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Coal Power in the CDM: Issues and Options

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Coal power in the CDM: Issues and options

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ABSTRACT

This paper examines several issues that arise in awarding emission reduction credits to coal projects in the Clean Development Mechanism (CDM). It identifies systematic weaknesses in the coal methodology's (ACM0013) design and application. The authors estimate that shortcomings lead to significant over-crediting of Certified Emission Reductions and discuss why a revision of the methodology to more accurately estimate emissions reductions may not be possible because of data constraints and weak signal-to-noise ratio. The paper also examines evidence that suggests the vast majority of these projects would have proceeded in the absence of the CDM, and are thus non-additional. It considers the suitability of coal in the CDM, given the identified flaws in the methodology, and in the light of coal's impact on climate change and its social and environmental burdens.

CONTENTS

EXECUTIVE SUMMARY

Coal has been the fuel of choice for many industrializing countries over the past two centuries. Coal plants generate over 40% of the world's electricity, and a much larger share in major emerging economies like India (70%) and China (80%). Since 1970, new coal-fired power plants have been the dominant source of added CO_2emissions in the power sector, the sector making the largest contribution to increases in global CO_2 emissions. According to International Energy Agency forecasts, these trends are likely to continue. It might seem surprising then that, since the approval of CDM Methodology ACM0013 in 2007, new coal plants in developing countries "using a less GHG intensive technology" are eligible to claim tradable Certified Emissions Reductions (CERs) under the Clean Development Mechanism (CDM). Such plants represent long-lived investments that will deliver emissions-intensive electricity for 30 years or more, with potentially significant local environmental and health impacts from air pollution and associated coal mining. Given this context, it is vital that any CDM methodology for ascribing emission reductions and providing carbon finance to new coal plants be robust and correctly applied. Coal project developers should have to demonstrate conclusively that in the absence of CDM support, a less-efficient, higher-emitting coal plant would have been built. Once operational, the plants must truly emit less CO_2 per unit of electricity than a non-CDM-supported plant would have emitted.

In this sense, using the CDM to improve a coal plant's efficiency is not unlike using it to improve the efficiency of a cement plant, commercial building, or other facility. Carbon finance, in the form of tradable CERs, can, in principle, provide sufficient incentive for a project developer to build and operate a facility that might cost more, but is lower-emitting, than what would have been built and operated absent the CDM. These CERs can be used in place of costlier emission reductions by a country or company subject to a binding emission cap. The cost of complying with the Kyoto Protocol, EU Emissions Trading System (EU ETS), or other relevant emission trading system would be reduced, resulting in economic benefits, and, arguably, increasing the likelihood of more ambitious emissions caps in the future. However, for all this to occur, the emissions reductions must be real and additional. The crediting methodology must ensure that the crediting baseline against which they are estimated is appropriate and realistic, and that indeed, higher-emitting facilities would otherwise have been built. This paper examines whether the ACM0013 methodology, and its application in practice, achieves these objectives.

CDM coal project pipeline overview

As of October 2011, there were 45 coal projects in the ACM0013 CDM pipeline, all in India and China. Six have been registered and approved to generate CERs, and 39 projects are at the validation or review stages. Table ES-1 summarizes the coal power project pipeline.

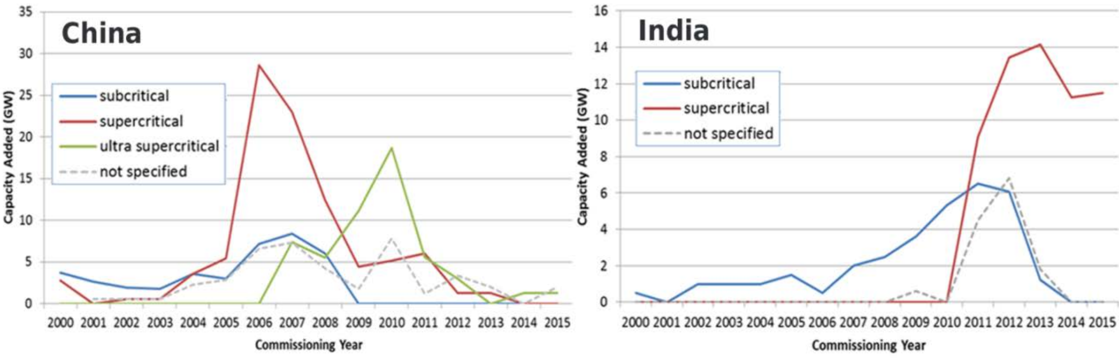
ES-1: Information on CDM coal project pipeline

Host Country	Number of projects registered	Total number of projects in the CDM pipeline	Total capacity of projects in the CDM pipeline	Coal boiler technology used	Expected start date of operation
India	5	32	56 GW	supercritical (all projects)	2011-2016
China	1	13	23 GW	ultra-supercritical (all projects)	2009-2012

If all 45 projects are approved under the current ACM0013 methodology, and perform as projected, they will generate 451 million CERs over their project lifetimes – 90% in India alone. (While this is a significant amount of CERs, it represents only 4% of the expected CERs from all project types in the full CDM pipeline.)

To qualify for the CDM, coal projects must show the CDM played a decisive role in moving from less-efficient subcritical coal technology to more-efficient and lower-emitting supercritical or ultra-supercritical technologies. As Figure ES-1indicates, however, the transition away from less efficient, subcritical technology to supercritical technology in India and to supercritical, and now, ultra-supercritical, in China is well under way, if not largely complete. There are several indications that this transition has occurred for reasons other than CER revenue.

Figure ES-1. Large (400+ MW) coal plants operating, under construction, and planned by commissioning date



A major factor behind the switch to supercritical and ultra-supercritical technologies is the rising price of coal. International coal prices rose steeply throughout the past decade, by about 10% per year on average. Dependence on coal imports and exposure to rising coal prices in international markets is likely to increase in the future, a problem that is particularly pronounced in Asian markets. In response, the Indian and the Chinese governments have established policies to decrease their dependence on coal and increase efficiency of their coal plants. In fact, China is currently building the world's most efficient new coal fired power plants.

Faced with persistent coal shortages, rising prices and the need to address major power supply deficits, the Indian government has placed a high priority on coal plant efficiency and has mandated the use of super-critical technology for the largest ("ultra mega") projects. Within a few years, almost no new large Indian new coal plants will come on line using subcritical technology, as illustrated in Figure ES-1. Despite this shift to supercritical technology, all coal projects in the CDM pipeline still claim subcritical to be the baseline technology, even for projects not expected to be commissioned until 2015. Furthermore, nearly all of the supercritical plants operating or under construction have applied for CDM funding, or indicated they that intend to do so.

Most of China's new ultra-supercritical plants are applying for CDM funding. Eight of 13 Chinese project documents claim that a subcritical plant would have been built without CDM support. However, as shown in Figure ES-1, no large subcritical unit has been commissioned since 2008. In addition, 11 of 13 Chinese coal projects in the CDM pipeline are expected to be operational by the end of 2011, and only one has been registered as of October 2011. Therefore, it would seem rather unlikely that the CDM was instrumental in technology decisions.

Significant over-crediting due to systemic flaws in ACM0013 and its application

TheACM0013 baseline and monitoring methodology determines how emission reductions will be quantified for improved efficiency coal power projects in the CDM. Among CDM methodologies, it is notable and innovative. It creates a standardized baseline, similar to the approaches now called for throughout the CDM, which is based on the average of the top 15% performing coal plants in terms of emission rate (tCO_2/MWh). This is known as the Option 2 baseline. ACM0013 also establishes a systematic approach to assessing the emission rate of the power plant likeliest to be built without the CDM. This emission rate is the Option 1 baseline. ACM0013 aims to be conservative by requiring the baseline to be the lowest of the Option 1 and Option 2 values.

Despite its careful design, however, ACM0013 has been routinely applied in ways that have led to a substantial overestimation of emission reductions.

- Developers are using unduly high emission baselines under Option 1 by identifying subcritical technology as the ”most likely” alternative without the CDM in all Indian projects and 8 of 13 Chinese projects, despite the transition away from this technology in both countries.
- Use of outdated historical data in the standardized Option 2 baseline ignores the rapid technological shifts away from subcritical technology occurring in both India and China. As the CDM Methodologies Panel has noted, the top performer baseline reflects the efficiency of plants built five or more years before the technology decisions on projects applying to the CDM. The Panel used an illustrative calculation to suggest that neglect of ongoing efficiency improvements in the Option 2 baseline might lead to over-crediting of 25%.
- Project documents for Indian projects inflate the benefits of switching from subcritical to supercritical technology. Specifications of technologies currently available in the market suggest the relative efficiency and emissions improvements are likely to be on the order of 2-4%. In contrast, these coal projects are claiming improvements on the order of at least 11%, on average.

The analysis in this paper shows that, taken together, these issues could lead to over-crediting on the order of 250%. By using an Option 2 baseline that reflect other plants implemented closer to the projects’ timing, and an Option 1 baseline that reflects a supercritical baseline in China, and more modest differences in efficiency for Indian projects, we estimate that instead 451 million CERs, the coal project pipeline would yield 132 million CERs. Echoing the CDM Methodologies Panel’s earlier findings, we believe the magnitude of this potential error should warrant immediate suspension of the current methodology, pending adequate revision.

Low signal-to-noise ratio and unintended outcomes

In addition, factors not controlled for by the methodology can influence plant efficiency on a scale similar to changes in boiler technology, e.g., from subcritical to supercritical. Coal unit efficiency is influenced by factors other than boiler technology such as cooling technology, the use of pollution abatement equipment, and the moisture, ash, and sulfur content of the fuel. Together, these variables can affect relative unit efficiency by 7% or more. In other words, these variables can have as great an impact on unit efficiency as the choice of boiler technology, which is what the CDM seeks to influence. Furthermore, uncertainty and annual variation in coal unit emissions data can, in some circumstances, be quite high, reducing confidence in standardized baseline values and reported emission reductions.

ACM0013 does not control for any of these variables, making it difficult to determine whether a plant that claims CERs under the standardized baseline (Option 2) actually reduces emissions due to improvements in boiler technology, or for other reasons. The addition of sulfur and particulate emission controls to mitigate local pollution impacts, for example, can have the effect of reducing net unit efficiency. As a result, ACM0013 may inadvertently penalize projects that minimize local air pollution impacts, if plants included in the standardized baseline calculation have not implemented similar controls. Conversely, it could reward projects that do not take steps to mitigate local air pollution impacts if plants in the Option 2 baseline have generally implemented pollution controls. This perverse outcome would run contrary to the sustainability objectives of the CDM.

Questionable additionality

We find the standard CDM additionality procedures, in particular the common practice test, are not appropriate for assessing coal technologies in India and China. Common practice analysis is intended as a credibility check to determine whether the proposed project type (e.g. technology or practice) has already diffused in the relevant sector and region. As we show in this paper, ultra-supercritical technology is already diffused and widely implemented in China, and a similar situation exists for supercritical technology in India. However, the common practice test excludes from consideration any project that is registered or applying for CDM approval. Nearly all supercritical and ultra-supercritical units in India and China, respectively, are excluded on this basis, and, therefore none are considered common practice. While this exclusion makes sense for project types where there are clearly decisive cost or technical barriers, that is not the case here, and a result the common practice analysis does not function as an important credibility check.

Given the pressure to build super or ultra-supercritical coal plants due to ongoing coal price increases and Indian and Chinese government policies that foster or require supercritical or ultra-supercritical coal designs, it is highly unlikely that a significant fraction, if any, of the coal projects in the pipeline are truly additional. We have also found significant limitations in the investment and sensitivity analyses used to assess additionality. Despite these issues, six of the seven coal plants that have applied for CDM registration have been approved. (The one rejected plant is in the process of reapplying – and in the meantime, is nearly done with construction, again raising questions about the need for CDM incentives.)

Conclusions

It might be possible to address the identified weaknesses in the application of the Option 1 and Option 2 baselines though further revisions of the ACM0013 methodology. However, the influence of factors other than boiler technology improvements, as well as uncertainty in coal plant emissions estimates (the low "signal-to-noise" ratio), may prove hard to control effectively. It is therefore unclear how a revised ACM0013 methodology could estimate verifiable emission reductions in a feasible, robust and conservative manner.

Coal plants represent major, long-lived investments using the highest-emitting electricity resource. For example, even at ultra-supercritical efficiency levels, coal plants produce twice the emissions per kilowatt-hour of a new natural gas plant. Using much-needed climate finance to support construction of these plants, even if it leads to slight increase in the efficiency of some coal plants, may undermine the overall objective of limiting dangerous climate change. Under the current rules, nearly 80 GW of new coal plants could be supported through the CDM, representing 3-4 billion euros in CER revenue at 8 euros per CER.

It is essential to re-evaluate whether an offset-based, incentive-only system such as CDM should support coal investments at all. The coal projects in the CDM pipeline offer, at best, marginal improvements in emission rates, while locking in over 400 million tCO_2 in annual emissions – as much as the annual CO_2 emissions of countries such as France, Spain and South Africa. Sectoral crediting or trading, if designed well and at the electricity sector-wide level, offers an alternative way to spur improvement in coal plant efficiencies and minimizes the risk of significant over-crediting and non-additionality that currently characterizes the pipeline of CDM coal power projects.

1. INTRODUCTION

This paper examines several issues that arise in awarding emission reduction credits to coal projects in the Clean Development Mechanism (CDM). Section 1 provides an introduction to coal projects in the CDM pipeline, and the potential scale of Certified Emission Reductions (CERs) they might produce. Section 2 explores trends in coal power plant technology and shows how the transition from less-efficient, subcritical technology for large coal units is already well underway, if not complete, in India and China, the two countries that account for all CDM coal plants. With these trends in mind, Section 3 analyzes the ACM0013 methodology for quantifying emission reductions. It identifies some systematic weaknesses in ACM0013's design and application, and explores their implications and potential remedies. Section 4 turns to the question of additionality, and reviews concerns with how projects have applied current additionality testing procedures, and with the procedures themselves. Finally, Section 5 reflects on the findings of the previous sections in light of the challenging role that coal power plays in mitigating global CO_2 emissions.

1.1 The challenge of including coal power in the CDM

In late 2007, the CDM Executive Board approved CDM Methodology ACM0013, which allows new, more efficient, coal plants to claim certified emission reductions (CERs). Under this methodology, entitled the "Consolidated baseline and monitoring methodology for new grid connected fossil fuel fired power plants using a less GHG intensive technology", proponents of new coal-fired power plants must demonstrate that without the CDM they would have installed a less efficient, higher-emitting technology. If project proponents can show their project would yield "additional" emissions reductions below what would have otherwise occurred, then ACM0013 provides the methodology for calculating the number of CERs the project can receive.

As shown in Figure 1, a sizeable and growing fraction of new coal builds are now seeking support through the CDM. Roughly one quarter of global coal capacity commissioned in 2011 has applied for or been approved to receive CDM credits using ACM0013. (

Figure 1 includes smaller coal plants (<600 MW), which are not in the CDM pipeline). Currently, nearly 79 GW of coal capacity is the ACM0013 pipeline. When these projects are brought on line, they will emit about 400 million tons CO_2 equivalent (tCO_2e) annually, representing over 1% of global CO_2 emissions (not including land-use change and forestry).[1]

Figure 1. Coal capacity added in 2011, globally, in India and China, and CDM pipeline

Sources: IEA (2011) and author updates for capacity with 2011 commissioning dates; project PDDs and IGES (2011) for CDM capacity with 2011 credit start dates.

[1] The 400 million tCO_2 estimate was derived from CDM project documents. In 2007, global CO_2 emissions excluding land use change and forestry were 29.6 billion tCO_2 (World Resources Institute 2011).

Given their contribution to global CO_2 emissions, and the CDM's explicit objective of promoting sustainable development in host countries, the eligibility of coal plants for CDM support may seem surprising. Among resource types for electricity production, coal plants are the most GHG intensive, pose the greatest environmental damages (e.g. local air pollution and the production of hazardous wastes such as coal ash), and have the worst worker health and safety record (coal mining) (Muller et al. 2011; National Research Council 2010).[2] However, in many ways, using the CDM to improve coal plants' efficiency is no different than using it to improve the efficiency of a cement plant, commercial building, or other facility. If a CDM methodology could be properly designed and followed correctly, it would, in principle, lead to a facility that is lower-emitting than one that would have been built and operated absent the CDM. And if such a project is properly verified to ensure that claimed emission reductions were actually realized, then the CDM can create real, additional certified emission reductions (CERs) that can be used in the place of costlier emission reductions by a country or company subject to a binding emission cap. The cost of complying with the Kyoto Protocol, EU Emissions Trading System (EU ETS), or other relevant emission trading system would be reduced, resulting in economic benefits, and, arguably, increasing the likelihood of more ambitious emissions caps in the future.

However, if the CDM methodology and its application produce significant amounts of CERs that do not reflect actual emission reductions, then the use of these CERs will undermine the integrity of the Kyoto Protocol and/or the EU ETS: caps will be exceeded, economic efficiency will be impaired, and the credibility of emissions trading will be reduced. Unfortunately, as we describe in this paper, that seems to be the case with coal plants in CDM. Revisions to ACM0013, and improvements in how it is applied, may be able to address some, but likely not all, of the concerns we raise here.

1.2 Coal power and the ACM0013 project pipeline

As of October 2011, 49 projects were listed on the United Nations Framework Convention on Climate Change (UNFCCC) website as using or intending to use ACM0013. Of these, 45 are for new large coal plants (with units 660 MW and above) in either India or China. The remaining ACM0013 projects are for three natural gas plants and one oil power plant, and are not discussed further here (UNEP Risoe Center 2011; IGES 2011).

Of the 45 CDM coal plants, currently:

- 6 projects are registered and eligible to generate CERs;
- 39 are at validation or review stage; in other words, they have developed project design documents (PDDs) and are in the process of seeking CDM approval and the ability to generate CERs.

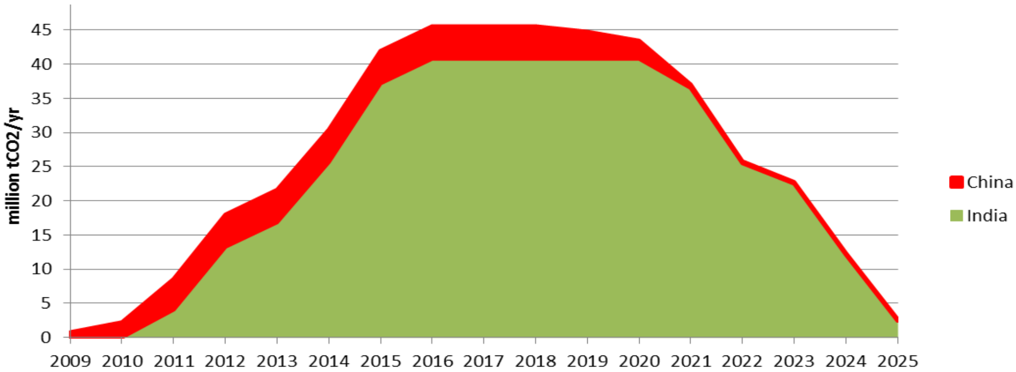
The 45 coal projects in the CDM pipeline encompass nearly 79 GW of new coal capacity, with 17 GW approved, and 62 GW seeking validation or registration. One project (Tata Mundra) was previously rejected by the CDM Executive Board due to concerns about its additionality (see Section 4), but has revised its PDD and is seeking validation.

Looking more closely, the projects in the pipeline in India and China are distinct in several respects. All the Indian coal projects, totaling 56 GW, are using supercritical coal technology, and are expected to come into operation between 2011 and 2016. The Chinese coal projects all rely on ultra-supercritical technology with start of operation varying between 2009 and mid-2012. (See Section 2 for a discussion of coal technologies.)

[2] See also http://www.asianresearch.org/articles/2997.html; http://factsanddetails.com/china.php?itemid=321&catid=13&subcatid=85#00

Figure 2 shows the stream of CERs that would ensue if all projects are registered and perform as projected in the PDDs. While only 30 million CERs are expected by 2012, by 2020 another 319 million would be produced. By the end of their crediting periods, these projects would yield a cumulative 451 million CERs, nearly 90% for projects in India.[3] While these are significant sums, they are relatively small compared with the expected CERs from all projects in the CDM pipeline: roughly 4% as shown in Figure 3.

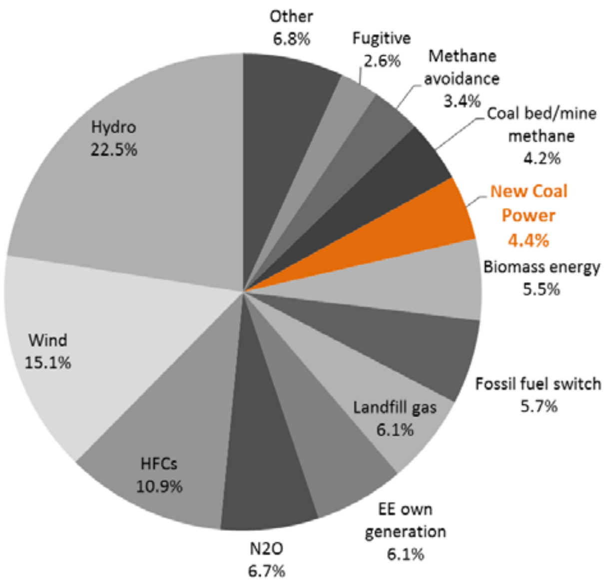
Figure 2. Projected Annual CERs from ACM0013 coal plants in CDM pipeline



Sources: IGES *(2011), PDD data.*

As we discuss in Section 3, we believe that Figure 2 presents a significant overestimate of the CERs that should be attributed to ACM0013 coal plants, due to flaws in the application of the baseline emission rate methodology. In the following section, we provide background on the evolution of coal power technologies in India and China, and its implication for the baselines and additionality of CDM projects.

Figure 3. Projected share of CERs by project type through 2020



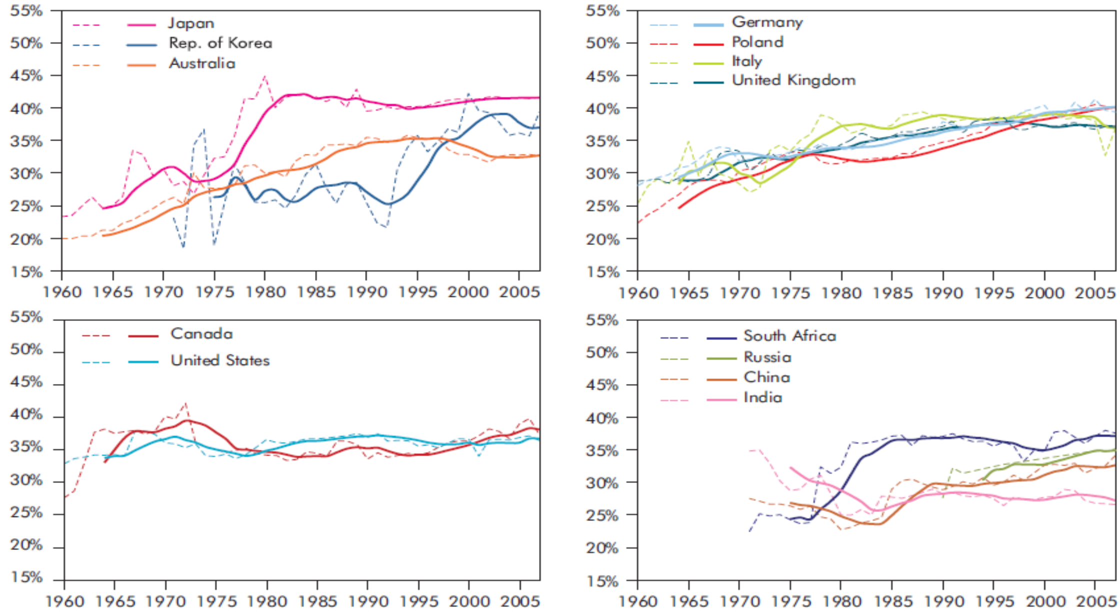
Source: UNEP Risoe Center, August 2011

[3] Such projections of CERs should be viewed as "optimistic" since, historically, CDM projects, collectively, have yielded fewer CERs than anticipated due to delays in the registration and issuance processes.

2. TRENDS IN COAL POWER TECHNOLOGY

Technological advances have tended to make new coal plants progressively more efficient over time. As shown in Figure 4, in many countries, the efficiency of coal-fired power has improved considerably over the last 50 years.

Figure 4. Change in coal-fired heat and power plant efficiency over time in selected countries (IEA)



Source: IEA (Burnard and Bhattacharya 2011), from IEA databases. Dashed lines show annual data; solid lines show 5-year moving averages.

In recent years, power plant efficiencies have risen as coal unit sizes have increased, the efficiencies of subcritical plants have increased, and greater numbers of supercritical and ultra-supercritical plants have come on line. Globally, super- and ultra-supercritical units comprised one-quarter of all new coal plant capacity in 2009 (Burnard and Bhattacharya 2011).

Aside from coal quality and location-specific parameters (ambient temperatures, cooling technologies, pollution controls), the major determinant of coal use efficiency is the boiler type, typically classified by the pressure and temperature conditions. Traditionally, pulverized coal (PC)[4] plants have used subcritical boiler technologies with lower operating pressures, and steam and reheat temperatures. Current sub-critical plants can reach efficiencies of 38% to 39% (LHV, net)[5] (Burnard and Bhattacharya 2011). At high pressures and temperatures, water becomes a single-phase fluid, and conditions are “supercritical”, with no distinction between gas and liquid phases, increasing plant efficiencies. Operating at even higher pressure and temperature, state-of-the-art ultra-supercritical plants can achieve design efficiencies of 45% to 46% (LHV, net; Burnard and Bhattacharya 2011)

As we will discuss in the next section, the efficiency increase and emissions reduction associated with moving from subcritical to supercritical, and supercritical to ultra-

[4] Pulverized coal plants are the predominant coal plant technology today. Other technologies such as integrated gasification combined cycle (IGCC) or fluidized bed, though promising, are not part of the CDM pipeline and are not discussed here.

[5] LHV refers to a fuel’s lower heating value, and “net” refers to electricity sent to the grid, net of own power plant use.

supercritical, technology depend on the specific technologies available, and their design parameters (operating pressure, steam temperature, and reheat temperature). Switching from subcritical to a state-of-the-art ultra-supercritical theoretically could produce a 7% increase in *absolute* efficiency (e.g. 38% to 45%), and a 16% reduction in coal consumption and CO_2 emissions (Burnard and Bhattacharya 2011). However, the performance differences among technologies available to utilities and developers in the market at a given time and site are likely to be less. For example, the U.S. Environmental Protection Agency found that for a given plant size, and for "steam conditions representative of current market offerings" in the United States in mid-2008, supercritical technology offers an improvement in relative efficiency of only 3.1%, and ultra-supercritical offers only another 1.5% improvement over supercritical (Sargent & Lundy 2009).[6]

The potential for further efficiency improvements still remains, but absent any major breakthroughs (e.g., advanced materials for much higher temperatures and pressures) such improvements will likely be in small increments. According to the International Energy Agency (Burnard and Bhattacharya 2011), successful advances in high temperature and pressure materials could push the efficiency of the best (pulverized) new coal plants towards 50% (LHV, net) in the next 10 to 15 years. While this would be a notable achievement, it would still amount to less than a 0.5% annual improvement, far from the pace of change required for coal power to contribute to steep reductions in global GHG emissions.

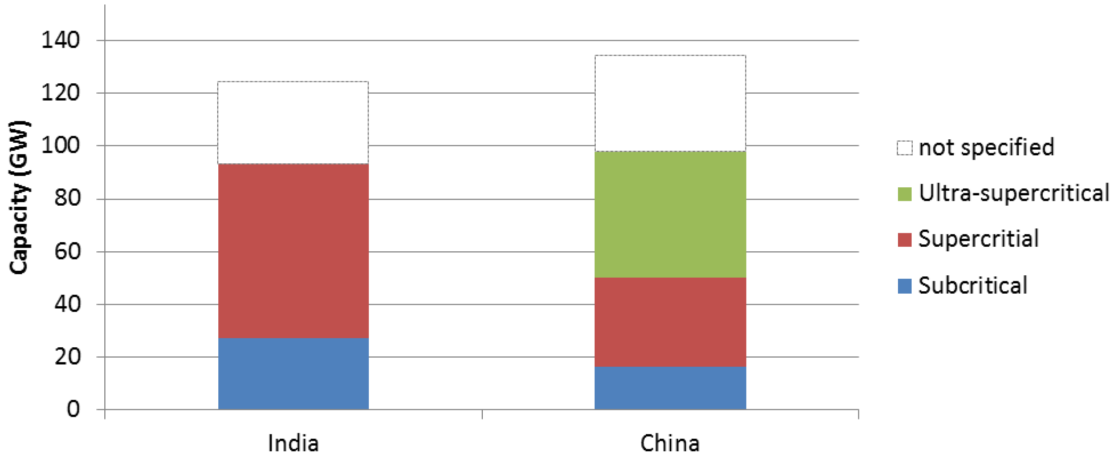
While carbon capture and storage (CCS) technology could theoretically allow coal power to play a role in a low-carbon future, major economic and technological challenges remain, including high costs, large water requirements, uncertainties associated with long-term storage, and an increase in coal requirements (due to the added power needed to run the capture technologies). Moreover, retrofitting an existing coal-fired plant originally designed to operate without carbon capture would require major technical modification. Even if CCS is successfully commercialized, retrofitting existing plants, such as the ones in the current CDM pipeline, would likely be cost prohibitive (MIT 2007).

Globally, supercritical and ultra-supercritical technologies have rapidly gained market share, without major support from climate policies or incentives such as CDM. Instead, a combination of operational advantages, rising coal prices, and government policies has led utilities, power companies and manufacturers to abandon subcritical designs. Today, supercritical boilers represent the standard technology of choice for new coal-fired power plants (Burnard and Bhattacharya 2011).

As shown in Figure 5, since 2008, very few large new coal plants have used or planned to use subcritical technology. In India, the large majority of new coal capacity is now supercritical, while in China, slightly more capacity is ultra-supercritical than supercritical.

[6] Advanced ultra-supercritical (311 bar, 704° steam/reheat) could achieve another 6.4% improvement. Ultra-supercritical technologies in the CDM pipeline for China tend to have steam and temperature parameters slightly better than the standard ultra-supercritical in the EPA study (258 bar, 593° steam/reheat).

Figure 5. Capacity of large (400 MW+) coal plants with commissioning dates from 2008 onward (operating, under construction, or planned) (GW)



Source: IEA (2011). Does not include plants for which commissioning dates are not readily available; the dashed line (no fill) shows plants where the technology is not specified.

First and foremost, supercritical and ultra-supercritical technologies have been rapidly adopted because they provide a hedge against rising coal prices.[7] As shown in Figure 6, international coal prices rose steeply throughout the past decade, by roughly 10% per year. While prices dropped slightly after 2008, since 2010, international coal prices have begun to rise steeply again.[8] This problem is particularly pronounced in Asian markets, and sector analysts have warned that it will only get worse. Surging demand and coal's high correlation with oil prices will lead to rising and more volatile coal prices as operators look increasingly far afield to source their supply (UBS 2011). Supply shortages have also encouraged exporters to flex their increased market power. For example, in February, Indonesia cancelled long-term fixed price coal contracts to capture rising rents in international coal markets.[9]

The rising costs of imported coal can squeeze plant operator profit margins in India and China (Chikkatur and Sagar 2007; Rui et al. 2010). Indeed, it has already forced a number of plants to operate below capacity. It has also called the financial viability of a number of proposed coal projects into question, and induced several companies to halt construction on projects under development.[10]

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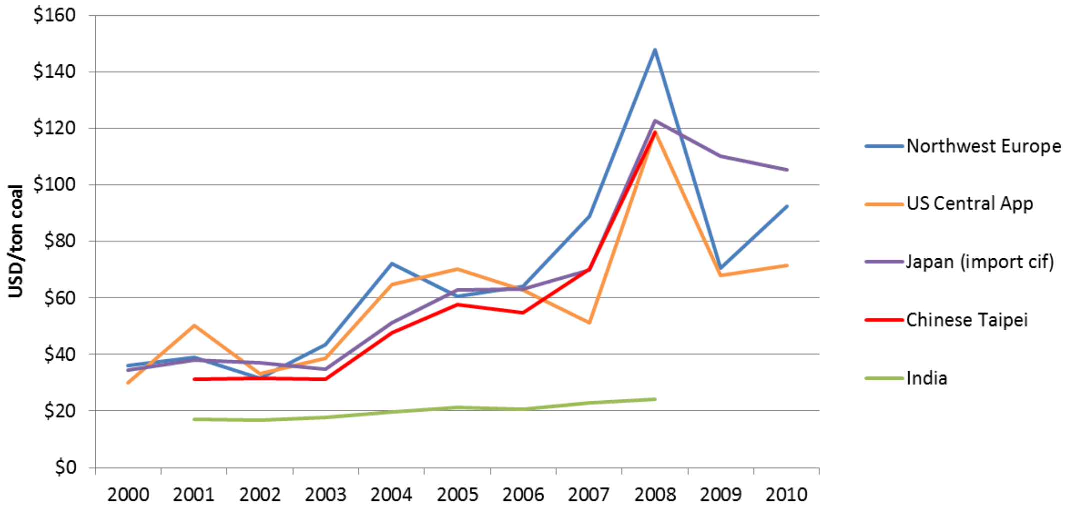
[7] See, e.g., David G. Victor, "He protests too much: India is already going green," *Newsweek*, Aug. 17, 2009, which notes: "Shortages in coal, which supplies about three quarters of India's electricity, are forcing India to accelerate this trend to higher efficiency."

[8] See, for example, http://www.argusmedia.com/Methodology-and-Reference/Key-Benchmarks/%7E/media/0489419CB40C47B1BFC1D70D8828BD03.ashx.

[9] http://articles.economictimes.indiatimes.com/2011-06-22/news/29689883_1_coal-prices-coal-imports-coal-india; http://www.cybex.in/exim-news/Indonesian-Coal-Price-Hike-Singes-2006.aspx.

[10] *The Hindu Business Line*, "RPower halts work on mega AP project citing costlier imported coal", July 8, 2011, available at http://www.thehindubusinessline.com/industry-and-economy/banking/article2211624.ece; *Business Standard*, "Power plants in pause mode, lenders press panic button", August 3, 2011, available at http://www.business-standard.com/india/news/power-plants-in-pause-mode-lenders-press-panic-button/444689/; Bloomberg News, "Tata Power Said to Seek Government Help to Curb Plant Losses as Coal Soars", August 10, 2011, available at http://www.bloomberg.com/news/2011-08-09/tata-power-said-to-seek-government-help-to-curb-losses-at-plant.html.

Figure 6. Coal prices, 2000-2010, selected countries



Sources: BP (2011) and U.S. Energy Information Administration (2010).

In the following sections, we discuss China's and India's transition to supercritical and ultra-supercritical technologies, respectively, and observe that these transitions appear to be taking place independent of the CDM.

2.1 India

India's power sector is highly coal-dependent, with coal plants representing slightly over half of total installed capacity (87 of 168 GW) and providing two-thirds of total generation in 2007-2008 (Remme et al. 2011). Most coal plants were built in the past three decades, and are supplied by domestic coal resources. In 2008, India was the third leading coal producer in world, with state-run Coal India accounting for over 80% of coal production (Remme et al. 2011). However, Indian coal tends to be of particularly poor quality due to high ash content; indeed, this high ash content has constrained the development and deployment of ultra-supercritical technology, unlike in China (Chikkatur 2008). Furthermore, many of India's coal reserves lie beneath heavily populated areas, posing particularly difficult environmental and social challenges for local communities and mining companies. And many of these reserves are far from major demand centers in India's coastal cities.

Transportation constraints and supply shortages have led to reduced electricity production,[11] and forced both plant operators[12] and Coal India to increase coal imports.[13] Indian coal

[11] See, e.g., "Thermal plants' coal shortage worsening," *The Hindu Business Line*, Apr. 4, 2005, available at http://www.thehindubusinessline.com/industry-and-economy/article2534912.ece; "Thermal plants face acute coal shortage", *India Business Insight*, April 2, 2008; "Coal situation worsens at thermal stations (several stations super critical with stocks for less than 4 days)," *India Business Insight*, May 9, 2008, available at http://www.thehindubusinessline.com/2008/05/09/stories/2008050952240100.htm; "Corporate power crisis looms large as key thermal stations starve for coal," *The Hindu Business Line*, Aug. 9, 2008, available at http://www.thehindubusinessline.com/2008/08/09/stories/2008080950460300.htm; "Inadequate coal linkages hit power stations," *The Press Trust of India*, Jan. 26, 2009, available at http://www.highbeam.com/doc/1G1-192610842.html; "Govt revises coal import target upwards to 35 MT in FY'10," *The Press Trust of India*, March 20, 2009; "Thermal stations continue to battle coal shortages," *Business Line*, April 16, 2009, available at http://www.thehindubusinessline.com/2009/04/16/stories/2009041651511500.htm; "Shortage of coal, gas to hit power sector," *Financial Express*, Nov. 2, 2009; "Indian market ready for plants, but needs steady supply of coal," *Platts Coal Outlook*, Nov. 16, 2009; "India's NTPC shuts two coal plants on coal shortages," *Platts International Coal Report*, Nov. 23, 2009.

[12] "Adani to invest $1.6 billion in Indonesian project," Reuters, available at http://in.reuters.com/article/2010/08/25/idINIndia-51045420100825.

imports grew by 36 percent between 2007 and 2009, reaching 16.5 percent of total consumption in 2009 (IEA 2010c). In 2010, India imported 61 million tons of coal. Estimates for 2012 range from 74 million tons (UBS 2011) all the way up to 160 million tons (the Indian government's high-end estimate), while estimates of India's demand for imported coal in 2030 range as high as 650 million tons.

Imported coal is considerably more expensive than domestic coal, in part because Coal India subsidizes domestic coal by as much as 50 percent below global prices.[14] This is a particular problem for the numerous planned coastal projects (including several Ultra-Mega Power Plants (UMPPs) that will rely primarily on imported coal (Remme et al. 2011).

When the costs of coal are considered, supercritical boilers are now cost-competitive with, or cheaper than, subcritical boilers. According to one source, supercritical plants in India cost only 2 percent more to install than modern subcritical plants, and the incremental difference in capital costs can be offset by greatly reduced variable fuel costs over the life of the project.[15] Other studies have similarly found that supercritical technologies entail no additional costs over subcritical (Bhushan 2010), and that supercritical units can actually deliver electricity at lower cost over their operating lifetime (MIT 2007). Indeed, India's planned Ultra-Mega Power Plants are expected to produce power at tariff rates well below those that are economically feasible from subcritical plants, due to their operational efficiency and economies of scale.[16]

Aside from reduced coal consumption, supercritical technology also offers considerable advantages over subcritical, including larger boilers due to improved plant efficiency and fuel tolerance; reduced ash production and pollutant emissions; and better operational performance (Gupta 2008). These reasons have led India's National Thermal Power Corporation (NTPC) to switch to supercritical technology for its larger boilers.[17]

NTPC is the largest state-owned power company in India. It operates nearly 27 GW of coal-fired capacity[18] – over a quarter of India's total.[19] As early as 2008, it had already adopted supercritical technology for units over 500 MW, and was moving towards even higher steam parameters (ultra-supercritical) for upcoming projects.[20] At that time, NTPC already had six 660 MW units of supercritical technology in advanced stages of construction, and orders

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[13] "CIL readies war chest for acquiring overseas mines," *The Asian Age*, available at http://www.asianage.com/business/cil-readies-war-chest-acquiring-overseas-mines-082.

[14] However, Coal India has expressed its intent to more closely align its prices with world markets, as demonstrated by raising prices by 12 percent in February 2011. "CIL to hike coal prices by 15 pc from tonight," *Times of India*, February 26, 2011, available at http://articles.timesofindia.indiatimes.com/2011-02-26/india-business/28636394_1_coking-coal-coal-production-cil. While this price hike excluded the power sector, future price hikes are expected to cover all sectors: http://articles.economictimes.indiatimes.com/2011-03-16/news/28697785_1_price-hike-salary-hike-cil.

[15] Boben Anto, M.M. Hasan, undated. *Analysis of Supercritical technology in Indian Environment and Utilizing Indian coal*, at 113 "Fire without smoke making the switch (supercritical technology considerably lowers the costs of coal based power generation)," *India Business Insight*, Aug. 29, 2007.

[16] *See, e.g.*, "Rs 1.19 per unit tariff feasible: Shahi," *The Press Trust of India*, Dec. 19, 2006, which notes: "Government today said the Rs 1.19 per unit tariff proposed by Lanco Infratech for the 4,000 MW Sasan Ultra mega power project is feasible…'Super critical system gives you an advantage of fuel input and cost of power which has helped lowering the tariff,' he said."

[17] Supercritical boilers are a "mature and established" technology that use materials that are "proven and already in use" and equally as available as subcritical. Moreover, NTPC also has concluded that project implementation and operations and maintenance are "essentially [the] same as subcritical." Gupta (2008, pp.10, 13).

[18] http://www.ntpc.co.in/index.php?option=com_content&view=article&id=96&Itemid=175&lang=en.

[19] Ministry of Power, Government of India. "India Electricity Scenario: Power Sector at a Glance", available at http://www.powermin.nic.in/.

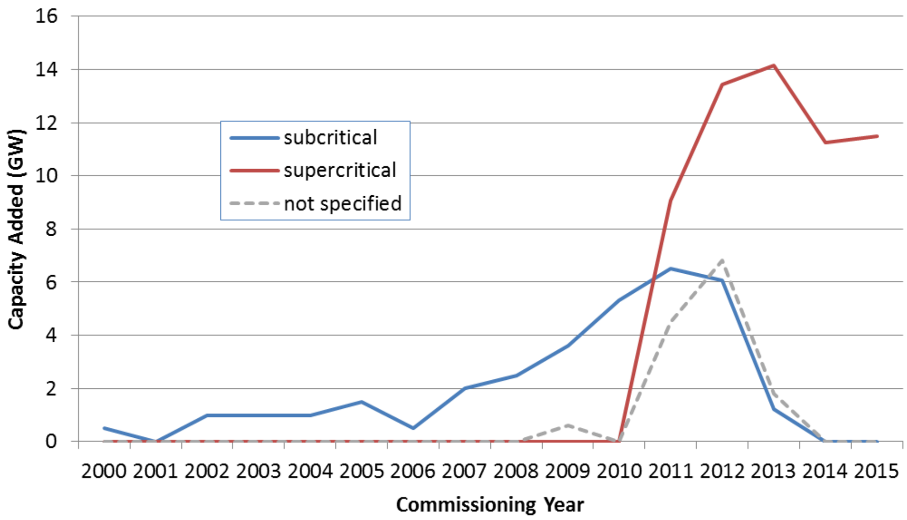
[20] Gupta (2008).

placed for two more.[21] It also had seven other 660 MW units and sixteen 800 MW units "upcoming."[22]

Since the partial deregulation of the power sector in 2003, private-sector actors are playing a greater role in power plant development. Yet they have invested minimally in subcritical coal projects (only 1,120 MW of subcritical coal generation in all of India) and have not undertaken any such projects in the last 3 years.[23]

As of 2010, India had 37 supercritical units between 660 MW and 800 MW under construction (Burnard and Bhattacharya 2011). At least two units have come online in the past 12 months, and at least 8 more with a total capacity of 5,280 MW are slated to begin operations in the next year.[24] Figure 7 shows the planned surge in new Indian supercritical coal builds in coming years and the eclipsing of subcritical technology in the process.

Figure 7. Large (over 400 MW) Indian coal plants operating, under construction, and planned by commissioning date



Sources: IEA (2011), PDD data, and author calculations. Does not include plants for which commissioning dates are not readily available; the dashed line shows plants where the technology is not specified.

The Indian government of India has driven many of these developments. Caught between persistent coal shortages, rising prices and the need to address massive power supply deficits, it has placed a "very high priority [on]…developing or obtaining the technology for coal-based plants of high efficiency."[25] India is mandating that roughly 60% of the 75 GW of

[21] Sipat-I (3x660MW) and Barh-I (3x660MW) were in advanced stages of construction, while orders had been placed for Barh-II (2x660MW) (Gupta 2008).

[22] North Karanpura (3x660MW), Tanda-II (2x660MW), Meja (2x660MW), Darlipali, (4x800MW), Lara (5x800MW), Cheyyur (3x800MW), Marakanam (4x800MW) (Gupta 2008).

[23] Det Norske Veritas, 2010. Response to request for review "GHG Emission Reductions through grid connected high efficiency power generation", at 12-13, available at http://cdm.unfccc.int/filestorage/5/L/8/5L8JTCSFON1WHYZ4KG2DPU3BE6Q0A7/3020%20RfR%20response%20DNV.pdf?t=NkV8MTMxMTE4ODIxNS43OQ==|Aat17nr3_GfKZU4WhGv-2M_yMjQ.

[24] "Media Release: Adani Power Synchronizes Country's First supercritical 660 MW unit at Mundra", December 23, 2010, available at http://www.adanipower.com/Data/APLMediaReleasefirst660Unit.pdf; "Barh 1 and II, 3,300MW Coal-Powered Plant Barh, India," http://www.power-technology.com/projects/barh-coal/ ; "NTPC's first supercritical tech unit commissioned," iGovernment, February 24, 2011, available at http://www.igovernment.in/site/ntpc%E2%80%98s-first-supercritical-tech-unit-commissioned-39347.

[25] Government of India, 2006, at 49.

thermal power contemplated in the 12th Five-Year Plan (2012-2017) be supercritical,[26] moving to 100% of new coal-fired plants in the 13th Five-Year Plan (2017-2022), as suggested by Figure 7 (Indian Planning Commission 2011). Supercritical units are likely to contribute up to 50 GW by 2020 (Remme et al. 2011).

The Indian government also mandates the use of supercritical technology for the largest power projects. The Ultra Mega Power Projects (UMPPs) – 14 projects with a minimum size of 3,960 MW each – must be based on supercritical technology.[27] Moreover, in 2009, the Power Ministry and the Coal Ministry decided to use only supercritical technology for new capacity additions wherever possible,[28] and the government is considering new policies that would give supercritical generators priority access to scarce coal supplies[29] and may remove all policy supports from subcritical plants.[30]

In summary, the combination of government policy, rising coal prices, and increasing dependence on imported coal have spurred a switch to supercritical technology. Within a few years, few, if any, new large coal plants using subcritical technology will be coming on line in India. Yet, as discussed below, all projects in the CDM pipeline claim this to be the baseline technology, even for projects not expected to be commissioned until 2015.

2.2 China

China is the world's leading coal producer, accounting for 39% of world production in 2007 (IEA 2009). Coal is also China's dominant source of energy, accounting for 63% of primary energy consumption and more than 80% of electricity generation in 2007. China's rapid pace of coal plant construction has been widely referenced; as of a few years ago, it was building the equivalent of a 500 MW coal-fired unit every 2.5 days.

In recent years, Chinese demand for coal has grown faster than domestic supply, causing increases in domestic coal prices to avoid electricity shortages, rising coal imports, and with it, greater exposure to international coal prices. While China has vast coal resources and proven reserves, extraction of these resources is still subject to several challenges, including: increasing average mining depth and associated increased costs, low resource recovery rates, location of mines in environmentally sensitive areas with limited water supplies, high mining fatalities, and long and congested transport routes (Tu 2011).

Similar to India, but years ahead, the Chinese government has turned away from subcritical technology. Given near-term production shortages and coal prices, the Chinese government decreed that coal-fired power plants be built with state of the art, commercially available – or better – technology. As a result, Chinese power companies today are building the world's most efficient coal-fired plants (Seligsohn et al. 2009).

The Chinese government has also placed a high priority on conserving coal, beginning with the energy conservation plan of 2004, which had a goal of saving 240 million tons coal

26 Planning Commission, 2011. Interim Report of the Expert Group on Low Carbon Strategies for Inclusive Growth at 37..available at http://moef.nic.in/downloads/public-information/Interim%20Report%20of%20the%20Expert%20Group.pdf

27 See, Central Electricity Regulatory Commission, Petition 128/2010; paragraph 22, 25, available at http://www.cercind.gov.in/2010/ORDER/July/signed_order_in_Pet_No_128-2010.pdf

28 International Coal Report, March 23, 2009, *Platts*, available at http://china.platts.com/IM.Platts.Content/ProductsServices/Products/intlcoalreport.pdf.

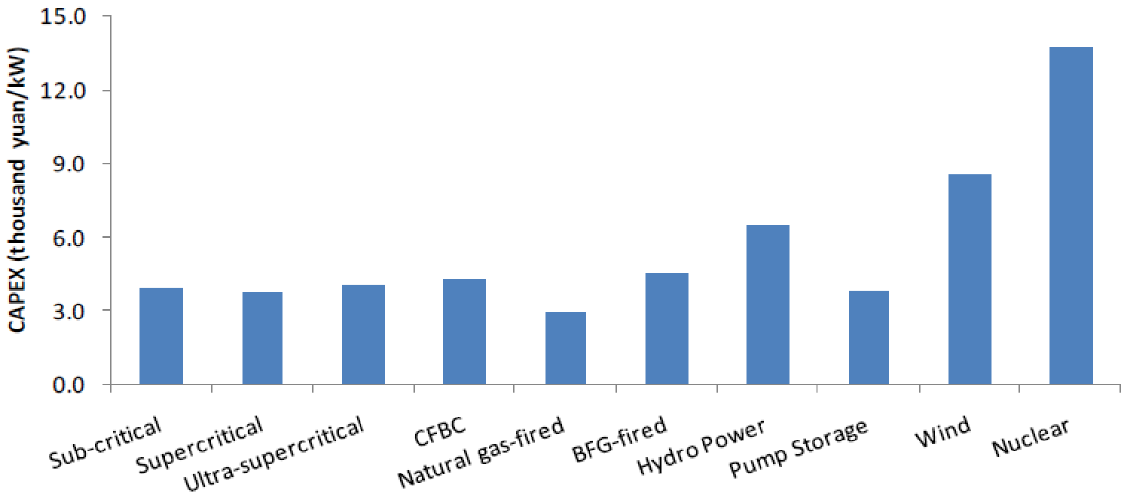
29 "Large utilities to get priority on coal supplies," *Livemint.com*, Dec. 23, 2009, available at http://www.livemint.com/2009/12/23234919/Large-utilities-to-get-priorit.html (quotes a CLP Managing director).

30 "Sub-660 MW plants face denial," *Financial Express*, Jan. 5, 2010.

equivalent by 2010.[31] The government now aims to control the growth of the coal industry and cap annual coal production capacity at 3.8 billion tons by 2015.[32] In addition, companies can receive $29-$36 for every ton of coal saved.[33] Moreover, the cost of coal accounts for 60-80% of Chinese power producers' costs. These costs cannot be passed on to end consumers due to strict regulation which, in recent years of supply shortages and rising prices, has had significant impacts on power producers' profit margins. Between 2004 and 2008, Chinese coal prices rose by 77 percent, and power-generating firms lost 70 billion yuan (7.9 billion euros) on coal-fired power generation in 2008 (Rui et al. 2010). Taken in combination, power producers have a strong incentive to economize fuel consumption by investing in more efficient coal burning technology.

Heavy emphasis on fuel savings has been a key factor in the shift from subcritical to supercritical and ultra-supercritical coal units (Tu 2011). According to the IEA, the Chinese power sector now chooses ultra-supercritical and supercritical technology for new capacity additions and the national industry policy has made 600MW supercritical and 1,000MW ultra supercritical units the standard in the coming years (IEA 2009).

Figure 8. Unit Capital Expenditures for New Power Plants, by Generation Type, China, 2006



Source: Tu (2011).

By 2007, nearly 95 supercritical and ultra-supercritical units were in operation, with another 70 expected by 2010. That same year, 60% of new coal plants in China were large supercritical units (IEA 2009). Figure 9 shows that since then, ultra-supercritical technology has begun to dominate, notwithstanding the fact that to date only one 2 GW project has been registered under the CDM, while subcritical technologies have been completely phased-out for new Chinese coal builds. Yet as noted in the next section, the majority of Chinese coal plants in the CDM pipeline have nonetheless cited subcritical technology as the most likely baseline scenario. As Figure 9 illustrates, it would appear that the last new, large subcritical

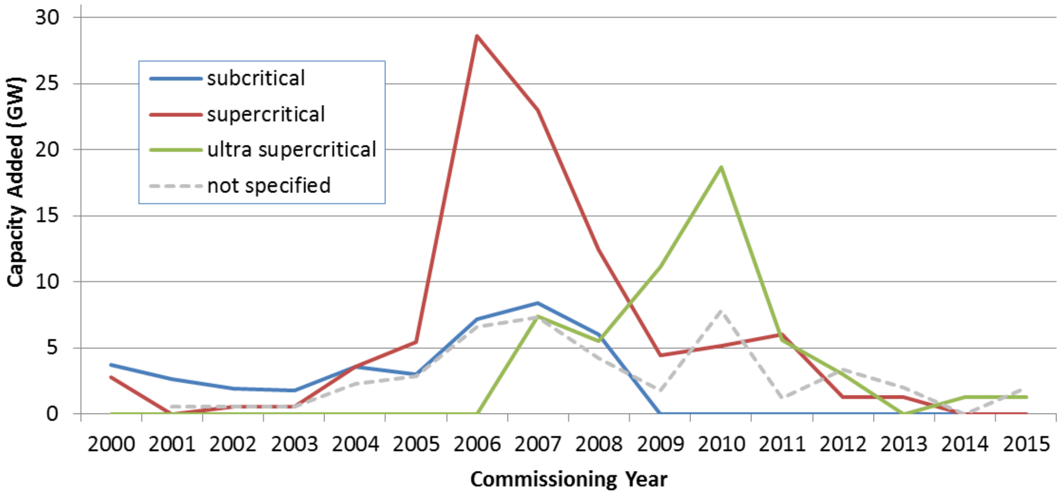
[31] JLJ Group, *China clean burning Fossil Fuel Technology*, available at http://www.israeltrade.org.cn/hebrew/The%20JLJ%20Group%20-China%20Targets%20Clean%20Burning%20Fossil%20Fuel%20Technology.pdf.

[32] The Climate Group, 2011. Delivering Low Carbon Growth: A Guide to China's 12th Five Year Plan, available at http://www.hsbc.com/1/PA_1_1_S5/content/assets/sustainability/110314_delivering_low_carbon_growth.pdf.

[33] ChinaFAQs, 2009; "China's Ten Key Energy Efficiency Projects, available at http://www.chinafaqs.org/files/chinainfo/ChinaFAQs_China's_Ten_Key_Energy_Efficiency_Projects.pdf.

unit in China was commissioned in 2008; according to available information, no such plants are planned or under construction.

Figure 9. Large (over 400 MW) Chinese coal plants operating, under construction, and planned by commissioning date



Sources: IEA (2011), PDD data, and author calculations. Does not include plants for which commissioning dates are not readily available; dashed line shows plants where the technology is not specified.

2.3 Summary

In the case of India, nearly all of the supercritical plants operating or under construction have applied for CDM funding, or indicated they intend to do so. In China, the same is true with respect to ultra-supercritical plants. However, as we have seen, the transition to supercritical and ultra-supercritical boiler designs is already well underway, if not complete. As noted here, there are many non-CDM related reasons for the move away from subcritical technologies, most notably, growing pressures on coal supplies, increasing reliance on imported coal, and growing exposure to rising international coal prices, along with greater access to, and growing experience with, supercritical and ultra-supercritical technology by Indian and Chinese boiler manufacturers. However, the attribution of emission reductions to CDM coal projects under the ACM0013 methodology depends heavily on the notion that subcritical technology continues to be the baseline. We explore the application of ACM0013 in India and China, and its ramifications, in the next section.

3. ACM0013 AND THE QUANTIFICATION OF EMISSION REDUCTIONS

Baseline and monitoring methodologies provide the basis for estimating the emissions reductions of a given CDM project. Prospective projects cannot apply for registration under the CDM until a methodology has been approved by the CDM Executive Board (EB) that is applicable to the type of project involved. The EB approved its first methodology, AM0001 for HFC23 destruction projects, in 2003. Four years later, the EB adopted ACM0013 (UNFCCC 2007), the first and only methodology applicable to new coal plants. This methodology is designed to promote the adoption of lower-emitting technologies for new fossil fuel power plants where, without the CDM, a power plant using the same fossil fuel would have otherwise been constructed. This latter condition is essential, as it would undermine climate mitigation goals if the CDM were to encourage the construction of, say a coal plant, where a natural gas or renewable energy facility might otherwise have been pursued.

In order to demonstrate that is the case, ACM0013: (1) requires that at least 50% of generation in the last 3 years has used this same fossil fuel, and (2) provides specific guidelines for identifying the most plausible alternative scenarios, and for determining which among them is the likeliest baseline. Compared with other methodologies, ACM0013 is laudable in a number of respects. It is designed specifically as a standardized, "top performer", technology-driving methodology, and as such, embodies features that stakeholders called for in the move toward more standardized baselines. ACM0013:

- requires a transparent analysis of the levelized cost of electricity (LCOE) of several alternative electricity supply options that determines the "most likely baseline scenario" as the option with the lowest LCOE;
- requires sensitivity analysis to "confirm that the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions (e.g. fuel prices and the load factor)" (UNFCCC 2007, p.4);
- uses the investment and sensitivity analyses, along with common practice analysis, to determine additionality using the standard additionality tool;[34]
- establishes the baseline emission rate (tCO_2/MWh) as the lowest of two options, the "most likely baseline scenario" (Option 1) and a "top performer" benchmark (Option 2), as described below. By setting the benchmark at the average emissions rate of the top 15%, this approach is more ambitious than the top 20% benchmark enshrined in the Marrakesh Accords (48c). Furthermore, unlike many other CDM methodologies (and the common practice analysis described in Section 4), the benchmark includes other CDM projects in the calculation of the baseline.

These features made ACM0013, in its design, one of the more careful and innovative CDM methodologies when it was approved in 2007. However, as with many designs, the original methodology could not readily anticipate the various permutations in its application. Subsequently, numerous issues arose in the submission of Project Design Documents (PDDs) under ACM0013. Several of these issues were addressed in the three approved revisions to ACM0013[35] (e.g. potential to award CERs for changing fuel emission factors rather than technology). Many of the other, arguably more serious concerns, are raised by critiques such as the ones submitted by the Stanford Environmental Law Clinic and the Sierra Club regarding the accuracy of additionality and baseline scenario assessments, which have not, for the most part, been addressed.[36] Most recently, in July 2011, the Methodology Panel ("Meth Panel") of the CDM Executive Board, the body charged with reviewing and recommending CDM baseline and monitoring procedures, identified potential flaws in how ACM0013 is used to determine baseline emission rates (CDM Methodologies Panel 2011).

Together, these critiques suggest that, through ACM0013, the CDM may be awarding CERs to coal projects that are not actually producing real, additional emission reductions. As shown in Table 1, the ACM0013 projects in the pipeline, if they are approved and perform as projected by the developers, will produce about 450 million CERs by 2030 – 400 million of them in India. The last column in Table 1 shows the projected average reduction in emissions relative to the baseline emissions estimated in the respective PDDs. On average, these PDDs are claiming that their projects will improve relative efficiencies, and reduce emissions, by slightly more than 11% in India and 5% in China, or roughly 10% overall. In this section, we examine how these emission reduction estimates were made, and show that they appear to

[34] (UNFCCC 2008)

[35] For the latest version of ACM0013, 4.0.0, see UNFCCC (2010).

[36] For example, http://www.cdm-watch.org/wordpress/wp-content/uploads/2010/03/annex1_comments_on_acm0013.pdf and http://www.cdm-watch.org/?page_id=2545.

greatly exceed the emission reductions that should be expected (assuming all these projects were additional).

Table 1. ACM0013 coal project pipeline and projected emissions reductions

Country	# projects	Total GW	Emission Reductions by 2030 (million tCO_2e)	% improvement against the baseline
India	32	56	400	11.2%
China	13	23	51	5.1%
Total	**45**	**79**	**451**	**9.9%**

Source: PDD data, IGES (2011), author calculations.

3.1 Determining the baseline emission rate

As noted, ACM0013 requires that projects use the lower of two baseline emission factors (tCO_2/MWh), calculated as follows:

- The Option 1 baseline emission factor is the emission factor of the "most likely baseline technology" as determined through an investment analysis. A PDD will compare a series of alternatives, typically encompassing lower efficiency coal plants as well as alternative resources such as natural gas or renewable energy. These alternatives are then whittled down to those considered "plausible". Nearly all PDDs have found that only lower-efficiency coal plants are plausible alternatives. The levelized cost of electricity (LCOE) is then calculated for the project and plausible alternatives, and the option with lowest LCOE (subject to sensitivity analysis) is considered the most likely baseline technology. All Indian PDDs have found subcritical coal technology to be the most likely baseline, while in China, 8 have found subcritical, and 5 have found supercritical, to be the baseline. In principle, the Option 1 baseline should help to ensure that projects do not gain excessive credits in the instance that the top performer baseline is not representative.
- The Option 2 baseline emission factor is the weighted average of the lowest 15% emitting units from among a cohort of plants of a similar size (+/- 50%) in a given region or country, using a the same fossil fuel category (e.g. "coal"). This emission factor is calculated for a "reference year", which is typically the most recent historical year for which data are available at the time of PDD preparation, which can be as much as 7 years prior to a given coal project becoming operational.

In contrast to the Option 1 baseline, for which project developers conduct the analysis and select the assumptions, the Option 2 baseline has in practice been determined by national authorities in India and China, who have annually conducted this calculation and published the ACM0013 baseline values for each grid region in the country.

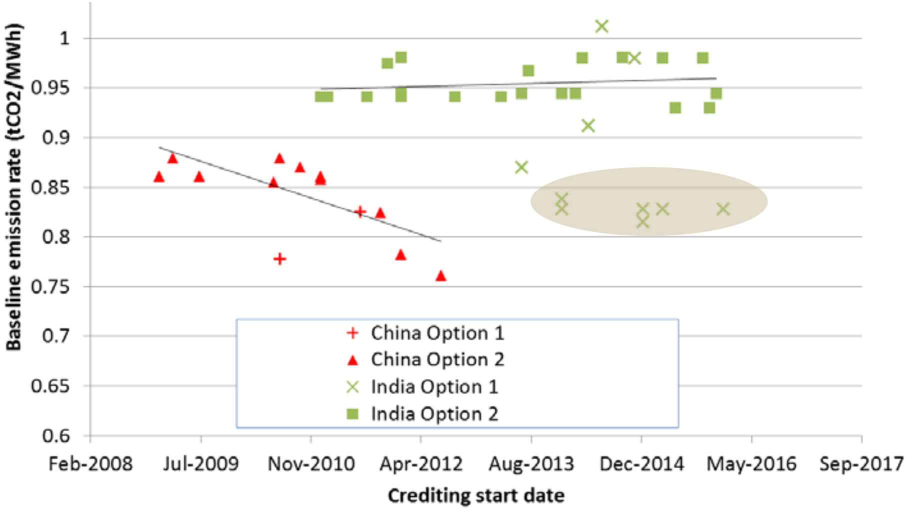
Among the 45 projects registered or under validation, Option 2 has yielded the lowest, and thus determining, baseline emission factor in about three-quarters (33) of the cases. Figure 10 shows the actual baseline emission factors put forth in the PDDs, arranged by crediting start date (a reasonable proxy for the start of plant operation), country, and option that ultimately determined the baseline emission rate. This chart illustrates the difference in the timing of Indian as compared with Chinese projects.

In the case of China, 11 of 13 projects in the pipeline are expected to be operational by the end of 2011[37], but as of October 2011, only one has been registered, calling into question the

[37] Operating date is assumed to be the reported CDM crediting start dates.

importance of CDM in investment decisions. The chart also shows a steep decline in the Chinese Option 2 baseline, reflective of the commissioning of a large number of supercritical and ultra-supercritical units in the 2003-2008 period.

Figure 10. Baseline emission rate by crediting start date, country, option, and unit size for all 45 coal projects currently in the CDM pipeline (as of October 1, 2011)



Note: Shaded area indicates PDDs that erroneously used fuel oil rather than coal emission factors to calculate the Option 1 baseline.

In contrast, in India, the first supercritical projects, after some delays, came on line earlier this year. Many projects that are not due to be operational (and start crediting) for another 3 to 4 years have already submitted PDDs. Although this does not raise the same additionality concerns as do the Chinese plants, these PDDs have effectively locked in Option 2 emission factors of plants built a decade or more prior to their commissioning. As a result, instead of a coal emission factor benchmark that decreases over time (of crediting start and project commissioning) as one might expect, the Option 2 emission factor stays roughly constant over time. All projects, regardless of timing, are using a benchmarked baseline based on a similar cohort of plants built prior to 2009.[38]

Finally, Figure 10 shows that the Option 1 baseline is used by a number of PDDs in India with later crediting dates, and the corresponding values are significantly lower than the Option 2 values used. Most of these lower emission factors in Option 1 appear to be the result of a systematic error – using the fuel emission factor for residual fuel oil rather than coal – and are indicated by the shaded area in the chart.[39]

3.2 Analysis of Option 1: Emission factor of the most likely baseline technology

A key element of ACM0013 is the baseline scenario analysis, by which plausible alternatives are compared, and the "most likely baseline technology" is determined through investment analysis (see Section 4). This analysis is used both for assessing additionality and for determining the Option 1 baseline emission rate. If done correctly, the Option 1 baseline should provide a "best guess" of the emission rate of the power plant that would otherwise be

[38] Oddly enough, the trend line in fact increases slightly over time. While this is an artifact of the regions and annual variations in plant operation, it provides all the more reason for concern with ACM0013. In fact, the same plant (Mundra) has now submitted two PDDs (the first was rejected), and its baseline emission rate increased very slightly during that time. The first PDD (Jan. 4, 2010) had a baseline emission rate of 0.941 tCO_2e/MWh while for the second PDD (June 13, 2011) it rose to 0.944 tCO_2e/MWh.

[39] To date, none of the PDDs containing this error have been registered.

built absent the CDM. However, as we discuss below, application of ACM0013 methodology has resulted in two issues of concern with the Option 1 baseline:

- the finding that subcritical is "most likely baseline technology" in all but 5 of 45 PDDs, despite the transition away from this technology as discussed in Section 2, and
- the determination of an Option 1 baseline emission rate that, in many cases, is far higher, than one would expect for a state-of-the art subcritical unit.

The first concern is most evident in China. Eight of 13 Chinese projects find subcritical plants to be the most likely baseline and thus use a subcritical emission rate for the Option 1 baseline, even though only a small fraction of new capacity since 2005 has used this technology (See Table 3). If the Option 1 baseline were to reflect supercritical technology instead, the result would be a more reasonable and conservative baseline than was used by those projects. In the majority of Chinese projects, emissions reductions projected in the PDDs (based on the difference between baseline and project emissions) exceed the emission reductions that one would expect if the Option 1 baseline had been a supercritical plant. In other words, were Chinese CDM projects to use what is arguably a more realistic "most likely baseline" of supercritical technology for the Option 1 baseline, the result would be a baseline emission rate lower than the Option 2 standardized baseline. The Option 1 baseline would then serve its purpose of providing a more appropriate baseline, in cases where the Option 2 standardized baseline is not reflective of top performing plants (see next subsection).

The second concern with Option 1 baseline emission rates –that they are unrealistically high for a given technology (i.e. subcritical)[40] – can be seen in the India project pipeline. As discussed in the next subsection, the Option 2 standardized baseline reflects the average emission factor of the top 15% of plants that came on line from 2001 to 2008. In contrast, projects in the CDM pipeline are expected to come on line from 2011 to 2015, nearly a decade later on average than the plants in the standardized Option 2 baseline. Therefore, one would presume that Option 1 baseline should reflect nearly a decade of improvement of subcritical unit designs and efficiencies, and thus the Option 1 baseline emission rate should be, in principle, lower than the Option 2 baseline. However, this is the case in only 4 of 25 India coal plant PDDs, leaving aside the 7 PDDs that erroneously use a fuel oil rather than coal emission factor.

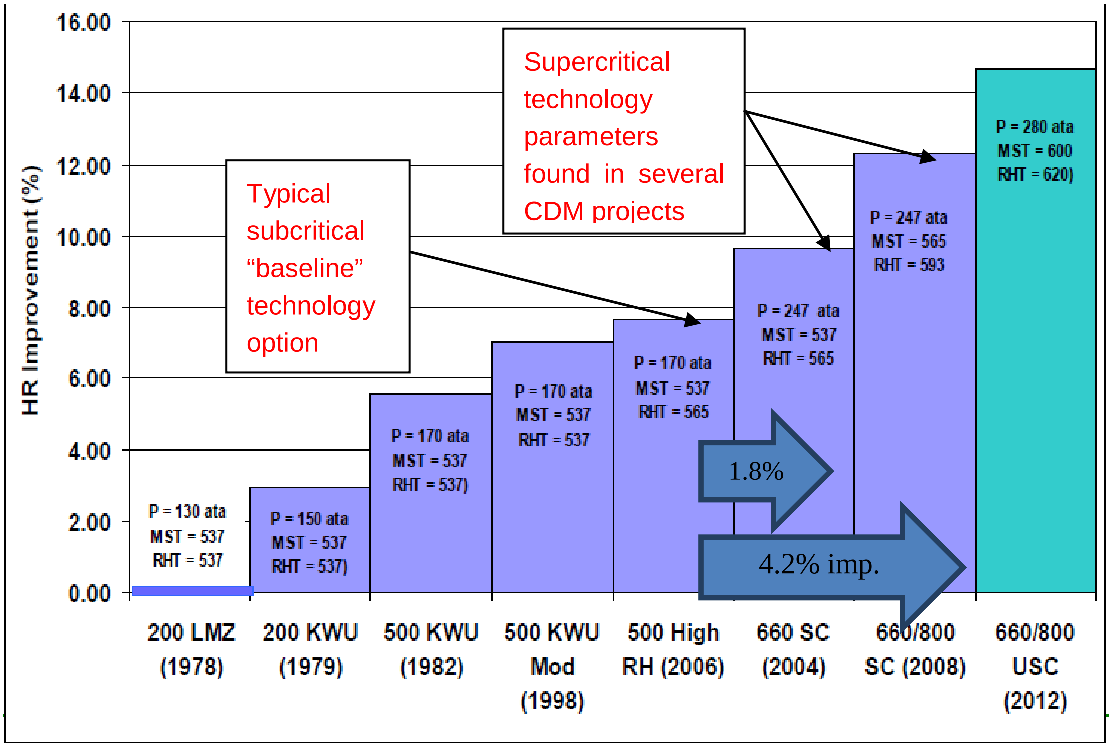
The systematic overestimation of Option 1 baselines, and as a result, of projected CERs can also be observed at the expected efficiency improvements of moving from subcritical to supercritical technology. The Option 1 baseline emission rates found in most coal project PDDs suggest an improvement well in excess of 10% in relative efficiency and emission rates. Available sources, however, suggest that currently available technology choices (or "market offerings") provide much more modest improvements. As noted in Section 2, current market offerings circa 2008 in the United States suggested an improvement of roughly 3% (Sargent & Lundy 2009).

Data provided by largest state-owned utility in India, NTPC, suggests similar levels of improvement for technologies under consideration at that time. According to a conference presentation (Gupta 2008), the move from subcritical to supercritical technology offered relative efficiency improvements and emission reductions on the order of 1.8% to 4.2%, a far lower level of improvement than indicated by baseline and project emission rates found in Indian PDDs. Figure 11 illustrates how these efficiency improvements (and emission reductions) relate to specific technology changes. Moving from state-of-the art subcritical

[40] The notable exception is where fuel oil emission factors were erroneously used instead of coal emission factors, as noted above.

technology to lower temperature (537° steam/565° reheat) supercritical boiler conditions provides a 1.8% improvement, and moving to higher temperature (565° steam/593° reheat) supercritical boiler conditions would provide a 4.2% improvement. Projects with each of these supercritical specifications are in the CDM pipeline for India.

Figure 11. Heat rate (efficiency) improvements from various coal plant technology options in India



Source: Adapted from Gupta (2008).

Therefore, if we assume for the sake of illustration that CDM projects represent an equal mix of these technologies, then the expected improvement should be around 3% rather than the 11.2% found, on average, across the CDM portfolio (see Table 1). On this basis alone, one might surmise that emission reductions of Indian ACM0013 coal projects are overstated by a factor of nearly 4 (11.2/3.0). Or, put another way, the Option 1 baseline methodology is not working as it should, limiting efficiency benefits to what one would expect. Similarly, the Option 2 “top performer” standardized baseline, as noted above, does not appear to account for the fact that supercritical projects have come to dominate new coal builds in this decade.

3.3 Analysis of Option 2: ‘Top-performer’ standardized baseline

When the CDM Methodologies Panel came to the conclusion that ACM0013 “may lead to significant over-estimation of emission reductions” and called for the methodology to be put on hold with immediate effect, it pointed to the need to revise both Option 1 and Option 2 (CDM Methodologies Panel 2011). For Option 1, it found the baseline efficiency values determined by project proponents are “rather low”, which we confirm above. For Option 2, it found serious concerns with the vintage of data used to determine the top 15% performer plants. The panel cited an example that illustrates that in many cases (especially in India), “the decision on the technology employed by the top 15% performer plants was undertaken … at least five years before the decision on the technology employed in the CDM project.”[41]

[41] CDM Methodologies Panel (2011, p.1).

As many studies have shown, and the panel concurred, coal plant technology has improved steadily over time – by 0.2% on average over the past 50 years. Thus, by introducing a time lag in plant vintages used for the baseline, Option 2 over-estimates the baseline and thus emission reductions (CDM Methodologies Panel 2011). In fact, as we note in Section 2, improvements in efficiency have likely been even steeper in recent years, as India and China have transitioned to supercritical and ultra-supercritical technology. Because of the lag time introduced by reliance on historical data, Option 2 largely neglects this transition.

Using an illustrative calculation based on the 0.2% annual efficiency improvement noted above, the Meth Panel suggested that this lag effect might lead ACM0013 projects using Option 2 to overstate emission reductions by 25% (CDM Methodologies Panel 2011). We suspect however, that the extent of overstatement may be far higher. By 2011 in India, well over 15% of new large coal capacity brought on line was supercritical, and within a few years all capacity is projected to be, as shown in Table 2. Therefore, ACM0013's top performer baseline (which includes all plants, including those that have applied for CDM) should reflect supercritical technology as of 2011 or 2012. By the logic of Option 2, only the first 15% of such capacity should be able to use subcritical technology as its baseline. As it stands, a large majority of the supercritical plants listed in Table 2 are applying for CERs using a top performer baseline that reflects only subcritical technology.

Table 2. Fraction of New Indian Coal Capacity by Boiler Technology Type, units 400 MW and larger, by Commissioning Year

Year	Subcritical	Supercritical	Ultra-supercritical	Not Specified
2005	100%	0%	0%	0%
2006	100%	0%	0%	0%
2007	100%	0%	0%	0%
2008	100%	0%	0%	0%
2009	86%	0%	0%	14%
2010	100%	0%	0%	0%
2011	32%	45%	0%	22%
2012	23%	51%	0%	26%
2013	7%	82%	0%	10%
2014	0%	100%	0%	0%
2015	0%	100%	0%	0%

Sources: IEA (2011), PDD data, and author calculations. Does not include plants for which commissioning dates are not readily available.

The situation in China is similar. As shown in Table 3, in 2005 supercritical technology dominated the new large coal plant builds. By 2009, subcritical technology was no longer being installed, and ultra-supercritical had become the dominant technology. Since it takes years to select, finance, and build these plants, decisions to go the ultra-supercritical route were likely made in the early- to mid-2000s, well before ACM0013 was approved or even seriously discussed, a point we return to in the next section on additionality.

Table 3. Fraction of New Chinese Coal Capacity by Boiler Technology Type, units 400 MW and larger, by Commissioning Year

Year	Subcritical	Supercritical	Ultra-supercritical	Not Specified
2005	26%	48%	0%	26%
2006	17%	67%	0%	16%
2007	18%	50%	16%	16%
2008	21%	44%	20%	15%
2009	0%	26%	64%	10%
2010	0%	16%	59%	25%
2011	0%	47%	44%	9%
2012	0%	17%	39%	44%
2013	0%	40%	0%	60%
2014	0%	0%	100%	0%
2015	0%	0%	39%	61%

Sources: IEA (2011), PDD data, and author calculations. Does not include plants for which commissioning dates are not readily available.

In addition to lag time, there are a couple of other concerns with the Option 2 baseline*:*

- **Lack of effective DOE oversight.** The Designated National Authorities (DNAs) in China have annually issued a brief 3-5 page document providing ACM0013 emission factors for each grid region.[42] However, the underlying data are unavailable for review. In contrast, the Indian authorities provide a rather complete database of units, efficiencies, and emission factors, which they make publicly available. However, even in this case, it is our understanding that the underlying emissions data are never examined or reviewed by Designated Operational Entities (DOEs). Moreover, no credible evaluation of the uncertainty and systemic bias associated with these factors has been undertaken. The ability to verify data quality and incorporate inherent uncertainty into the result is fundamental to the CDM process.
- **Potential bias in baseline emissions data.** Historical emissions data for the Indian coal plants may be systematically high, due to the financial incentive for plant owners to overstate fuel consumption. According to Michaelowa (2011), "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 [emission factor] by several percentage points."

Together, these concerns question the ability to implement an ACM0013 top performer baseline that is based on fully representative and well verified historical data.

3.4 An alternative estimate of potential over-crediting

As noted, in July 2011, the CDM Methodologies Panel presented a simple example indicating that the use of older projects in the Option 2 baseline calculation could lead to over-crediting on the order of 25%. Here, we consider how the concerns identified above with both Option 1 and Option 2 baseline calculations might introduce error into the estimation of emissions benefits. We conduct an illustrative analysis as follows:

- For the Option 1 baseline, we assume that all Indian projects involve the switch from subcritical technology to supercritical as described in the prior section. In fact, in

[42] See for example, http://cdm.ccchina.gov.cn/english/NewsInfo.asp?NewsId=4907.

many (if not all) cases, the appropriate baseline may be supercritical, but we make this assumption to illustrate a separate point. (See Section 4 on additionality.) While not all plant developers face the same technology choices as NTPC, we assume this switch yields the average of the emission reductions associated with NTPC's two supercritical technology options (relative to subcritical): 3%. In other words, we assume that the baseline emission rate for Option 1 is approximately 3% higher than the project emission rate, as reported in the PDD. For Chinese projects, we assume all projects involve a switch from supercritical to ultra-supercritical technology, and use the relative efficiencies (or specific coal consumption) values found in each PDD for such a switch.

- For the Option 2, we reduce the lag time in the standardized baseline by considering the top 15% of units commissioned in year the PDD was submitted for comments.[43] This change produces a cohort that is somewhat more representative of the technology options available to the project developers at the time of investment decisions. Since in India, the first supercritical plant was commissioned just this year, this refinement in the Option 2 baseline does not have much effect. It is more relevant in China, where projects have tended to submit their PDDs much closer to the commissioning dates. To simplify this calculation, we use a national rather than regional grid boundary.[44]

Applying these two modifications to ACM0013, we find a 71% reduction in CERs relative to the CERs that are projected in the PDDs, across the full CDM coal plant pipeline (See Table 4). This calculation suggests an overestimate of CERS of about 250%, a magnitude of potential error that should warrant immediate suspension of the current methodology pending adequate revision. Overall, however, as we discuss next, the challenge of distinguishing the "signal" of small efficiency improvements from the "noise" of other situational factors may defy a simple standardized approach for CDM coal projects.

Table 4. Cumulative CERs across project lifetimes, PDD estimates vs. alternative baseline calculation (million CERs)

	PDD	Alternative Baseline	Difference
India	400	107	-73%
China	51	25	-51%
Total	451	132	-71%

3.5 Signal-to-noise: Variation in other, non-technology factors

The intention of ACM0013 "is that emission reductions are only claimed due to the higher efficiency of the power generation technology".[45] For this reason, ACM0013 was revised in 2010 to avoid the potential to inappropriately gain CERs "from using fuel types with lower CO_2 emissions factor" in the project than in the baseline (e.g. anthracite vs. lignite coals). The methodology now requires that the same emission factor be used for both baseline and project

[43] In practice, such a baseline would require an ex post assessment, since data for a given year won't be available until a year or two later. We are not necessarily suggesting that this approach be used for ACM0013; rather we are using it for illustration of the baseline that would result from using a more appropriate cohort.

[44] It is not clear in which direction this simplification would affect the baseline emission factors. It is also not clear whether use of a regional rather than national cohort is justified. While there may be regional factors that affect the ability to adopt new technologies (e.g. available coal quality), technology development and availability tends to be more of a national level question.

[45] Clarification for Computing the emission reductions - Sasan Power Ltd.: AM_CLA_0173 http://cdm.unfccc.int/methodologies/DB/4WI60R4AYL8NRPAPIVSWTRK4C6EVBQ/view.html

emission calculations. However, this revision did not address the fact that by switching to higher-quality coals at a given power station, efficiency could be improved, without changing the power generation technology itself (IEA 2010a). In India, according to the Central Electricity Authority (CEA), "imported coal may lead to a higher boiler efficiency by 2-3 percentage points, thus lowering the unit heat rate of about 50-75 kcal/kWh."[46]

Indeed, in addition to electricity generation technology (e.g. super vs. subcritical), coal unit efficiency is influenced by a wide range of site, environmental, and market factors. These include cooling water temperature, the use of pollution abatement equipment, and the moisture, ash, and sulfur content of the fuel. In India, as noted earlier, domestic coal is relatively inefficient due to high ash content, and coal plants are increasingly using higher quality, imported coal (Central Electricity Authority 2010).

ACM0013 neither fully controls for this effect, nor does it account for the fact that sulfur dioxide and particulate controls (flue gas desulfurization, fabric filtration, etc.) can increase net heat rates and CO_2 emissions. Table 5 lists efficiency correction factors that the IEA recommends for the comparison of coal plant efficiencies to account for various conditions and factors. As can be seen, coal unit CO_2 emission rates and heat rates (which are inversely related to efficiency) can vary by:

- 2.9% based on cooling system type
- over 2% based on flue gas cleaning (since some technologies can be deployed in combination)
- 1.5% for a difference of 10 degrees C in ambient temperatures, such as might be found between high elevation and coastal areas in a given region
- 1% or more as the result of differences in fuel quality (sulfur, ash, and moisture content).[47]

The combined effect of the external and controllable variables listed in Table 5 – 7% or more – can have as much or greater impact on plant efficiency than the choice of boiler technology (e.g. 2-4% for subcritical vs. supercritical) that is the objective of ACM0013.

This creates a major signal-to-noise problem with respect to the use of a standardized baseline for coal plant efficiencies (Option 2). To avoid variations in extraneous factors overwhelming the measurement of boiler technology improvements, the methodology would need to control for each of these other "noise" variables for the project and the other plants used for the baseline calculation. This would be challenging, as some of the variables are not fixed over time. Fuel quality, for example, can vary from year to year. Furthermore, simply collecting and verifying plant fuel consumption data has proven challenging enough; doing the same for environmental controls, cooling technologies, and fuel quality across plants would be a daunting, and arguably infeasible task.

[46] The switch to imported coal can occur without changing the "type" of coal. For example, coals from both India and Indonesia, the principal source of India's imported coal today, can be classified as bituminous (CEA 2008).

[47] For example, Indian coal can be over 30% higher in ash content than Indonesian coal: http://www.productivity.in/knowledgebase/Energy%20Management/c.%20Thermal%20Energy%20systems/4.1%20Fuels%20and%20Combustion/4.1.3%20Properties%20of%20Coals.pdf

Table 5. IEA recommended heat rate correction factors for comparing coal plant efficiencies (for a reference plant operating at 80% load)

Technology/Parameter	Correction Factor: Change in Heat Rate (and CO_2 emissions rate)
Cooling system type (relative to closed-circuit, wet tower)	
Seawater (once-through)	+2.4%
River water (once-through)	+1.5%
Closed-circuit, dry tower	-0.5%
Flue gas cleaning	
Wet FGD (compared with no FGD)	+2.0%
Dry FGD (compared with no FGD)	+1.0%
LNB and OFA	+0.5%
SCR	+0.5%
Bag filter (instead of ESP)	+0.5%
SNCR	+0.3%
Fuel quality	
Sulfur content	+0.3% per 1% increase in S
Moisture content	+0.01% per 1% increase in H20
Ash content	+0.03% per 1% increase in dry ash
Ambient temperature	+0.15% per 1 °C increase

Source: IEA (2010a). Key to abbreviations: FGD = Flue Gas Desulfurization; LNB = Low NOx Burners; OFA = Over Fire Air; SCR = Selective Catalytic Reduction; ESP = Electrostatic Precipitator; SNCR = Selective Non-Catalytic Reduction.

Because ACM0013 does not control for such "noise" factors, it is not possible to determine whether a plant that claims CERs under the standardized baseline (Option 2) actually reduces emissions.[48] Moreover, because the addition of sulfur and particulate emission controls can reduce net efficiencies, ACM0013 may have the unintended effect of penalizing projects that minimize local air pollution impacts, if plants included in the standardized baseline calculation have not implemented similar controls. Conversely, it could reward projects that do not mitigate local air pollution impacts if plants in the Option 2 baseline have generally implemented pollution controls. This perverse outcome would run contrary to the sustainability objectives of the CDM.

Finally, uncertainty and annual variation in emission factor data may present an additional source of "noise" that needs to be accounted for in the estimation of emission reductions in ACM0013. This is discussed in Box 1 below.

[48] Local factors (cooling and pollution controls technologies and ambient temperature) are less of a concern for Option 1 baselines, assuming the appropriate baseline is a coal plant built at the same location with the same output and under the same local requirements. However, Option 1 does not account for the fact that with the added incentive of CERs, a coal plant operator might purchase coals with higher efficiency characteristics than otherwise. While a fuel quality improvement might lead to actual emission reductions in the plant, ACM0013 is not intended to account for such reductions. For example, it would need to account for potential supply constraints on higher quality coals, and related leakage potential, as in blended cement methodologies and their treatment of cement substitutes.

Box 1. Variation and uncertainty in coal unit emissions data: Another signal-to-noise concern?

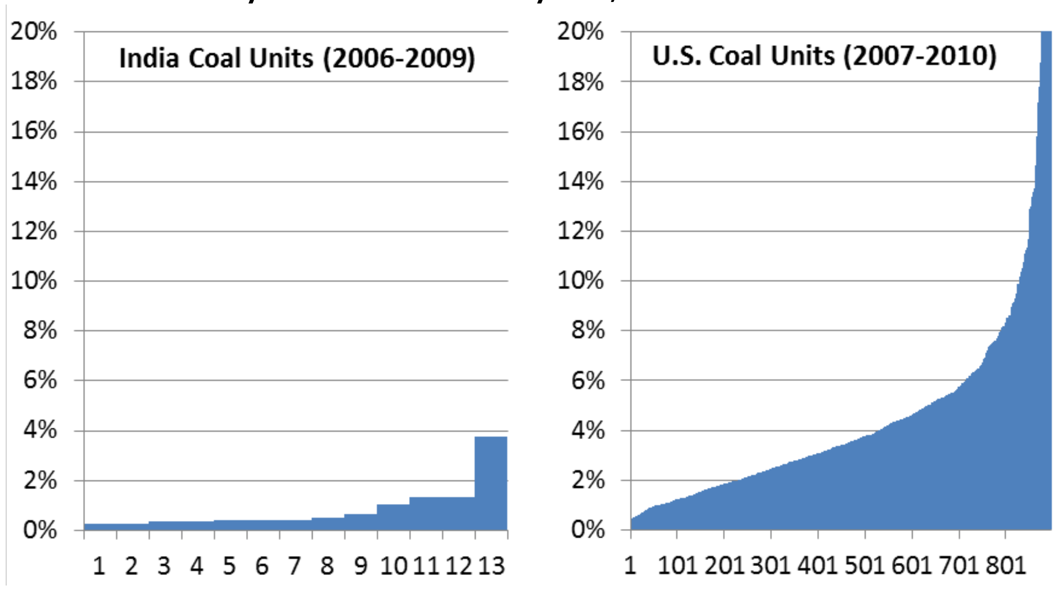
Another potential concern with ACM0013 is the potential magnitude of uncertainty and annual variation in emission factor data (noise) relative to the emission reduction (signal) from the CDM project activity. The Indian Central Electricity Authority produces an annual database of unit emission factors, a notably transparent resource for analyzing emission rates and developing emission baselines. (We are unaware of any similar database readily available from Chinese authorities.) As shown in the figure below, the annual variability of India coal unit emission factors -- expressed in terms of the coefficient of variation or standard deviation relative to the mean value -- is quite low. Surprisingly, the annual variation is 1% or less for over half of the 13 Indian coal units for which continuous data are provided from 2005/6 to 2008/9 in the CEA database.

In contrast, this figure shows that there is far greater variability across coal units in the U.S., where detailed on-site measurements are available a large number of facilities. The median annual variability of the U.S. coal units shown is on the order of 4%, and exceeds 10% for many. We cannot fully explain why the variation in emissions data is so high in the U.S., where continuous CO_2 emissions monitoring systems are in place, and so low by comparison in India. As noted above, Indian coal plant data on fuel consumption are self-reported and may be subject to systematic bias.

Annual variations in coal plant emission rates can be expected from changes in coal quality as different coal seams or mines are sourced for a given unit, or as units are subject to differing operational conditions or repairs. Coal consumption or emissions measurements are also subject to their own uncertainties depending on the methods used.

Currently measurement uncertainties and annual variations are not accounted for in ACM0013, either in the calculation of the Option 2 standardized baseline or in the monitoring of project emissions. However, if the U.S. coal plant data are a good indication, such uncertainties and variations could be of a similar magnitude as the relative emissions reductions from higher-efficiency coal unit technologies, and warrant further analysis and consideration.

Four-Year Variability in Emission Factors by Unit, India and U.S.



Source: India's Central Electricity Authority (2011) for India coal unit emission factors; only values for the 13 units with more than two years of reported data are shown. U.S. Environmental Protection Agency EGrid data for U.S. coal units (only data for plants with single units included), as available at http://epa.gov/cleanenergy/energy-resources/egrid/index.html, provided courtesy of Bruce Buckheit, independent consultant.

3.6 Summary

ACM0013 remains a notably innovative methodology: it has provided an example of how project-specific and standardized baseline approaches in principle could be combined to yield a methodology that encourages ever-increasing efficiencies. It has also provided an important laboratory to expose some of the pitfalls in practical application. Still, it has a number of shortcomings. Reliance on outdated historical data (in the standardized Option 2 baseline) can conceal the presence of a rapid technological shift, e.g. away from subcritical technology, that is occurring ostensibly for non-CDM reasons. Project proponents can exaggerate the benefits of technology improvements in the project-specific (Option 1 baseline) analysis leading to major overstatement of the benefits of switching from subcritical to supercritical technologies. Together, these effects may lead to over-crediting of CERs by about 250%. Finally, while the ACM0013 methodology seeks to detect improvements in boiler technology, and credit CERs accordingly, this signal can be overwhelmed by variation in fuel quality, environmental controls, and ambient conditions, factors not controlled for by the methodology. Together, these shortcomings could be very challenging to address through the revision process.

4. ADDITIONALITY AND ACM0013 COAL PLANTS

In this section, we further examine the issue of additionality, i.e., whether the CDM really was pivotal in the decisions to proceed with the technologies used in ACM0013 coal plants, or whether these technologies likely would have been used even without the prospect of CDM support. In doing so, we look at the question of additionality broadly, not merely whether projects have followed the required procedures in demonstrating additionality. While there are shortcomings in the assessments provided in the PDDs – a Stanford University report in 2010 found that "all projects fail in significant ways to comply with the [ACM0013] methodology" (Mills Legal Clinic 2010) – there are also limitations to the procedures themselves.

Like most CDM project methodologies, ACM0013 applies the standardized "tool for the demonstration and assessment of additionality" (UNFCCC 2008), with three basic steps. First, the project proponent must identify alternatives to the project activity. Second, it must conduct an investment analysis or barrier analysis to prove the project would not otherwise proceed, either because it is less economically or financially attractive or because it is impeded by greater barriers than other alternatives. Third, it must undertake a common practice analysis to provide a "credibility check" to ensure that the type of project activities is not already commonly implemented.

ACM0013 also provides additional guidance for the identification and analysis of alternatives. It requires use of investment analysis and calculation of the levelized cost of electricity production (LCOE) in $/kWh in order to determine the most plausible / "most economically attractive" baseline scenario. As noted in Section 3, this analysis is used to determine the emission rate for the Option 1 baseline. Though not required to do so, all ACM0013 projects also use this LCOE-based investment analysis to claim additionality.[49] In all cases, PDDs for ACM0013 coal plants have argued that a less-efficient coal plant of similar capacity is more economically attractive than the project activity. All Indian projects, and most Chinese projects, have argued that subcritical technology is the most economical technology, even though, as noted in Section 2, large subcritical units are (to our knowledge)

[49] They could instead use barrier analysis or conduct investment analysis against a benchmark, which at least one project does in addition to the LCOE analysis.

no longer being built in China, and in India, have become less common than supercritical ones. This raises two questions: Are the alternatives analyses comprehensive? And, are the investment analyses robust and credible? While one can examine the former question,[50] here we focus on the latter.

The investment analyses conducted for the coal projects in the CDM pipeline typically find relatively small differences in LCOE between the proposed project and its less efficient alternative, sometimes on the order of as little as 2%. As a result, the LCOE analysis can be very sensitive to inputs such as construction costs, fuel costs or load factors, and minor variations in these parameters could alter the determination of additionality. Sensitivity analysis is especially important given that assumptions for these parameters are made by project proponents in the development of their PDD, and there is often a range of reasonable sources for these assumptions such as engineering studies, historical data, or alternative forecasts. This makes it especially difficult for the verifiers, or Designated Operational Entities (DOEs), to question these assumptions, and to ensure that they are consistent and unbiased.

While the additionality tool and ACM0013 require sensitivity analyses, the sensitivity analyses we examined failed to properly consider a "reasonable variation in critical assumptions" as required by the these methodologies. In the PDDs, construction costs are rarely, if ever, compared to independently published figures by different entities for similar projects in the country and around the world. Fuel prices are typically varied by only 10%, even though fuel price projections are notoriously uncertain, and coal prices have surged in recent years by far more than 10 percent (see Section 2).

Sensitivity analyses also fail to consider *independent* variation in key parameters: all comparisons use the same percentage increase or decrease across alternatives (e.g. increase load factors 10% for *both* the project and alternatives). While identical variation makes sense for some parameters, such as fuel prices, that are independent of project technology, for others, it does not. It is conceivable for example that a more efficient plant might have a higher load factor due to lower operating costs or lower emissions. Under China's 2007 energy-saving approach to power dispatching, for example, more efficient plants receive priority access to the grid.[51] In one case, a load factor 3% higher for the project than for the alternative coal plant would render the project more economically attractive (Mills Legal Clinic 2010, p.15). Similarly, the difference in construction costs between subcritical and supercritical plants may vary among sources, and thus sensitivity analysis should consider such variations.

Furthermore, investment analyses typically lack systematic consideration of revenues. The LCOE analysis required by ACM0013 calculates the cost of electricity generated by alternative baseline options. LCOE analysis can readily incorporate some types of additional

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50 Under ACM0013 and the Additionality Tool, plausible alternatives must include "all possible realistic and credible alternatives…i.e. all type [sic] of power plants that could be constructed as an alternative." Alternatives need not be easy, cheap, or very likely, only plausible. For project participants, this means that they may not reject an alternative simply because it is less likely to be implemented (e.g., due to cost). Project participants routinely dismiss renewable energy alternatives with little or no documentation or explanation and never consider energy efficiency as an alternative to supply expansion.

51 http://www.gov.cn/zwgk/2007-08/07/content_708486.htm. See also Regulatory Assistance Project, *China's Power Sector: A Backgrounder for International Regulators and Policy Advisors*, Feb. 2008, available at http://www.raponline.org/docs/RAP_ChinaPowerSectorBackground_2008_02.pdf: "The rule modifies the current practice of dispatch based on average total cost (i.e., contract price) to one based on the environmental (primarily emissions) impacts and thermal efficiencies of the units. The dispatch, or loading, order of units calls for the operation of non-emitting resources first, then by low-emissions resources, and, lastly, the highest emitting units."

revenues, such as tax credits, if they are available. However, it cannot readily account for the core source of revenue, i.e. the tariff paid by utilities or local authorities. Typically LCOE analysis presumes that the tariff revenue is the same (in $/kWh) regardless of the supply alternative. However, different generation alternatives may face different tariffs, based on their operational characteristics (e.g. ability to follow load) or specific government policies, such as feed-in tariffs or price controls.[52] In some cases, projects subject to competitive bidding may have options to bid for lower or higher rates. In fact, one reason behind the Executive Board's decision not to register the Tata Mundra project as originally submitted was because it "had not considered a tariff that would enable it to achieve its ROE benchmark and implement the project activity without considering CDM revenues".[53] The Executive Board also has recently initiated reviews of two other requests for registration by Indian supercritical projects, in part because they did not consider alternative tariffs or provide a sensitivity analysis of the proposed tariff.[54]

Perhaps the most troubling element of the additionality assessment is the treatment of common practice. Common practice analysis is intended as a "credibility check" to determine whether "the proposed project type (e.g. technology or practice) has already diffused in the relevant sector and region" (UNFCCC 2008, p.10). As shown in Section 2, ultra-supercritical technology is already diffused and widely implemented in China, and a similar situation exists for supercritical technology in India.

Part of the problem lies with the common practice test itself, which requires that "other CDM project activities (registered project activities and project activities which have been published on the UNFCCC website for global stakeholder consultation as part of the validation process) are not to be included in this analysis" (UNFCCC 2008, p.10). There is a rationale for this exclusion, and in some cases, it makes sense. Where CDM is truly required for projects to proceed, including CDM projects would undermine support for all but the first few.

The situation is significantly different if a majority of projects are non-additional, but all are nonetheless applying for CDM. This would be the case, for example, where a transition to more efficient technologies is already underway, such as from CRT to LCD monitors, or as suggested here from subcritical to supercritical and ultra-supercritical boiler technology, for reasons other than CDM support. All such projects would be automatically excluded from the common practice analysis even if few have yet to be deemed additional and successfully registered. But by virtue of nearly all such activities applying for CDM, the common practice test cannot serve as an effective credibility check, since all projects will pass even if few or none are additional. Indeed, this appears to be the case for ACM0013 coal projects.

Addressing this weakness would require changes to the common practice test to enable distinction among the two situations described above: one, where exclusion of CDM projects from consideration is warranted, and the other where it is not. For example, where the project

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[52] The role of government policy in additionality determination is complex, guided by the so-called E+/E- framework. The EB has yet to take a comprehensive position on how to address some policies such as feed-in tariffs.

[53] Executive Board of the Clean Development Mechanism, Report of Fifty-Fifth Meeting of the Executive Board of the Clean Development Mechanism, 10 July 2010, p.13

[54] Registration Request for Review: Greenhouse Gas Emission Reductions through Super Critical Technology - Jharkhand Integrated Power Ltd. (4629), available at http://cdm.unfccc.int/Projects/DB/TUEV-RHEIN1301452084.68/Review/QHZKRH4KHWRXTR5711DV4J3PE9PFBV/display; this project was subsequently registered. Registration Request for Review: Project: 4807 Energy Efficient Power Generation by Nabha Power Limited, available at http://cdm.unfccc.int/Projects/DB/RWTUV1305574742.42/history As of October 26 2011, this project is still under review.

technology is much less economically attractive than the baseline alternatives, exclusion may be warranted; however, where there are no decisive barriers that differ among the project and its baseline alternatives or large differences in economic returns, the case could be made to include CDM projects in the baseline. While the CDM Executive Board recently approved changes to the common practice definition, under the new definition, all CDM projects are still included.[55]

Finally, it is worth noting many ACM0013 coal projects have been either completed or are well into construction prior to being approved for CERs. For example, the Guangdong Pinghai project is currently seeking registration and has already been completed. The Tata Mundra project continued construction after its original application for CDM registration was denied, is now about 83 percent complete,[56] and is slated to begin delivering power in early 2012.[57] Its second application for CDM registration is now at validation stage. While these facts do not disqualify such projects from the CDM, they do further question the importance of CERs in making project decisions.

In summary, there are several reasons to question the additionality claims of many ACM0013 projects, particularly in their investment and sensitivity analyses. Most importantly, however, we find the additionality procedures, in particular the common practice test, are not appropriate for the situation encountered with coal technologies in India and China. Supercritical and ultra-supercritical technologies have become common practice in India and China, and the additionality test does not function in a manner that detects this fact.

5. DISCUSSION

5.1 CDM coal plants in the climate change context

Because of its abundance and low cost, coal has been the fuel of choice for many industrializing countries throughout the past two centuries. Coal plants generate over 40% of the world's electricity, and much larger shares in India (70%) and China (80%).[58] However, high dependence on coal has come with serious social and environmental consequences. In addition to the toll of coal mining on human health and local communities, coal use is a leading cause of climate change and local air pollution: in China, coal combustion now accounts for 70% of particulate emissions, 90% of sulfur oxide, and two thirds of nitrous oxide and CO_2 emissions (Sims et al, 2007). Coal ash, the residue of combustion, is now the number one source of solid waste in China, resulting in toxic ash dust storms as witnessed this spring in Beijing.[59]

The continuing rapid expansion of coal power presents one of today's greatest challenges in reversing the growth in global greenhouse gas emissions. Over the past 30 years, the power sector has been the largest contributor to growth in global CO_2 emissions,[60] with most of this growth due to new coal-fired power plants. According to IEA projections, coal power is poised to continue as the leading source of growth in CO_2 emissions. Absent new policies, the

[55] Executive Board of the Clean Development Mechanism, Meeting 63, Annex 12.
[56] Tata Power, 2011. *Investor Presentation July 2011*, at 16, *available at* http://www.tatapower.com/investor-relations/pdf/investor-presentation-july-2011.pdf
[57] See http://articles.economictimes.indiatimes.com/2011-10-05/news/30246808_1_mundra-project-mundra-umpp-transmission-network
[58] http://www.worldcoal.org/resources/coal-statistics/
[59] See www.greenpeace.org/raw/content/international/.../true-cost-coal.pdf.
[60] See Sims et al. (2007), Figure 1.2 from Contribution of Working Group III to the IPCC Fourth Assessment Report.

IEA projects, 670 GW of coal-fired capacity will be added from 2008 to 2020 (IEA 2010b).[61] This increase translates to 2.7 $GtCO_2e$ in added annual emissions from coal power, and 43% of the global growth in energy-related CO_2 emissions.

In contrast, IEA's scenario that aims to maintain global warming within 2 degrees (450 scenario), shows that this growth in coal plant capacity from 2008-2020 would have to be reduced by one-third, despite the fact that much of the capacity is already operational or under construction. The IEA 450 scenario foresees a 707 GW drop in global coal capacity from 2020 to 2035, including declines in China and India of over 340 GW, to total coal capacities below 2008 levels. In other words, recently built coal plants would need to be shut down well before the end of their economic lifetimes. Thus, if one takes the Cancun Agreements' 2°C goal seriously, it makes little sense to build new coal plants (at least without carbon capture and storage). Coal plants represent major, long-lived investments in the highest emitting of electricity sources: even at ultra-supercritical efficiency levels, coal plants produce twice the emissions of a new natural gas plant. Supporting the construction of these plants with climate finance such as credits from the CDM, even if it leads to slightly more efficient technologies, may run counter to the aims of the Cancun Agreements, and the goal of limiting dangerous interference with the climate.

As we have shown in this paper, it is unlikely that the CDM has had a significant, if any, effect on the rate and type of new coal plant builds. Despite this, a sizeable amount of carbon finance and institutional support is being directed towards these coal plants. If all coal projects in the ACM0013 pipeline are approved and generate nearly 400 million CERs by 2020 as projected, this could amount to 4 billion euros in CER revenue at a price of 10 euros per ton.

This raises a fundamental question of whether and how carbon finance should be directed to the coal power industry. Given the pivotal role of new coal plants in the rapid growth of global CO_2 emissions, it is worth considering whether an offset-based, incentive-only system such as the CDM should to be used support coal investments that at best offer only marginal improvements in emission rates, while locking in over 400 million tons per year in GHG emissions, as much as the current CO_2 emissions of countries such as France, Spain and South Africa (UNEP Risoe Center 2011; IGES 2011; World Resources Institute 2011).[62] This question is even more relevant in light of the sustainable development objective of the CDM, and the significant health and environmental burdens associated with coal use.

5.2 Coal plants and standardized baselines in the CDM: Methodological challenges

A rapid technology transition presents some dilemmas for standardized baselines. How does one determine which project proponents are the early adopters and thus top performers with the 15% who should be credited? If an entire sector is shifting technology, is it appropriate to reward some actors and not others, especially if it were based upon dates of document submission? Are historical rates of efficiency improvement appropriate when change is discontinuous, as is often the case with a shift in technology? How does one appropriately account for the fact that investment decisions are made several years in advance of plant commissioning?

[61] Figures here are drawn from IEA's current policies scenario.
[62] National emissions are for energy-related CO_2 in 2007 (not including land-use change & forestry or international bunker fuels).

These questions are fundamentally difficult to address. Furthermore, the stakes associated with coal plants from climate change and sustainability perspectives are particularly high, in contrast to most other CDM project types. As a result of these factors, as well as the signal-to-noise problem, we suspect that it may be exceedingly difficult to revise ACM0013 in a manner that finds an appropriate balance between rigor, conservativeness, and incentives for project developers.

Is ACM0013 distinct from other standardized baseline methodologies such as ACM0002 that are subject to significant uncertainties and potential bias problems?

The same concerns regarding additionality apply to both, particularly in the case of large project investments that are less likely to rely on CDM to proceed. While ACM0002, the widely used, standardized methodology for renewable energy projects,[63] presents concerns similar to ACM0013 regarding the accuracy of the baseline emission factor, in ACM0013 the lag time between project and baseline plants, and the impact of uncertainty and errors is greatly attenuated by the much larger difference between project and baseline emissions rates. With renewable energy projects in ACM0002, a 5% variation in the baseline emission rate, say between 0.85 and 0.80 tCO_2e/MWh, would result in a difference of about 6% in the amount of CERs generated, since the project emission factor is typically 0 tCO_2e/MWh. However, in the case of ACM0013, the same variation in baseline emission rate, would yield a much larger difference in CERs, approaching 100% if the project emission rate were close to the lower end of the (uncertainty) range (0.80 tCO_2e/MWh). Even though the range of uncertainty is likely to be smaller with ACM0013 than ACM0002, given that the fuel type (coal) does not vary in the baseline cohort, the “signal-to-noise” ratio is inherently far lower in ACM0013.

Would the same concerns regarding low signal-to-noise ratio also apply to other standardized baselines for other sectors?

They could. Our analysis of ACM0013 shows that historical data can be a poor basis for establishing appropriate baselines, especially amid ongoing technology change. It also suggests that methodologies need to control for factors such as feedstock or fuel quality or pollution controls, that could otherwise lead to attribution of emission reductions for reasons other than intended project activity (e.g. higher efficiency technology), or conversely, the underestimation of actual emission benefits. In sectors where technological change is ongoing, such as the coal power sector in India and China, methodology developers should consider standardized baselines that are based on dynamic assessments of where a sector is headed under business-as-usual. While this type of assessment may require expert judgment, it may prove more robust than the alternative of relying on historical data that is not adequately representative of future actions and trends (and on judgment-based stringency thresholds, such as the 15% (ACM0013) or 20% (Marrakech Accord) percentiles).

5.3 Coal plants, NAMAs, and market mechanisms

Shouldn’t government policies that require higher-efficiency investments be recognized and rewarded?

India requires supercritical technology for all UMPPs, and China provides priority dispatch for more efficient facilities. These indeed are positive measures in terms of GHG emissions and local air pollution. Furthermore, both India and China have made emissions pledge-based Nationally Appropriate Mitigation Measures (NAMAs) under the Copenhagen and Cancun

[63] Consolidated baseline methodology for grid-connected electricity generation from renewable sources, available at: http://cdm.unfccc.int/methodologies/DB/C505BVV9P8VSNNV3LTK1BP3OR24Y5L/view.html.

agreements. If CERs are generated by ACM0013 coal plants, and used to meet emissions obligations of the buyer countries, then in principle, these emissions benefits would not count towards India and China's pledges. In fact, the amount of CERs sold and used elsewhere should be added to their emissions accounts when assessing progress towards pledge fulfillment, in order to avoid double counting these emission reductions in both buyer and seller countries (Erickson et al. 2011). As a result, there may be reason for the host countries not to allow sale of coal-based CERs, especially given their dubious additionality, and count these benefits as NAMAs and towards their own emission reduction pledges.

In fact, sectoral mechanisms, such as sectoral crediting and trading may avoid the concerns with ACM0013 coal project and CERs, while providing a more efficient way to incentivize improvements in coal plant efficiencies. Sectoral crediting or trading, if designed well and at the electricity sector-wide level, and not just for coal plants, could avoid the risk of providing additional revenue for new coal plants investments that are likely to proceed regardless of climate finance.

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