# Cleaner generation, free riders, and environmental integrity:

## Clean Development Mechanism and the Power Sector

An analysis for the World Wildlife Fund

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# Executive Summary

This study provides a first-cut estimate of the potential carbon emissions impacts of the CDM, focusing on new power plants in the power sector of non-Annex 1 countries. We conclude that while the CDM could induce some legitimate lower-emission electricity generation in host countries, it could also give rise to a considerable amount of spurious emissions allowances by crediting non-additional ("free-rider") activities – activities that would have taken place even in the absence of the CDM. We find that under some plausible CDM regimes, the CDM could serve primarily as an instrument for generating spurious credits, and only secondarily as an instrument for economic efficiency or sustainable development.

In this analysis, we construct four illustrative CDM regimes, designed to represent a range of approaches that are under general consideration within the climate community. The stylized CDM regimes are framed in terms of the following three defining characteristics: (a) the type of power supply projects eligible for the CDM; (b) the effectiveness of methods used to assess a proposed project's additionality and exclude non-additional activities from the CDM; and (c), the emissions baseline used to calculate an approved project's carbon credits. Of the four CDM regimes, Regime A is the most restrictive; only (non-hydro) renewable activities are eligible for CDM consideration and the baselines are fairly conservative. Regime D is the least restrictive; all project types are eligible and the baselines are more lax. We examine the impact of these CDM regimes on investments in *new* generation facilities. (An analysis of retrofits of existing facilities and demand side efficiency, which could also generate free-rider credits, would be a useful extension of the present study.) We consider illustrative carbon trading prices of $10/tC and $100/tC. A restrictive CDM regime, supplementary caps, and limited crediting for sinks might lead to carbon prices of $100/tC or more, while unfettered use of the CDM and sinks might lead to average carbon prices at or lower than $10/tC.

***Impact of the CDM on electric sector investments:*** We find that the impact of the four CDM regimes on the generation mix in the power sector is not large. Even in the cases that are most conducive to CDM activity (at $100/tC), roughly 94% of new generation investments are identical to the business-as-usual situation, with only 6% shifted from higher to lower carbon intensity technologies. This modest redirection of investment could be important for the development of renewables. We find that the CDM could bolster markets for renewable energy generation technologies by as little as 15% at $10/tC or as much as 300% at $100/tC. This difference is hardly surprising given that at $10/tC, renewable energy projects would receive a boost of only 0.1 to 0.2 cents per kWh. But even at $100/tC, renewable generation comprises only 4% of total new generation. Higher carbon credit prices will be necessary for renewable energy projects to compete widely against conventional electricity generation options that typically cost 1 to 3 cents less per kWh and offer less intermittent power. Carbon credit prices would be driven downward by the eligibility of low-cost forest sinks and conventional technologies (hydro and natural gas, in particular), which will compete for investment dollars and the limited demand for carbon credits.

***Free-riders as a major outcome of the CDM:*** The most striking finding of this analysis is the magnitude of the potential free-rider problem. By intention, the CDM is not designed to reduce global greenhouse gas emissions. CDM projects that reduce emissions in the host countries will generate emissions credits that enable the investor countries to increase their domestic emissions, exceeding their Annex B emissions targets. Thus, at best, if the CDM operates as intended, it will be carbon-neutral on a global scale. However, in practice, to the extent that the CDM generates *unwarranted free-rider credits*, it will cause a *net increase* in global carbon emissions.

Under the two least restrictive CDM regimes we considered (C and D), the number of cumulative free-riders credits is impressive, totaling 250 to 600 MtC through the end of the first budget period in 2012[1]. This volume of free riders could satisfy 10 to 23 percent of the likely OECD emissions reduction requirement during the first budget period, 2600 MtC.[2] This result is largely insensitive to the carbon price scenarios we considered. While not analyzed here, similar CDM design considerations could lead to additional free-rider credits from power supply retrofits, demand-side management, land-use sinks, and other categories of CDM projects. Nor do we analyze "free drivers", added emission reducing activities in non Annex 1 countries that could result from new technologies and markets created by CDM projects, but are particularly difficult to quantify or even identify.

Arguably, a small flow of free-rider credits might be acceptable, if the overall outcome of the CDM were to help achieve the ultimate objectives of the Climate Convention. This outcome would occur if the CDM catalyzed development and adoption of technologies that could underpin a global transition away from carbon-intensive fuels and contribute to sustainable development. But, in the cases investigated here, it is not evident that the magnitude of potential free-rider credits is justified by the obtained benefits, such as the transfer of some renewable energy technologies to the host countries.

Figure ES-1 shows the extent to which the volume of free-riders is sensitive to the three key characteristics of the CDM regimes: eligibility criteria, additionality testing, and baseline emissions levels. At the left of each set of bars in Figure ES-1 is the 600 MtC free rider estimate for CDM Regime D at $10/tC, the most lax of the four regimes considered where all project types are eligible, 100% of all eligible projects are accepted (additionality testing does not screen out any free riders), and the emissions baseline is equivalent to the average carbon intensity of expected new power sector activity (0.165 kgC/kWh). (Note, virtually all coal generation falls above this baseline, and therefore receives no free rider credit. If coal generation were instead credited against its own fuel-specific baseline, this would add another 50 MtC in free riders.) The other bars illustrate the effect of tightening eligibility requirements, increasing the effectiveness of additionality testing, and lowering the emissions baseline level.

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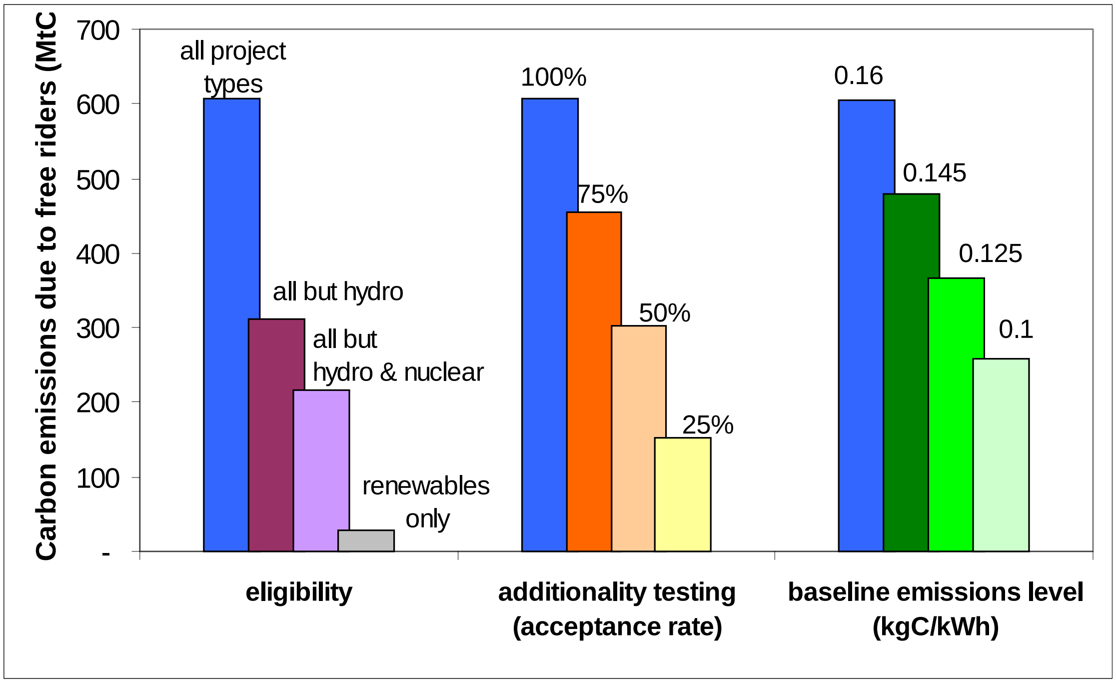
[1] These figures, and other figures in this report for emissions or credits (in MtC), are cumulative from 2000-2012.

[2] To meet their Kyoto Protocol targets, OECD countries will need to reduce their emissions from business-as-usual levels by approximately 520 MtC in 2010, according to one estimate reported in R. Baron, 2000, *The Kyoto Mechanisms: how much flexibility do they provide?*, International Energy Agency, Paris. (http://www.iea.org/clim/cop5/pubs/lanza.pdf) The figure of 2600 MtC is the resulting, cumulative five-year total, assuming that OECD requirements average 520 MtC throughout the first Kyoto Protocol budget period from 2008-2012.

**Figure ES1. Sensitivity of free rider estimates (Regime D) to key design characteristics**



For example, if large-scale hydropower projects were deemed ineligible for the CDM, the volume of potential free-riders would be reduced nearly in half to around 300 MtC. Eliminating nuclear projects would reduce the free-rider potential to 200 MtC, while restricting the CDM only to non-hydro renewables would drop the potential net carbon emissions to around 30 MtC. Additionality testing methods, such as project-specific reviews and market assessments, could also reduce free riders, but it is difficult to quantitatively judge the effectiveness of these techniques. We simply show the overall effectiveness in terms of assumed free-rider acceptance rates. Finally, the last set of bars shows that making the emissions baseline more stringent, e.g. reducing from 0.165 (as in Regime D) to 0.100 kgC/kWh (as in Regime A), would reduce free rider potential by over 50% to 260 MtC. These three design characteristics could clearly be combined and, indeed, Regime A, with only 17 MtC in free-riders, demonstrates the effect of such an integrated CDM design.

Our principal conclusion, therefore, is that free-rider credits from non-additional CDM projects threaten to undermine the environmental integrity of the Kyoto Protocol. Some CDM regimes could lead global emissions to increase by as much as 600 MtC relative to the Kyoto Protocol target, if credits awarded spuriously to projects that would have happened anyways are used in place of real carbon reductions. In economic terms, 600 MtC of free-rider credits would be worth $6 billion at $10/tC or $60 billion at $100/tC. These free riders would amount to a multi-billion dollar cross-subsidy to CDM project participants at the expense of the global environment. It is therefore imperative that policy makers devise and adopt a CDM regime that effectively encourages legitimate projects, while rigorously screening out non-additional activities.

# 1. Introduction

Since the drafting of the Kyoto Protocol in November 1997, the international discourse on climate policy has been dominated by the so-called flexibility mechanisms of the Protocol – emissions trading, joint implementation, and the Clean Development Mechanism (CDM). These flexibility mechanisms allow Annex B Parties – the industrialized nations – access to emission reduction opportunities that are likely to cost less than those available domestically. By obtaining credits for such reductions, these nations could emit more than their domestic target as set by the Protocol. Thus, many policymakers and stakeholders are keen to see the flexibility mechanisms implemented quickly and designed in a manner that maximizes their use. The costs of complying with the Kyoto Protocol emissions targets would be lowered, new market opportunities would arise, and certain sectors and political constituencies would be less likely to offer resistance to ratification of the Protocol.

The CDM is arguably the most important of the flexibility mechanisms, offering the promise of technology transfer, sustainable development, and economic efficiency in meeting the goals of the Protocol. By intention, the CDM is not designed to reduce global greenhouse gas emissions. While CDM projects will presumably reduce emissions in the host countries, they will generate emissions credits that enable the investor countries to avoid emissions reductions at home. Thus, if the CDM operates as envisioned, it would be globally carbon-neutral at best.

The CDM 's effectiveness as an instrument for protecting the global climate therefore cannot be measured simply by the total volume of emissions reductions obtained by CDM projects, since these reductions are balanced by emissions increases elsewhere. Its effectiveness must therefore be measured in terms of more subtle indicators of economic efficiency, promotion of environmentally benign technologies, enhancement of developing country capacities, and other contributions to long-term global sustainable development. Indeed, these are among the stated goals of the Climate Convention, the Kyoto Protocol and the CDM.

At a very minimum, the CDM should preserve environmental integrity; i.e., it should not generate credits for substantially more greenhouse gas emissions reductions than were actually obtained. Indeed, to the extent that the CDM generates unwarranted credits, it will cause a net *increase* in global carbon emissions. Arguably, some unwarranted credits might be acceptable, if the extra emissions in the near term were somehow compensated in the long term, and if this helped to achieve the ultimate objectives of the Climate Convention. For example, some CDM activities might be uniquely effective catalysts for the development and adoption of those environmentally sustainable technologies that will ultimately underpin the global transition away from fossil fuels. Such activities might merit credit for more emissions reductions than they strictly earn in the near term, because of their prospects for long-term benefits.

This study indicates, however, that satisfying even the minimum requirement of preserving environmental integrity is a daunting challenge, and under some plausible CDM design approaches the magnitude of sacrifice in environmental integrity could be very great for small and uncertain longer term benefits. It provides an estimate of the potential global emissions impacts of the CDM, focusing on new power plants within the power sector. It concludes that while the CDM could induce some legitimate lower-emission electricity generation in host countries it could also give rise to a considerable amount of spurious emissions allowances by crediting non-additional ("free-rider") activities – activities that would have taken place even in the absence of the CDM. As a consequence, the Annex B countries would be in compliance with letter but not the spirit of the Protocol. The results of this study demonstrate the critical importance of devising a CDM regime that effectively encourages legitimate projects, while rigorously screening out free-rider activities.

# 2. Project Eligibility, Additionality, and Baselines

Three fundamental issues – project eligibility, additionality, and baselines – stand at the heart of the challenge of making the CDM effective. Resolving these issues will mean establishing: (a) what type of projects are eligible for CDM participation; (b) how rigorously a proposed project's additionality is tested and how effectively are non-additional activities excluded from the CDM[3]; and (c) what emissions baseline is used to calculate how much credit an approved project will earn.

The answers these questions will ultimately determine the effectiveness of the CDM in terms of environmental integrity, economic efficiency and sustainable development. In judging the effectiveness of a proposed CDM approach, this study investigates two key impacts that are of central importance:

- **Type of activity induced.** From the standpoint of meeting near-term targets, "a ton is a ton is a ton," so Parties could pursue near-term economies by seeking out the cheapest tons regardless of the technology and fuel employed. But very different mitigation options might be pursued if the objective were long-term, cost-effective climate protection and consistency with other dimensions of sustainability (e.g. social and environmental benefits, technology transfer benefits, low carbon intensities, and potential for innovation and cost reduction).
- **Net emissions impact (environmental integrity).** It is generally assumed that the CDM is carbon neutral, since each ton of actual emission reductions in a non-Annex B host country is offset by an extra ton emitted by an Annex B Party that purchases the corresponding credit. However, the CDM might not be climate neutral, because of:
  - **Over-crediting (or under-crediting)** of additional projects, to the extent that they are compared against a baseline emissions level that is an "inaccurate" reflection of the hypothetical counterfactual situation.
  - **Free-riders:** non-additional projects, which generate Certified Emission Reductions (CERs) that are not backed up by real reductions. *Free-drivers* could also arise if CDM projects generate "spin-off" effects that give rise to emission reductions that are not credited (e.g., from the quicker development and adoption of advanced technology). Such spin-off effects, which are indirect and thus particularly difficult to quantify or even identify, have not been included in this study.

The power sector provides an ideal laboratory for examining how eligibility, additionality, and baselines influence these two central impacts of the CDM. The International Energy Agency (IEA) projects that roughly 500 GW of new power plants will come on-line in non-Annex B countries between now and 2012, producing roughly 2000 MtC of carbon during that time. If the Kyoto Protocol is ratified and the CDM becomes an active stimulus to clean investment, it is hoped that this 500 GW of new power plants could comprise considerably more environmentally sound and technologically advanced power plants than would otherwise be the case.

This analysis explores the three elements of the CDM discussed above – eligibility requirements, additionality testing, and emissions baselines – to test how the power sector might respond to the CDM. We examine how much and what types of new power sector activity the CDM might induce, as well as the how over/under-crediting and free riders might affect the net emissions impact of the CDM.

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[3] We have presented eligibility, additionality, and baselines as three distinct issues, even though they are often discussed as part of a single indivisible process. This separation of issues helps clarify some of the questions and problems arising out of the CDM.

# 3. Analytical Approach

The straightforward language of the Protocol makes the issues of eligibility, additionality, and baselines appear less vexing than they have proven to be. The Protocol simply suggests that projects would be eligible and additional if they “assist Parties not included in Annex I in achieving sustainable development,” cause “real, measurable, and long-term” mitigation benefits, and induce “reductions in emissions that are additional to any that would [otherwise] occur…” [Kyoto Protocol, Art. 12.2 and 12.5]. Additional projects are simply those that would not have otherwise occurred, and the credited emissions reductions are the difference between the emissions of the eligible project and the emissions displaced by the project. Baselines are defined so as to reflect the activity that was displaced by the project.

However, this counterfactual situation (what would have otherwise occurred) is inherently unknowable. At best, one can make reasonable approximations and well-informed judgments. To this end, a number of methodologies are now on the negotiating table, most notably: project-specific baselines, multi-project baselines (e.g., benchmarks), and additionality tests[4]. Technology lists and matrices have also been proposed as means to make advance determinations of project eligibility.

Our analytical approach is summarized in the following box and described in detail below.

**Step 1:** Define four sample CDM regimes, to represent existing proposed methodologies.

**Step 2:** Select a “business-as-usual” forecast for the global power sector as a reference case for new generation facilities built between 2000 and 2012.

**Step 3:** Estimate economic incentives posed by the four CDM regimes for a menu of different generation options.

**Step 4:** Estimate the activity induced by the CDM, in response to the economic incentives calculated above.

**Step 5:** Calculate the “free-rider” credits awarded to generation activities that would have occurred even in the business-as-usual scenario.

### Step 1: Define four sample CDM regimes

To investigate a range of proposed methods for defining eligibility, additionality, and baselines, we construct four illustrative CDM regimes. The regimes are stylized prototypes, designed to span the variety of approaches that are under general consideration. They embody a set of assumptions, described below, ranging from more restrictive (Regime A) to less restrictive (Regime D).

Table 1 describes these CDM regimes in terms of their eligibility requirements, their approach to additionality testing, and their assigned baselines. Figure 1 summarizes this process of approval and crediting of projects under a CDM regime, as modeled in this exercise. This process and the corresponding regimes are simplifications of actual proposed CDM methodologies, capturing the key elements needed to carry out this analytical exercise.

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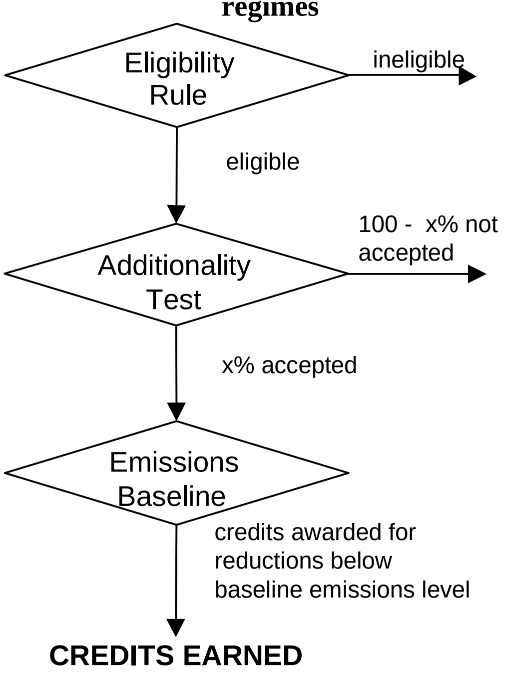
[4] For detailed definition and discussion of these methods see Ellis, J. and Bosi, M., 1999, *Options for project emission baselines*, ECD and IEA Information Paper, International Energy Agency, Paris, October 1999 (http://www.oecd.org/env/docs/cc/options.pdf) and Lazarus, M., Kartha, S., Bernow, S., 2000, *Key Issues in Benchmark Baselines for the CDM: Aggregation, Stringency, Cohorts, and Updating*, prepared for USEPA, Tellus Institute. (http://www.tellus.org/seib/publications/cdmjune2000.pdf).

- *Eligibility requirements:* The Parties must eventually reach a consensus regarding what types of activities are eligible under the CDM. Currently, some Parties are advocating a completely unrestrictive CDM that allows any project type, while others are arguing that CDM projects in the power sector should focus on renewables, while strictly excluding fossil, nuclear and large-scale hydro. We reflect the range of perspectives in the four CDM regimes modeled here. In Regime A, only (non-hydro) renewable activities are eligible for CDM consideration. In Regime D, projects of any type are eligible. Regimes B and C fall in between these two. The first part of Table 1 states which project types are eligible under each regime.

- *Additionality testing:* Even if a project is deemed eligible, it may nonetheless have occurred even in the absence of the CDM. Many proposed CDM regimes would attempt to distinguish such potential “free-rider” activity from additional activity, by imposing additionality tests based on financial assessments, market barrier analyses, examination of planning documents, and other such project-specific evaluations. It is impossible to model in detail such additionality tests. Instead, we characterize the rigor of each regime’s additionality testing procedure by an assumed “acceptance rate”, to reflect how effectively the regime filters out non-additional projects. A regime that accepts all proposed (and eligible) activity would have an acceptance rate of 100%. Some in the climate community are proposing additionality procedures that correspond to an acceptance rate of 100% for some technologies, driven by the desire to initiate an active CDM, secure the interest of investors, and avoid a burdensome administrative apparatus. A regime that involves more extensive additionality testing would screen out some fraction of the non-additional activities, which would be reflected in an acceptance rate lower than 100%. Explicit, practical methodologies have not yet been proposed, reflecting the fundamental difficulty of determining “what would have happened otherwise”. The acceptance rates of the regimes explored here vary from 25% to 100%, as shown in Table 1 in the second section under each regime.

**Figure 1. A stylized model of CDM regimes**



- *Emissions baselines:* Each regime must have well-defined, quantitative emissions baselines for prospective CDM activities, so that emissions reduction credits for approved CDM projects can be calculated and awarded. The climate community has proposed several methodologies for setting the emission baseline. Broadly speaking, these attempt either to reflect the emissions rate of the presumed counterfactual reference situation emissions or to establish a standard based on normative considerations. For each of the four regimes, emissions baselines are expressed as carbon intensities (kgC/kWh), as shown in the third section of Table 1. For Regime A, the baseline for renewable options is 0.1 kgC/kWh, which is approximately equal to the carbon intensity of a new natural gas combined cycle facility (NGCC, the lowest carbon fossil technology widely available today). For Regimes B-D, the carbon intensity of the baseline for zero-carbon options (renewables, large-scale hydro, and nuclear) is 0.165 kgC/kWh, the average carbon intensity for all new generation coming on line up to 2012. (See discussion of IEA forecast below). Regimes B and C establish a unique baseline specific to each fossil fuel (coal, oil, and gas). For Regime B the baseline is 25th percentile of new plants using the same fuel, for Regime C it is the median (i.e., 50th percentile). This approach credits CDM projects as if the improve generation efficiency, but do not alter fuel choice. For Regime D, the baseline for all CDM projects – both fossil and zero-carbon – is the sector-wide average carbon intensity for new generation (0.165 kgC/kWh). This implicitly precludes most coal plants from crediting, while increasing the credits available to natural gas facilities.

**Table 1. Defining characteristics of four additionality regimes, from most restrictive (Regime A) to least restrictive (Regime D).**

| | **Regime A** | **Regime B** | **Regime C** | **Regime D** |
|---|---|---|---|---|
| **Eligible project types** | **Projects are either eligible or ineligible for the CDM as indicated below.** | | | |
| Fossil (coal, oil, gas) | No | Yes (“very efficient”) | Yes (“efficient”) | Yes (“low carbon”) |
| Large hydro, nuclear | No | No | Yes | Yes |
| Renewables | Yes | Yes | Yes | Yes |
| **Additionality tests** | **The “acceptance rate” reflects how discriminating are the additionality tests (if any) imposed on prospective CDM projects.** | | | |
| Fossil (coal, oil, gas) | NA | 25% accepted | 50% accepted | 100% accepted |
| Large hydro, nuclear | NA | NA | 50% accepted | 100% accepted |
| Renewables | 100% accepted | 100% accepted | 100% accepted | 100% accepted |
| **Emissions baseline** | **Percentile and absolute benchmarks are based on emissions rates for new generation in non-Annex 1 region projected for the period 2000-2012** | | | |
| Fossil (coal, oil, gas) | N/A | 25%ile (“very efficient” relative to generation from same fuel) | 50%ile (“efficient” relative to generation from same fuel) | 0.165 kg C/kWh (“efficient” relative to emissions from sector ) |
| Large hydro*, nuclear* | N/A | N/A | 0.165 kg C/kWh | 0.165 kg C/kWh |
| Renewables* | 0.100 kg C/kWh (typical emissions for natural gas CC) | 0.165 kg C/kWh | 0.165 kg C/kWh | 0.165 kg C/kWh |

*For the purposes of this analysis, hydro, nuclear, and renewables (biomass, geothermal, wind, solar) are all assumed to have carbon intensities that are precisely zero. Life-cycle emissions, including manufacturing-related emissions and methane emissions from reservoirs, could be introduced if deemed necessary.
N/A = Not Applicable

**Step 2: Select a “business-as-usual” forecast for the global power sector**

To examine the impacts of the CDM, it is necessary to compare what happens due to the CDM to what would have happened otherwise. To represent the latter, we adopt a business-as-usual reference scenario from the IEA’s most recent *World Energy Outlook* (1998), which projects the amount of new generation by type and region expected to be added during the time period of interest (2000 to 2012). We adopt the IEA’s generation mix across different fuels and technologies, and assume that the generation from each source is characterized by a range of efficiencies (and thus carbon intensities) consistent with empirical observations from the power sector. For example, coal generation ranges from inefficient subcritical plants to relatively efficient supercritical plants. Thus, there is a significant contribution to business-as-usual generation from relatively efficient sources, giving ample potential for large amounts of fossil free-riders.

The next two steps allow us to calculate what might happen to the anticipated generation mix because of the CDM.

**Step 3: Estimate economic incentives for different generation options under the CDM**
The fundamental premise underlying the CDM is that it will offer sufficient economic incentive to investors in the form of CERs to increase their investments in lower GHG emitting activities. Although the CDM will create other incentives (e.g. access to emerging carbon mitigation markets) and disincentives (e.g. transaction costs), we examine only how CERs might affect the relative cost of a range of generation options, which is likely to be the principal long-term impact of the CDM.

We consider fourteen electricity generation options[5], and compute their levelized (or "busbar") costs based on cost and performance parameters drawn primarily from International Energy Agency and Energy Information Agency of the US DOE. For each option, we calculate the CERs generated (tC) by subtracting its emission rate from the baseline specific to each CDM regime above. We then calculate the economic value of the CERs using low and high international carbon trading price assumptions of $10/tC and $100/tC for the first budget period. This wide range of carbon trading price reflects the large uncertainties that will ultimately affect carbon prices: e.g., how expensive domestic mitigation options turn out to be, whether or not Parties impose supplementarity caps on the flexibility mechanisms, whether LUCF projects are included in the CDM, and so on. The price will also be influenced by the baseline regime itself. For example, an unrestrictive CDM regime with a high supply of CDM projects will suppress the carbon trading price compared to a restrictive regime with a limited supply of CDM projects. For clarity, this analysis simply models each of the four CDM regimes (A through D) at each of the two carbon credit prices ($10/tC and $100/tC).

Subtracting the CER value (in cents/kWh) from the busbar cost yields the net cost of electricity for each option, if the option were approved as a CDM activity. The largest CDM-induced credits are earned by zero carbon generation options under Regimes C and D. These options garner 0.165 cents/kWh at $10/tC, and 1.65 cents/kWh at $100/tC. This impact on the total cost of generation options is significant, but not overwhelming, and can be expected to induce some investors to change their investment choices. How much these choices might change is examined in the next step.

**Step 4: Estimate the activity induced by the CDM**
Given these costs estimates for generation options, we use a simple economic model to explore how the availability of CERs might alter the IEA "business-as-usual" forecast, displacing generation from higher-carbon technologies with low-carbon and zero-carbon technologies. We assume the demand for a given new generation option will increase as CERs induce its price to fall (all other things being equal). Using a price elasticity, we calculate its increased contribution to new electricity supply (holding total electricity demand constant)[6]. We incorporate lag times of 2 to 5 years to reflect the time required to initiate planning and complete construction of different power plant types in response to the CDM. Investment choices in electric sector generation also depend on many non-price factors, such as need for fuel diversity, barriers to technologies, conventional technology lock-in, etc. – influences that are reflected in the IEA business-as-usual reference scenario.

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[5] The fourteen technology/fuel options are as follows: conventional coal, advanced coal (IGCC- integrated gasifier/combined cycle), oil combustion turbine, oil combined cycle, conventional and advanced natural gas combustion turbine, conventional and advanced natural gas combined cycle, nuclear, hydro, biomass, geothermal, wind, solar.

[6] In effect, this analysis simulates a simple cross-price elasticity response, where the CDM decreases the cost for some generation options and increases their demand, at the expense of other options. This reflects the implicit assumption of the CDM itself that CDM projects will provide lower-carbon electricity to *displace* – rather than *supplement* – existing supply. However, it is conceivable that the CDM, by reducing the cost of electricity, would induce additional demand. This would imply the generation of credits with no corresponding emissions reduction (and perhaps an emissions increase), and a further weakening of the environmental integrity of the CDM.

For example, as shown in the tables in the appendix, generation from new wind power facilities in non-Annex 1 countries is projected to be 44 TWh in IEA's reference case[7]. Under Regime A, at $10/tC, the generation of power from new wind facilities would increase during this period by 8 TWh, to 52 TWh. On the other hand, generation from natural gas combined cycle facilities decreases by 6 TWh, from 2954 TWh in the reference case to 2948 TWh.

Thus, some new generation is induced by the CDM, and some generation that would have occurred is displaced. Each CDM regime thereby yields a new CDM scenario for the power sector, which closely resembles the business-as-usual scenario, but with marginal changes due to this induced and displaced generation.

**Step 5: Calculate the credits awarded to "free rider" CDM activities**

The most of the generation in each scenario constructed in Step 4 is identical to the business-as-usual generation. Of this generation, which would have occurred anyway, some still satisfies the requirements of the CDM regime – creating the potential for free-rider CDM projects that are eligible for CDM credits. For example, 44 TWh of wind power, the amount that would have been provided by new wind facilities even in the reference case, is potentially eligible for CDM credits under all four CDM regimes considered here. After all, it is indistinguishable from the 8 TWh of new wind generation induced by the CDM. (Similarly, to the extent that natural gas generation has a low enough carbon intensity to receive credit, some of the remaining 2648 TWh above could receive credit, depending on the requirements of the CDM regime.)

Of this potential free-rider generation, some fraction is deemed additional and approved as CDM activity. This fraction is given by the acceptance rate, as described in step 1 above in the discussion of additionality testing. As mentioned, this acceptance rate is a single parameter that embodies likelihood that free-rider activities will satisfy the applicable additionality tests and receive CDM approval. As seen in Table 1, the acceptance rates vary from Regime A to Regime D, and also depend on project type.

# 4. Findings

The full, detailed results of analysis of the four CDM regimes under each carbon price scenario ($10/tC and $100/tC) are shown in Appendix A below, and summarized in Table 2 and Figures 2 and 3 below.

It is interesting to first consider the type of additional activity that might be generated. Generally speaking, we find that the impact on the generation mix in the power sector is not large. Even in the cases that are most conducive to CDM activity (at $100/tC), roughly 94% of new generation is identical to the business-as-usual situation, with the remaining 6% shifted from higher to lower carbon intensity technologies. Roughly two-thirds of the shifted generation goes to renewables.

Table 2 shows how much additional renewable generation is induced (cumulatively through the end of the first budget period) under the two carbon prices and four regimes considered. At $10/tC, Regime A, essentially a renewables-only CDM with a relatively conservative baseline (lowering the amount of credits per kWh), produces the lowest amount of new activity, adding only 16% or 27 TWh to the expected new renewable generation of 172 TWh. This limited increase is not surprising since this carbon price and the relatively low baseline associated with Regime A produce only a small economic incentive for new renewable energy projects, approximately 0.1 cents per kWh. The higher baselines of Regimes B-D combined with the $10/tC CER price result in a somewhat higher level of renewable generation, but still only a 26% increase in new renewable energy activity.

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[7] These figures, and all other figures for generation (TWh), are cumulative over the period 2000-2012.

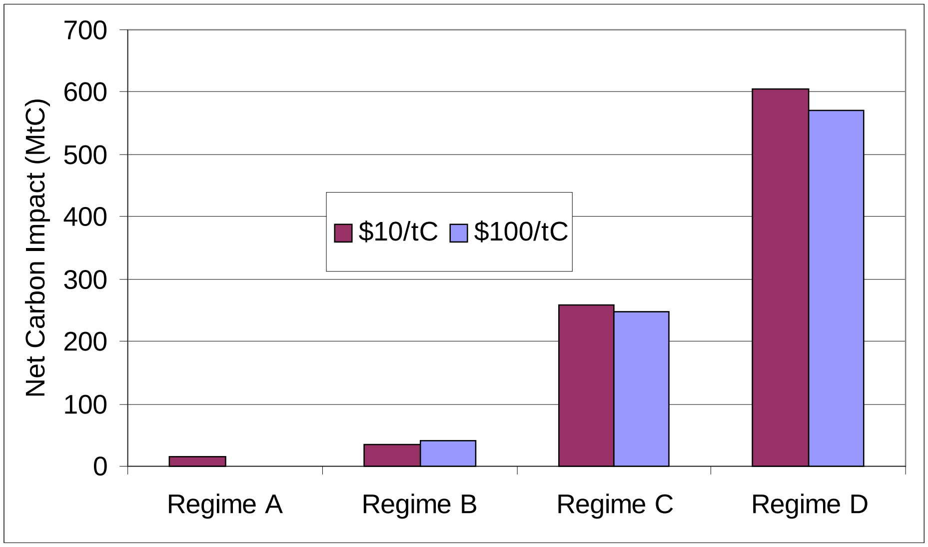
**Table 2. New renewable energy generation, cumulative to 2012**

| | Projected levels without the CDM (TWh) | Percentage increase induced by the CDM | | | |
|---|---|---|---|---|---|
| | | Regime A | Regime B | Regime C | Regime D |
| Renewables induced at $10/tC | 172 | 16% | 26% | 26% | 26% |
| Renewables induced at $100/tC | 172 | 178% | 324% | 318% | 308% |

Carbon credit prices are likely to be the major factor that can stimulate greater renewable energy activity in the power sector. As shown in Table 2, a trading price of $100/tC could increase where renewable energy generation by approximately 178 to 308%. Such high prices, however, may be unlikely unless the competition from low-cost forest sinks and conventional technologies in the CDM (hydro and natural gas, in particular) is somehow limited. And it is important to note that even though at a given price, Regime A produces the lowest increase in renewable energy activity, since it curtails competition from fossil CDM projects, it is likely to lead to higher market prices for CERs than the other 3 regimes. It would thus be misleading to infer that Regime A is less favorable to renewables. A streamlined process for submission and approval could lower transaction costs and improve the competitiveness of prospective renewable CDM projects, but we do not explicitly examine this factor in our analysis.

Figure 2 illustrates the principal finding of this analysis: each CDM regime leads to net *increases* in global carbon emissions – ranging from near zero (Regime A at $100/tC) to 600MtC (Regime D at $10/tC). As a basis of comparison, 2600 MtC is roughly the total reduction below a business-as-usual level of emissions that the OECD countries will be required to make to meet their Kyoto Protocol targets during the first budget period.

**Figure 2. Net global carbon emissions increase at $10/tC and $100/tC, cumulative through 2012 (credited reductions minus actual reductions plus free-rider credits)**



The net impacts comprise three terms, as shown in Figure 3. The first reflects the actual emissions reductions of the CDM projects, which are simply the emissions of the CDM-induced generation subtracted from the emissions displaced from the reference scenario. (This is shown here as a negative quantity.) The second term reflects the credited reductions from these same projects, determined by subtracting the emissions of the CDM-induced generation from it's corresponding baseline. Third term reflects the credits awarded to free rider activities – generation that satisfies the requirements of the CDM regime and is deemed eligible for CDM credits, but would have occurred even in the reference case. In short, the net global carbon emission impacts of the CDM consists of the credits for free-rider CDM activities plus the credits for legitimate CDM activities minus the actual emissions reductions from legitimate CDM activities.

For all regimes, the actual reductions and credit reductions from legitimate projects are relatively close to one another, and their difference therefore reflects a fairly small under- or over-crediting[8]. However, the third term introduces a large volume of excess credits in almost all cases. In one case (Regime A at $100/tC) the free rider credits are offset by under-crediting of genuine, additional projects. However, in all other cases, the credits awarded to free-riders cause the CDM regime to be far from carbon-neutral.

**Figure 3. Net global carbon emissions impacts under 4 CDM regimes: three component terms**

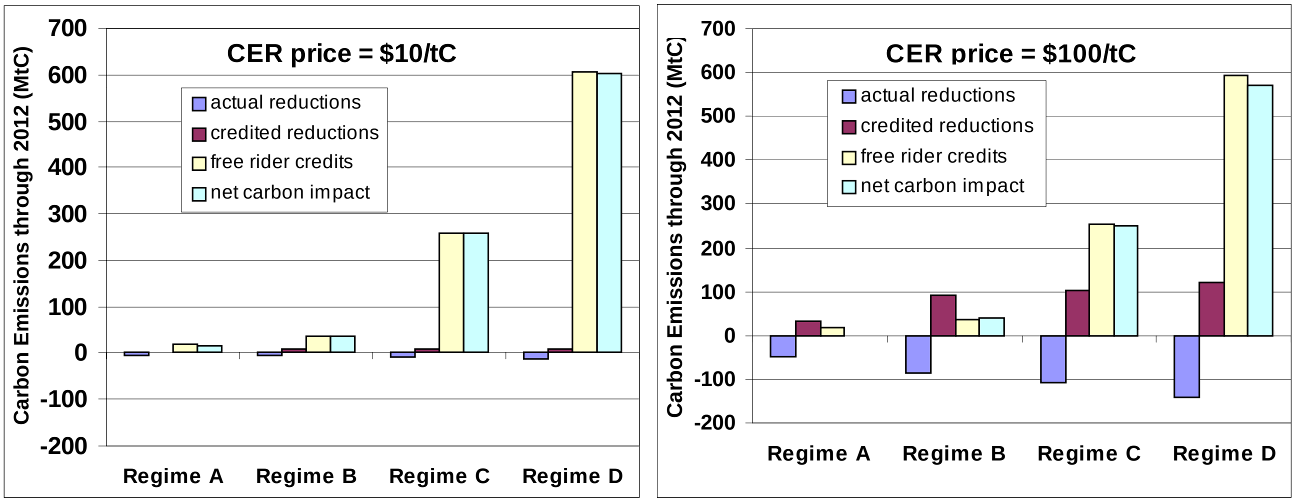


Figure 4 shows what types of power sector activities are giving rise to the free rider credits. The renewable generation appearing in the reference case is a source of free-rider credits in all regimes (between 17 MtC and 28 MtC, depending on Regime). In Regime D, natural gas combined cycle generation also garners a large volume of free rider credits (175 MtC). Relatively efficient coal generation gets some free-rider credit as well (up to 25 MtC in Regime C) [9]. Hydro and nuclear, however, provide the overwhelming share of free rider credits: roughly 200 MtC in regime C and 400 MtC in regime D.

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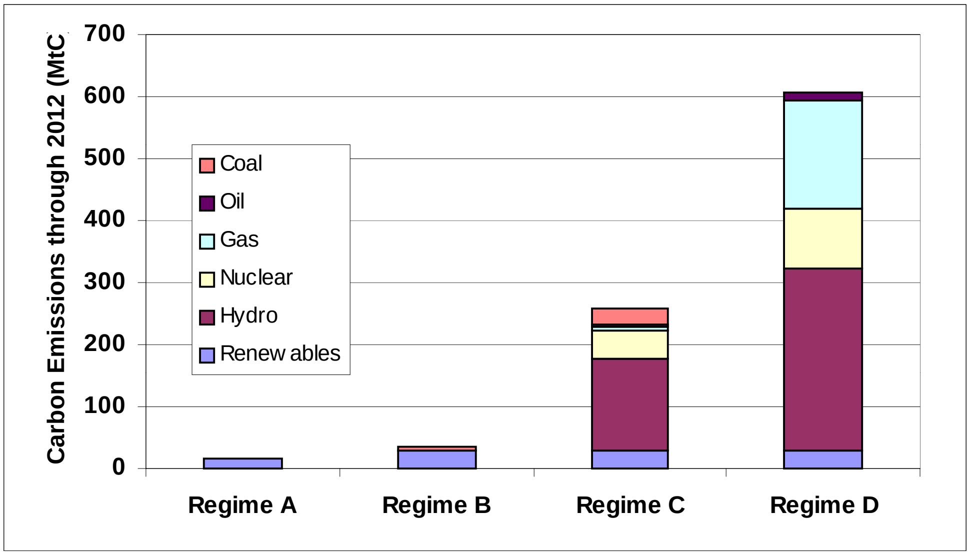
[8] As shown in tables, under-crediting is seen in Regimes A,C, and D, and over-crediting is seen in Regime B, for both carbon prices ($10/tC and $100/tC).

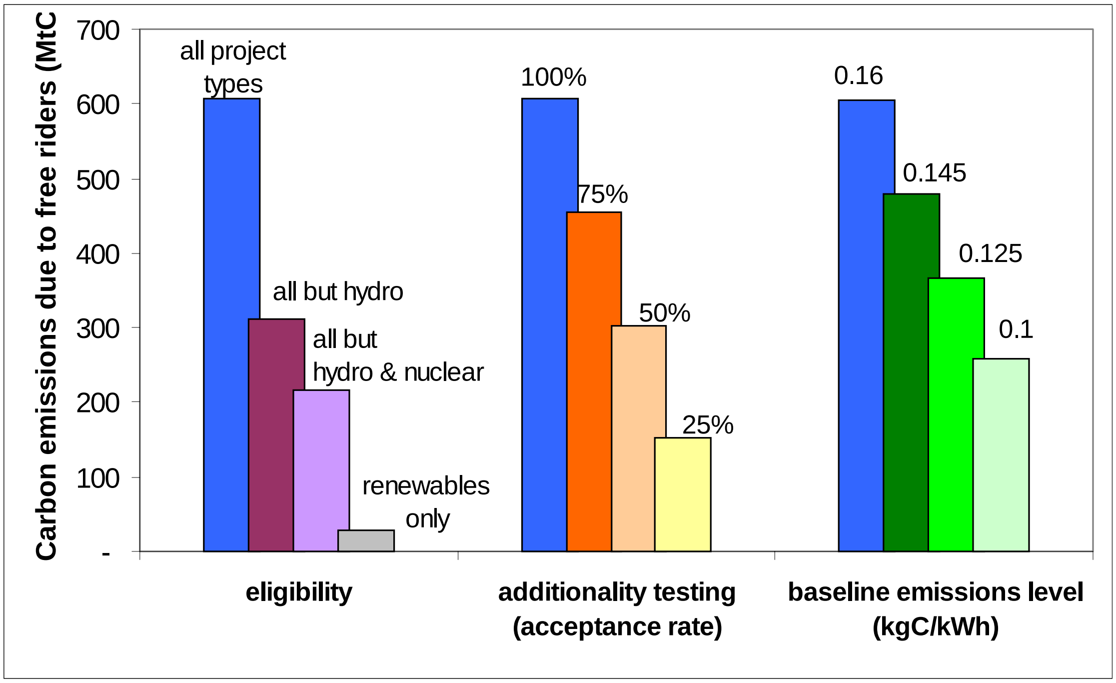
[9] As shown in the tables in the Appendix, technologies that are characterized as "advanced" coal and natural gas are not in the reference scenario, and thus earn no free-rider credits. However, as noted earlier, technologies characterized as "current" fossil technologies embody a range of carbon intensities, including relatively low carbon intensities that reflect efficient, existing fossil technologies, which *can* earn free-rider credits. Thus, the tables show that "advanced" fossil technologies earn no free credits, while comparably efficient "current" fossil technologies do earn free rider credits.

**Figure 4. Composition of Free Riders Under Four CDM Regimes at $10/tC**



The magnitude of free-rider credits is not very sensitive to the presumed market price of carbon credits. Unlike legitimate CDM credits for additional projects, the free rider credits are essentially zero-cost to the project developer (akin to hot air), and will be pursued whether the going price for carbon is high or low. Nor is it sensitive to the "responsiveness" of the electric sector to the CDM (embodied in our elasticity exponent and the participation rate). Figure 5 shows the extent to which the volume of free-riders is sensitive to the three key design characteristics of the CDM regimes: eligibility criteria, additionality testing, and baseline emissions levels. (See Table A-3.) At the left of each of the three sets of bars in Figure 5 is the 606 MtC free rider estimate for CDM Regime D at $10/tC, the most lax of the four regimes considered. This case reflects a CDM Regime in which all project types are eligible, 100% of all eligible projects are accepted (additionality testing does not screen out any free riders), and the emissions baseline is equivalent to the average carbon intensity of expected new power sector activity (0.165 kgC/kWh). (Note, virtually all coal generation falls above this baseline, and therefore receives no free rider credit. If coal generation were instead credited against its fuel-specific baseline, this would add approximately another 50 MtC in free riders.) The other bars illustrate the effect of tightening eligibility requirements, increasing the effectiveness of additionality testing, and lowering the emissions baseline level.

**Figure 5. Sensitivity of free rider estimates (Regime D) to key design characteristics**



For example, if large-scale hydropower projects were deemed ineligible for the CDM, the volume of potential free-riders would be reduced nearly in half to around 300 MtC. Eliminating nuclear projects would reduce the free-rider potential to 200 MtC, while restricting the CDM only to non-hydro renewables would drop the potential net carbon emissions to around 30 MtC. Additionality testing methods, such as project-specific reviews and market assessments, could also reduce free riders, but it is difficult to quantitatively judge the effectiveness of these technique. We simply show the overall effectiveness in terms of the free-rider acceptance rates. Finally, final set of bars shows that making the emissions baseline more stringent, e.g. reducing from 0.165 to 0.100 kgC/kWh, would reduce free rider potential by over 50% to 260 MtC. These three design characteristics could clearly be combined and, indeed, in moving from Regime D with 606 MtC free-riders to Regime A with 17 MtC free-riders shows the effect of such a combination.

In economic terms, the 600 MtC of free-rider credits generated in Regime D amounts to the creation of $6 billion (at $10/tC) or $60 billion (at $100/tC). This is in essence a cross-subsidy to the CDM project participants at the expense of the global environment.

## 5. Conclusions

This study supports two main conclusions.

Our principal conclusion is that the free-rider credits from non-additional projects could reach a magnitude that has not previously been appreciated. A small flow of free-rider credits might be acceptable, but if the magnitude of free riders were to approach the levels found in this exercise, it would severely compromise the environmental integrity of the CDM. Free-rider credits awarded spuriously to projects that would happened even without the CDM could be as great as 600 MtC. This volume of free riders, accumulated between 2000 and 2012, would satisfy almost a quarter of the projected OECD emissions reduction requirement of 2600 MtC during the first budget period. Significant free-rider credits could also arise from other categories of CDM projects such as power supply retrofits, demand-side management and land-use sinks, whose emissions impacts are especially difficult to estimate. The CDM would then serve primarily as an instrument for generating spurious credits, and only secondarily as an instrument for economic efficiency or sustainable development. Therefore, it is imperative that policy makers devise and adopt a CDM regime that effectively encourages legitimate projects, while rigorously screening out non-additional activities.

The volume of free riders is sensitive to the three key design characteristics of the CDM regimes: eligibility criteria, additionality testing, and baseline emissions levels. Measures for making a CDM regime less vulnerable to free riders would therefore involve making eligibility criteria more restrictive, additionality testing more rigorous, and baseline emissions levels more stringent and/or dynamically updated. Each of these measures, however, has its cost. For instance, legitimate projects might be rendered ineligible, project developers might be discouraged by more extensive additionality procedures, and the financial attractiveness of projects might be reduced under lower baselines. However, given the magnitude of the free-rider problem, it appears advisable to adopt a more rigorous CDM regime that is less susceptible to free-riders. A more focused and restricted CDM regime, such as one that is targeted at a limited positive list, would be less susceptible to being overwhelmed by free-rider activity.

Second, we find that the impact of the four CDM regimes on the generation mix in the power sector is not large. Even in the cases that are most conducive to CDM activity (at $100/tC), roughly 94% of new generation investments are identical to the business-as-usual situation, with the remaining 6% shifted from higher to lower carbon intensity technologies. This modest redirection of investment could be important for the development of renewables. We find that the CDM could bolster markets for renewable energy generation technologies by as little as 15% at $10/tC or as much as 300% at $100/tC. This difference is hardly surprising given that at $10/tC, renewable energy projects would receive a boost of only 0.1 to 0.2 cents per kWh. But even at $100/tC, renewable generation comprises only 4 % of total new generation.

Higher carbon credit prices will be necessary for renewable energy projects to compete widely against conventional electricity generation options that typically cost 1 to 3 cents less per kWh and offer less intermittent power. Carbon credit prices would be driven downward by the eligibility of low-cost forest sinks and conventional technologies (hydro and natural gas, in particular), which will compete for investment dollars and the limited demand for carbon credits.

# Appendix

**Table A-1a. Reference emissions (ktC) and results for Regimes A,B,C, and D at $10/tC (cumulative through 2012).**

| carbon price | $ | 10 |
|---|---|---|

| | | **Reference Case** | **Additionality Regime A** | | | **Additionality Regime B** | | |
|---|---|---|---|---|---|---|---|---|
| carbon intensity | Technology | actual emissions | change in actual emissions | credits awarded to add'l projects | credits awarded for free rider projects | change in actual emissions | credits awarded to add'l projects | credits awarded for free rider projects |
| kgC/kWh | | ktC | ktC | ktC | ktC | ktC | ktC | ktC |
| 0.244 | Coal - current | 1,294,074 | -2,662 | - | - | -4,582 | - | 4,806 |
| 0.197 | Coal - advanced | - | - | - | - | 291 | 50 | - |
| 0.233 | Oil - CT | 97,500 | -201 | - | - | -345 | - | 0 |
| 0.155 | Oil - CC | 151,413 | -311 | - | - | -536 | - | 562 |
| 0.163 | NG CT- current | 206,293 | -424 | - | - | -730 | - | 0 |
| 0.127 | NG CT- advanced | - | - | - | - | - | - | - |
| 0.108 | NG CC - current | 320,362 | -659 | - | - | -1,134 | - | 1,190 |
| 0.098 | NG CC - advanced | - | - | - | - | 14 | 1 | - |
| 0.000 | Nuclear | - | - | - | - | - | - | - |
| 0.000 | Hydro | - | - | - | - | - | - | - |
| 0.000 | Biomass | - | - | 616 | 2,965 | - | 1,685 | 4,891 |
| 0.000 | Geothermal | - | - | 1,168 | 9,630 | - | 3,209 | 15,887 |
| 0.000 | Wind | - | - | 826 | 4,363 | - | 2,265 | 7,198 |
| 0.000 | Solar | - | - | 123 | 268 | - | 334 | 442 |
| | **total** | **2,069,642** | **-4,258** | **2,733** | **17,226** | **-7,023** | **7,543** | **34,978** |
| | | | **net carbon impact**<br>**15,701** | | | **net carbon impact**<br>**35,498** | | |

| | | **Reference Case** | **Additionality Regime C** | | | **Additionality Regime D** | | |
|---|---|---|---|---|---|---|---|---|
| carbon int. | Technology | actual emissions | change in actual emissions | credits awarded to add'l projects | credits awarded for free rider projects | change in actual emissions | credits awarded to add'l projects | credits awarded for free rider projects |
| kgC/kWh | | ktC | ktC | ktC | ktC | ktC | ktC | ktC |
| 0.244 | Coal - current | 1,294,074 | -6,115 | - | 25,687 | -9,027 | - | 19 |
| 0.197 | Coal - advanced | - | 813 | 194 | - | - | - | - |
| 0.233 | Oil - CT | 97,500 | -461 | - | 0 | -680 | - | 5 |
| 0.155 | Oil - CC | 151,413 | -716 | - | 3,006 | -758 | - | 12,127 |
| 0.163 | NG CT- current | 206,293 | -975 | - | 1 | -1,425 | - | 9,520 |
| 0.127 | NG CT- advanced | - | - | - | - | 212 | 64 | - |
| 0.108 | NG CC - current | 320,362 | -1,514 | - | 6,359 | -1,298 | - | 166,429 |
| 0.098 | NG CC - advanced | - | 78 | 8 | - | 1,015 | 693 | - |
| 0.000 | Nuclear | - | - | 866 | 47,229 | - | 1,959 | 94,458 |
| 0.000 | Hydro | - | - | - | 147,562 | - | - | 295,238 |
| 0.000 | Biomass | - | - | 1,677 | 4,891 | - | 1,662 | 4,891 |
| 0.000 | Geothermal | - | - | 3,186 | 15,887 | - | 3,143 | 15,887 |
| 0.000 | Wind | - | - | 2,254 | 7,198 | - | 2,233 | 7,198 |
| 0.000 | Solar | - | - | 333 | 442 | - | 331 | 442 |
| | **total** | **2,069,642** | **-8,889** | **8,519** | **258,264** | **-11,962** | **10,086** | **606,215** |
| | | | **net carbon impact**<br>**257,894** | | | **net carbon impact**<br>**604,340** | | |

## Table A-1b. Reference generation (TWh) and results for Regimes A,B,C, and D at $10/tC. (cumulative through 2012)

| | | |
|---|---|---|
| **carbon price** | **$** | **10** |

| technology | Reference Case | Additionality Regime A | Additionality Regime B | Additionality Regime C | Additionality Regime D |
|---|---|---|---|---|---|
| | baseline generation TWh | change TWh | change TWh | change TWh | change TWh |
| Coal - current | 5,303 | -11 | -19 | -25 | -37 |
| Coal - advanced | 0 | 0 | 1 | 4 | 0 |
| Oil - CT | 419 | -1 | -1 | -2 | -3 |
| Oil - CC | 977 | -2 | -3 | -5 | -5 |
| NG CT- current | 1,266 | -3 | -4 | -6 | -9 |
| NG CT- advanced | 0 | 0 | 0 | 0 | 2 |
| NG CC - current | 2,954 | -6 | -10 | -14 | -12 |
| NG CC - advanced | 0 | 0 | 0 | 1 | 10 |
| Nuclear | 572 | -1 | -2 | 5 | 12 |
| Hydro | 1,792 | -4 | -6 | -4 | -3 |
| Biomass | 30 | 6 | 10 | 10 | 10 |
| Geothermal | 96 | 12 | 19 | 19 | 19 |
| Wind | 44 | 8 | 14 | 14 | 14 |
| Solar | 3 | 1 | 2 | 2 | 2 |
| | 13,455 | 0 | 0 | 0 | 0 |
| | baseline capacity MW | change MW | change MW | change MW | change MW |
| Coal - current | 117,739 | -242 | -417 | -556 | -821 |
| Coal - advanced | 0 | 0 | 33 | 92 | 0 |
| Oil - CT | 59,722 | -123 | -211 | -282 | -417 |
| Oil - CC | 25,337 | -52 | -90 | -120 | -127 |
| NG CT- current | 120,345 | -248 | -426 | -569 | -831 |
| NG CT- advanced | 0 | 0 | 0 | 0 | 159 |
| NG CC - current | 67,937 | -140 | -241 | -321 | -275 |
| NG CC - advanced | 0 | 0 | 3 | 18 | 238 |
| Nuclear | 10,490 | -22 | -37 | 96 | 218 |
| Hydro | 55,076 | -113 | -195 | -115 | -94 |
| Biomass | 844 | 175 | 291 | 289 | 287 |
| Geothermal | 2,103 | 255 | 425 | 422 | 416 |
| Wind | 2,601 | 493 | 819 | 815 | 807 |
| Solar | 195 | 89 | 147 | 147 | 146 |

**Table A-2a. Reference emissions (ktC) and results for Regimes A,B,C, and D at $100/tC. (cumulative through 2012)**

| carbon price | $ | 100 |
|---|---|---|

| | | Reference Case | Additionality Regime A | | | Additionality Regime B | | |
|---|---|---|---|---|---|---|---|---|
| carbon intensity | Technology | actual emissions | change in actual emissions | credits awarded to add'l projects | credits awarded for free rider projects | change in actual emissions | credits awarded to add'l projects | credits awarded for free rider projects |
| kgC/kWh | | ktC | ktC | ktC | ktC | ktC | ktC | ktC |
| 0.244 | Coal - current | 1,294,074 | -29,897 | - | - | -55,987 | - | 4,615 |
| 0.197 | Coal - advanced | - | - | - | - | 2,998 | 514 | - |
| 0.233 | Oil - CT | 97,500 | -2,253 | - | - | -4,218 | - | 0 |
| 0.155 | Oil - CC | 151,413 | -3,498 | - | - | -6,551 | - | 540 |
| 0.163 | NG CT- current | 206,293 | -4,766 | - | - | -8,925 | - | 0 |
| 0.127 | NG CT- advanced | - | - | - | - | - | - | - |
| 0.108 | NG CC - current | 320,362 | -7,401 | - | - | -13,860 | - | 1,142 |
| 0.098 | NG CC - advanced | - | - | - | - | 137 | 5 | - |
| 0.000 | Nuclear | - | - | - | - | - | - | - |
| 0.000 | Hydro | - | - | - | - | - | - | - |
| 0.000 | Biomass | - | - | 6,692 | 2,965 | - | 19,420 | 4,891 |
| 0.000 | Geothermal | - | - | 13,543 | 9,630 | - | 41,890 | 15,887 |
| 0.000 | Wind | - | - | 9,212 | 4,363 | - | 27,379 | 7,198 |
| 0.000 | Solar | - | - | 1,240 | 268 | - | 3,390 | 442 |
| | **total** | **2,069,642** | **-47,814** | **30,687** | **17,226** | **-86,406** | **92,598** | **34,716** |
| | | | **net carbon impact<br>99** | | | **net carbon impact<br>40,909** | | |

| | | Reference Case | Additionality Regime C | | | Additionality Regime D | | |
|---|---|---|---|---|---|---|---|---|
| carbon int. | Technology | actual emissions | change in actual emissions | credits awarded to add'l projects | credits awarded for free rider projects | change in actual emissions | credits awarded to add'l projects | credits awarded for free rider projects |
| kgC/kWh | | ktC | ktC | ktC | ktC | ktC | ktC | ktC |
| 0.244 | Coal - current | 1,294,074 | -73,038 | - | 24,353 | -103,095 | - | 18 |
| 0.197 | Coal - advanced | - | 8,510 | 2,033 | - | - | - | - |
| 0.233 | Oil - CT | 97,500 | -5,503 | - | 0 | -7,768 | - | 5 |
| 0.155 | Oil - CC | 151,413 | -8,546 | - | 2,849 | -9,243 | - | 11,444 |
| 0.163 | NG CT- current | 206,293 | -11,643 | - | 1 | -16,300 | - | 8,829 |
| 0.127 | NG CT- advanced | - | - | - | - | 2,024 | 615 | - |
| 0.108 | NG CC - current | 320,362 | -18,081 | - | 6,029 | -15,845 | - | 158,842 |
| 0.098 | NG CC - advanced | - | 755 | 80 | - | 10,738 | 7,330 | - |
| 0.000 | Nuclear | - | - | 10,748 | 47,229 | - | 23,841 | 94,458 |
| 0.000 | Hydro | - | - | - | 143,927 | - | - | 289,357 |
| 0.000 | Biomass | - | - | 19,085 | 4,891 | - | 18,495 | 4,891 |
| 0.000 | Geothermal | - | - | 41,094 | 15,887 | - | 39,692 | 15,887 |
| 0.000 | Wind | - | - | 26,903 | 7,198 | - | 26,063 | 7,198 |
| 0.000 | Solar | - | - | 3,338 | 442 | - | 3,245 | 442 |
| | **total** | **2,069,642** | **-107,547** | **103,280** | **252,807** | **-139,488** | **119,281** | **591,371** |
| | | | **net carbon impact<br>248,540** | | | **net carbon impact<br>571,164** | | |

## Table A-2b. Reference generation (TWh) and results for Regimes A,B,C, and D at $100/tC. (cumulative through 2012)

| | | |
|---|---|---|
| **carbon price** | **$** | **100** |

| technology | Reference Case | Additionality Regime A | Additionality Regime B | Additionality Regime C | Additionality Regime D |
|---|---|---|---|---|---|
| | baseline generation TWh | change TWh | change TWh | change TWh | change TWh |
| Coal - current | 5,303 | -123 | -229 | -299 | -422 |
| Coal - advanced | 0 | 0 | 15 | 43 | 0 |
| Oil - CT | 419 | -10 | -18 | -24 | -33 |
| Oil - CC | 977 | -23 | -42 | -55 | -60 |
| NG CT- current | 1,266 | -29 | -55 | -71 | -100 |
| NG CT- advanced | 0 | 0 | 0 | 0 | 16 |
| NG CC - current | 2,954 | -68 | -128 | -167 | -146 |
| NG CC - advanced | 0 | 0 | 1 | 8 | 110 |
| Nuclear | 572 | -13 | -25 | 65 | 144 |
| Hydro | 1,792 | -41 | -78 | -48 | -39 |
| Biomass | 30 | 67 | 118 | 116 | 112 |
| Geothermal | 96 | 135 | 254 | 249 | 241 |
| Wind | 44 | 92 | 166 | 163 | 158 |
| Solar | 3 | 12 | 21 | 20 | 20 |
| | 13,455 | 0 | 0 | 0 | 0 |
| | baseline capacity MW | change MW | change MW | change MW | change MW |
| Coal - current | 117,739 | -2,720 | -5,094 | -6,645 | -9,380 |
| Coal - advanced | 0 | 0 | 338 | 959 | 0 |
| Oil - CT | 59,722 | -1,380 | -2,584 | -3,371 | -4,758 |
| Oil - CC | 25,337 | -585 | -1,096 | -1,430 | -1,547 |
| NG CT- current | 120,345 | -2,780 | -5,207 | -6,792 | -9,509 |
| NG CT- advanced | 0 | 0 | 0 | 0 | 1,521 |
| NG CC - current | 67,937 | -1,570 | -2,939 | -3,834 | -3,360 |
| NG CC - advanced | 0 | 0 | 32 | 177 | 2,518 |
| Nuclear | 10,490 | -242 | -454 | 1,194 | 2,648 |
| Hydro | 55,076 | -1,272 | -2,383 | -1,469 | -1,189 |
| Biomass | 844 | 1,906 | 3,352 | 3,294 | 3,192 |
| Geothermal | 2,103 | 2,959 | 5,546 | 5,441 | 5,255 |
| Wind | 2,601 | 5,494 | 9,896 | 9,724 | 9,421 |
| Solar | 195 | 904 | 1,497 | 1,474 | 1,433 |

**Table A-3. Sensitivity of free rider estimates (Regime D) to key design characteristics**

| eligibility | | additionality testing | | baseline | |
|---|---|---|---|---|---|
| eligibility criteria | free-rider credits (MtC) | acceptance rate (%) | free-rider credits (MtC) | baseline emissions level (kgC/kWh) | free-rider credits (MtC) |
| all | 606 | 100% | 606 | 0.165 | 606 |
| no hydro | 311 | 75% | 455 | 0.145 | 479 |
| no hydro or nuclear | 217 | 50% | 303 | 0.125 | 367 |
| no hydro, nuclear, or fossil | 28 | 25% | 152 | 0.100 | 258 |