oil	Open cycle	30%	39.50%
Oil	Combined cycle	46%	46%
Gas	Steam turbine	37.50%	37.50%
Gas	Open cycle	30%	39.50%
Gas	Combined cycle	46%	60%

If plant-specific data are not available, the operating margin can be calculated using

- Total fuel used by all plants serving the grid, differentiated according to fuel types
- Net calorific values (NCV) of each fuel type used
- Net electricity generation for the entire grid, provided the electricity generation by renewable power sources is known

For host countries where plants with low operating costs generate more than 50% of the electricity, a load duration curve has to be calculated.

Data have to be provided for at least three adjacent years in the past.

The tool has been revised once since it first entered into force in July 2009, not counting a minor clarification. However, important revisions regarding grid EF calculations were earlier made to ACM 0002. Up to its version 7, which referred grid EF calculation to the Tool, the principles for data collection had a priority list as follows:

1. acquired directly from the dispatch center or power producers, if available; or
2. calculated, if data on fuel type, fuel emission factor, fuel input and power output can be obtained for each plant. If confidential data available from the relevant host Party authority are used the calculation shall be verified by the DOE and the CDM-PDD may only show the resultant carbon emission factor and the corresponding list of plants.
3. calculated, using default IPCC values for NCV and CO_2 emissions factors for fuels instead of plant-specific values, technology provider's name plate power plant efficiency or the anticipated energy efficiency documented in official sources; conservative estimates of power plant efficiencies, based on expert judgments on the basis of the plant's technology, size and commissioning date;
4. calculated, for the simple OM and the average OM, using aggregated generation and fuel consumption data, in cases where more disaggregated data is not available

Important revision elements are shown in Table A-2.

Table A-2: Revision history of the Tool to calculate the emission factor for an electricity system and ACM 2 prior to entry into force of the tool

Version	Date	Key changes
Tool v. 2	16 Oct 2009	• Inclusion of off-grid calculation option
Tool v.1	19 Oct 2007	
ACM 2 v.7	30 Nov 2007	• Reference to Tool
ACM 2 v.5	3 March 2006	• Power plant capacity additions registered as CDM projects excluded from the calculation of emission factors • If 20% falls on partial capacity of a plant for the calculation of the build margin, that plant should be fully included in the calculation

Baseline methodology ACM0013

The methodology ACM 0013 is special inasmuch it applies a benchmark approach. The baseline emission factor is the lower value of

- the technology and fuel type identified as the most likely baseline scenario
- the benchmark based on the performance of the ***top 15% power plants*** that use the same fuel category as the project plant and any technology available in the geographical area, from a sample including at least 10 comparable power plants.

The methodology is only applicable if ***over 50% of power generation*** serving the grid or the entire host country is derived from the fuel used by the project, applying the average of the last three years. This has to date limited application of the methodology to supercritical or ultra-supercritical coal power plants in India and China.

All data have to be collected for a reference year which is the most recent year prior to the date of submission of the PDD for validation – but not more than 2 years before - , for which the required data from the power plants to be included in the sample group for the emissions benchmark is available.

The plants from which the benchmark is calculated are selected as follows:

- use of the same fossil fuel category as the project, including plants which use small amounts of other fuels for start-up, up to 3% of the total fuel used annually on an energy basis;
- construction in the previous five years, where the last year of this 5 year period should be the reference year;
- comparable size to the project, i.e. ± 50% of the rated capacity of the project plant;
- operation in the same load category, i.e. at peak load (<3,000 hours per year) or base load (> 3,000 hours per year) as the project
- supply of electricity to the grid has been done in the reference year

The sample needs to include at least 10 plants. The sample selection is made as per the following steps, enlarging the area successively if less than 10 plants are found that fulfil the criteria:

- grid to which the project plants is connected
- country
- all neighbouring non-Annex I countries
- all non-Annex I countries in the continent
- data from power plants in Annex I or OECD countries can be used instead for the remaining plants required to complete the sample group.

The methodology has been revised three times already since it first entered into force in September 2007, not counting a minor correction of an equation. Important revision elements are shown in Table A-3.

Table A-3: Revision history of ACM 0013

Meth version	Date	Key changes
4	17 Sept 2010	• Requirement of first hand measurement of fuel use of benchmark power plant • Reference year approach instead of “most recent year prior to the start of the project” • Auxiliary fuel threshold of 3% specified
3	25 March 2010	• Differentiation between fuel category (liquid, solid, gaseous) and fuel type (e.g. lignite vs hard coal) • Requirement to use IPCC default CO_2 emissions factors instead of regional/national averages • Specification that OECD efficiencies are only to be used for the plants to fill up the sample
2	30 May 2008	• Grid can only cover host country
1	14 Sep. 2007	

The following data are required for the calculation of the efficiency of the benchmark sample power plants:

- Fossil fuel used in each power plant (in volumes or mass units). These data are to based on first-hand measurements of the actual quantity of fuel consumed by each power plant, and explicitly shall not come from second-hand calculations or estimations.
- Net calorific values (NCV) of each fuel type used
  - Plant-specific values
  - Well-documented and reliable national or regional average values
  - IPCC default values at the lower 95% confidence interval
- CO_2 emission factors for each fuel type used, using IPCC default values at the lower 95% confidence interval
- Net electricity generation of each plant
- Commissioning dates of power plant units