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Baselines for Greenhouse Gas Mitigation Projects in Central America

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Abstract

The Lawrence Berkeley National Laboratory (Berkeley Lab) and the Center for Sustainable Development in the Americas (CSDA) conducted technical studies and organized two training workshops to develop capacity in Central America for the evaluation of climate change projects. The work was sponsored by the U.S. Agency for International Development (USAID). The first workshop provided training on the use of two tools, MBase for the development of performance standards to estimate emissions reductions, and ProForm to assess the financial and environmental implications of climate change projects. The second workshop introduced participants to procedures for monitoring, evaluation, reporting, verification, and certification of greenhouse gas (GHG) emissions reductions. This paper describes the results of two baseline case studies, one for the power sector and one for the cement industry, that were devised to illustrate the MBase approach of baseline setting. Performance standards for the main Guatemalan electricity grid were calculated from data for 2000. In recent years, the Guatemalan power sector has experienced rapid growth; thus, a sufficient number of new plants has been built to estimate viable performance standards. We found that performance standards for baseload plants offsetting additional capacity ranged from 0.702 $kgCO_2/kWh$ (using a weighted average stringency) to 0.507 $kgCO_2/kWh$ (using a 10th percentile stringency). For power displaced from existing load-following plants, the rate is higher, 0.735 $kgCO_2/kWh$, as a result of the age of some plants used for meeting peak loads and the infrequency of their use. Due to the relatively small number of cement plants in the region and the regional nature of the cement market, all of Central America was chosen as the geographic boundary for setting cement industry performance standards. Unfortunately, actual operations and output data were unobtainable for most of the plants in the region, and many data were estimated. Cement industry performance standards ranged from 225 $kgCO_2$ to 205 $kgCO_2$ per tonne of cement.

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1. Introduction

1.1 GHG Mitigation Activity

Projects to reduce greenhouse gas (GHG) emissions below business as usual conditions are being advanced and considered under various national and international schemes. In the absence of emissions caps, hypothetical baselines must be calculated, against which to compare these projects' emissions. For example, the U.S. Department of Energy (DOE) is in the process of revisiting its reporting guidelines for the Voluntary Greenhouse Gas Reporting Program in an effort to improve its capacity to estimate avoided GHG emissions for use in potential tradable credit schemes (DOE, 2004). The U.S. Environmental Protection Agency (EPA) is looking at adopting guidelines for its Climate Leaders program for organizations that agree to meet GHG reduction targets. The World Resources Institute and the World Business Council for Sustainable Development have been working together to develop the GHG Protocol for estimating project-level GHG savings that could serve as an internationally accepted protocol. In addition, bilateral and international programs such as the Clean Development Mechanism, the Dutch government's Certified Emission Reduction Unit Procurement Tender, the Prototype Carbon Fund, and other preliminary carbon trading programs have provided guidelines for calculating avoided greenhouse gas emissions from mitigation projects.

1.2 GHG Mitigation Project Capacity Building in Central America

Staff from the Lawrence Berkeley National Lab (Berkeley Lab) have been working with the Center for Sustainable Development in the Americas (CSDA) and the U.S. Agency for International Development (USAID) to develop capacity in Central America to evaluate GHG mitigation projects in this region. As part of this work, Berkeley Lab, CSDA, and USAID organized two workshops in Central America to introduce stakeholders to a variety of publications and tools by the Berkeley Lab to assist project developers and program administrators with the implementation of GHG mitigation projects. The first workshop was held in Antigua, Guatemala in April 2003 and brought together more than thirty governmental, non-profit, private sector, and academic participants representing every Central American country to discuss various approaches to setting GHG performance standards.[1] The workshop introduced the MBase[2] spreadsheet tools (Sathaye et al., 2003; Murtishaw et al., 2003) for calculating performance standards in the electric power and cement industries. This workshop also covered the use of ProForm, a GHG mitigation project feasibility evaluation tool, which allows project developers, financial institutions and other parties to investigate how changes in basic assumptions affect key parameters of a project (Golove et al., 2004).[3] In addition to the presentations on these tools given by Berkeley Lab staff, participants were guided through practica, during which preliminary performance standards were created for several Central American countries and participants' own projects were evaluated using ProForm.

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[1] Performance standards are relative baselines expressed in units of GHG emissions per unit of output, such as $kgCO_2$ per kWh generated.

[2] MBase was developed with the financial support of the U.S. Environmental Protection Agency.

[3] Both MBase and ProForm are available free of charge from Berkeley Lab servers (see references for Golove et al., 2004; Murtishaw et al., 2003; and Sathaye et al., 2003 at the end of this paper).

The second workshop took place in San Salvador, El Salvador in May 2003 and focused on monitoring, evaluation, reporting, verification, and certification (MERVC) guidelines developed by Berkeley Lab for GHG mitigation projects (Vine and Sathaye, 1999). This workshop involved approximately fifteen participants from throughout Latin America, most of them from the private sector. The workshop covered all aspects of MERVC, and participants worked together to prepare and present several case studies.

This report focuses on findings of the Berkeley Lab study of the electrical grid in Guatemala and the cement sector in Central America. For the electricity sector, plant-specific operations data were collected in order to calculate various performance standards that represent the average emissions that may be expected to come online in the absence of mitigation projects. For the cement sector, issues of confidentiality impeded data collection for all plants in the region. In lieu of actual data, a theoretical baseline and two projects were fabricated to demonstrate the use of the tool for the cement industry.

1.3 Previous Performance Standard Studies

In previous studies (Sathaye et al., 2001; Sathaye et al., 2004), Berkeley Lab applied its baseline methodology to data for the power sectors of India and South Africa as well as the cement industries of China and Brazil. In the course of these studies, Berkeley Lab staff found that obtaining detailed plant operations data was not always possible. Some data had to be estimated on the basis of what was known about plant technologies and fuel choices. Once the necessary data were estimated, applying the methodology was straightforward and yielded interesting results. One challenge encountered in conducting the South Africa study was that the methodology is difficult to apply in cases where little recent construction has occurred. For the purposes of the study on the South African electricity sector, assumptions were made about the likely options for capacity expansion. These studies showed that, often, the most challenging aspect of calculating performance standards is collecting the plant-specific data necessary to evaluate recent trends in technology and fuel choice. Presumably, programs instituted by host country governments would have greater authority to obtain the necessary data.

2. Methodology

The basic methodological approach underlying MBase is to calculate performance standards based on the ratios of carbon dioxide emissions to product output emitted from existing plants.[4] These performance standards serve as approximations of emissions from sources displaced by GHG mitigation projects. The determination of a baseline requires the estimation of current and future activity (electricity generated or saved for an electricity project, or electricity or fuels saved for an industrial project) and emissions rates (e.g., kg C/kWh) under the reference case scenario.[5] Multiplying the activity and emissions rate yields an emissions baseline (kg C). Similarly, a project's emissions can be estimated as a function of the project's output and emissions rate. The estimated reduction due to the project is simply the difference between the

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[4] Planned units may also be included in the reference set of plants, but this introduces uncertainty with regard to actual plant completion, capacity utilization factors, and operating efficiencies.

[5] In this paper, we account only for emissions of CO_2, but we refer only to mass of carbon emitted. For the approximate mass of emissions of CO_2, multiply the emissions or emissions rates by 3.67.

project's emissions and the emissions that would have occurred to supply the same amount of electricity or produce the same amount of product in the reference case. For electricity, since grid operation and capacity planning are extremely complex, determining the precise sources of electricity offset by a given project poses a major challenge. For many industrial processes, multiple process steps and possible process emissions also make determination of precise sources of fuels or electricity offset by a given project taxing and cost-prohibitive.

One advantage to developing performance standards for a given grid or industry sector and region is that they can be used for any project on that grid or in that sector and region. There are several rationales for exploring the use of these multiproject baseline (MPB) approaches as an alternative to project-specific baselines. Most importantly, these approaches offer consistency across projects and rely on a transparent methodology open to all stakeholders. Another benefit is that developing MPBs helps to minimize transaction costs while ensuring environmental integrity. The higher transaction costs of setting project-specific baselines are likely to reduce the number of projects that attract investment, particularly for smaller renewable energy and energy efficiency projects. Experience with other project evaluations has shown that construction of project-specific baselines is time-consuming and costly, and can be highly uncertain.[6]

The performance standard values ultimately obtained depend heavily on which reference plants a project is compared to. There are four types of decisions that must be made to select the reference plants: geographic scope, plant vintage, fuel specificity, and stringency. Below we briefly describe the guidelines that were used for this analysis. A detailed explanation of the methodology used for determining performance standards for the electricity sector may be found in Sathaye et al. (2004).

The first decision that needs to be made is the geographic scope of plants to be included in the benchmark set. For the electricity sector, the scope should be determined by the extent of the grid since the emissions rates of electricity may differ substantially from one grid to another, and a new power plant is physically constrained to displacing power from other plants on the same grid. For Guatemala this is relatively straightforward, since there is relatively little trade in electricity with neighboring countries (Fundación Solar, 2002). Therefore, the Guatemala grid constitutes the grid in question. For the cement industry, the geographic scope is determined by the number of plants in a given region and the size and integration of the market served. One country in Central America would not have contained enough plants for a baseline and the cement used for projects in any of these countries is likely to come from any of the plants in the region. Therefore, the entire Central American region was chosen as the baseline for this study.

The second decision concerns the vintage of reference plants to use when constructing the performance standards. When recently built plants are used, a cut-off year must be chosen for plants to qualify as recently built. The cut-off year is somewhat arbitrary and may vary according to country-specific conditions. A tradeoff must be made between an overly restrictive cut-off

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[6] An evaluation of a number of World Bank-managed Prototype Carbon Fund projects found that the costs associated with preparing a project-specific baseline study and presenting a case for environmental additionality are about US$20,000 per project (PCF, 2000). Uncertainty related to calculation of emissions reductions using project-specific baselines has been estimated to range from ± 35% to ±60% for demand-side, heat supply, cogeneration, and electricity supply projects (Parkinson et al., 2001).

year that leaves too few plants to yield a representative sample and an overly inclusive cut-off that includes plants whose efficiencies or fuel sources are no longer indicative of plants being built today.

The third issue for determining the baseline is the fuel specificity of the plants to be used for comparison to the proposed project—plants of the same fuel type only, plants of another specific fuel type, or an average of all plants.

The fourth decision to make when estimating performance standards for projects is the stringency of the benchmarks. MBase generates four levels of stringency for build margins and industrial projects: weighted average, top 25th percentile, top 10th percentile, and best plant.[7] The weighted average is simply the reference plants' total sum of emissions divided by their total sum of output. The percentiles are calculated by ranking the plants within each fuel type from lowest emissions rate to highest, and using the emissions rate of the plant where 25% or 10% of the total generation occurs.[8]

3. Power Sector Results

3.1 Methodology Specific to the Power Sector

When determining the reference plant vintage for an electricity project, all units are included—regardless of age—for calculating the operating margin, since power may be displaced from any existing load-following unit. For build margins, the more recent baseload and load-following plants added to the grid are examined to give an indication of expected trends in the technologies and fuel sources that will be used in the near future. For some grids, however, the plants that will be built over the next several years may be significantly different from those recently constructed. This may be the case if a new technology has been introduced or if a new fuel source, such as natural gas, will become available. In this case, it may be preferable to use estimated data on planned capacity additions to produce a more accurate performance standard.

On grids for which no single fuel is predominant, large fluctuations in the build margin from year to year are likely. Guatemala's grid provides a good example, as shown in Table 1. There is a large variability from year to year in the average emissions rates of new baseload plants going on line. Average rates ranged from zero emissions in one year to a maximum of 1.039 kg CO_2 / kWh. Berkeley Lab has conducted an analysis of plant construction trends on several grids, including Guatemala's, to compare time series of build margins based on various ranges of plant construction (Murtishaw et al., 2004). Including plants built in additional numbers of prior years makes the average more stable and more representative of the range of resource options available to the grid. When there is a high degree of scatter in the data, it is important to use a large enough time period to yield a representative mean. Using multiple years offers a way to smooth over annual fluctuations in the type and sizes of power plants that might be built in a given year. We also found that a time series of build margins based on multiple years' worth of plants

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[7] The "best plant" stringency is only calculated for fuel-specific comparisons since, in the power sector, the best plant often will have zero emissions.

[8] Neither the fuel specificity nor the stringency decisions affect estimation of operating margin for the electricity sector, since this emissions rate reflects the actual emissions displaced from existing stations.

produces smaller prediction intervals around the performance standards due to a lower degree of scatter.

Table 1. Number and Capacity of New Baseload Plants in Guatemala, and One-Year, Three-Year, Five-Year, and Seven-Year GHG Emissions Build Margins (BM) in kg CO2 / kWh

Data	1994	1995	1996	1997	1998	1999	2000
New Capacity, MW	66	34	0	64	87	19	150
Number of Plants	2	1	0	3	3	1	2
One-yr BM	0.753	0.681	N/A	0.464	0.477	0.000	1.039
Three-Yr BM			0.735	0.530	0.474	0.383	0.744
Five-Yr BM					0.553	0.407	0.715
Seven-Yr BM						0.475	0.718

Circumstances that significantly affect the average emissions rate of plants built on a given grid may suggest a bound on the number of years' worth of plants to include in the reference set. There are four basic types of breakpoint events that may induce long-term changes in emissions characteristics of the plants built on a given grid: government policies, technological advances, changes in fuel supply, and market integration. See Murtishaw et al. (2004) for a fuller discussion of the causes and implications of break points.

Given the complexity of decisions regarding investments in new generation capacity, it is very difficult to demonstrate that a project displaces generation from any particular source. One way out of this dilemma is to take a weighted average of emissions rates of the recently built units, separated into baseload and load-following units, and use these rates as benchmarks for estimating baselines for all firm capacity power projects.

For the electricity sector, generation type must also be determined, in addition to the four criteria detailed above for all performance standard evaluations. The question is whether to differentiate performance standards based on differences in project generation profiles. For example, some projects provide intermittent power and may not always be able to generate power when needed. These types of projects are referred to as nonfirm power projects and may include sources such as wind power or energy efficiency projects whose impact on demand are not predictable. Since nonfirm generators cannot provide power on demand, they have relatively little effect on planning for future capacity. Thus, an argument can be made that their main impact is to reduce the need for energy from existing and future sources.

In contrast, firm power generating sources are able to reliably produce power on demand. These consist of two distinct types of technologies: baseload plants that operate at very high capacity factors and load-following plants whose output fluctuates according to demand. Baseload plants tend to be large plants with low operating costs, such as coal or nuclear plants. These plants require long lead times for construction. Load-following generators are generally smaller plants—often gas-fired turbines, reciprocating engines, or smaller hydro stations. Because of the differences in their emissions rates, baseload and load-following projects need to be evaluated separately, using reference plants of the same type. This distinction between the impacts of new projects on the operations of existing plants and the impact on the types of plants being built has been referred to as the operating margin and build margin effects (Kartha et al., 2002). For this case study, four different types of performance standards were generated: operating margin, load-following build margin, baseload build margin, and a combined build margin, which aggregates the recently built load-following and baseload plants.

3.2 History of Guatemala's Power Sector

The past two decades have been a tumultuous period for Guatemala’s power sector. In the 1980s, the publicly owned electricity sector in Guatemala became unable to finance the capital expenditures required for the sector’s sustainable growth and development. From 1959 to 1986, the power sector in Guatemala was completely state run (Fundación Solar, 2002). During this time INDE, the state power company, focused on developing Guatemala's indigenous power supply, which consists chiefly of hydropower. In 1986, INDE froze its investments due to a lack of outside financing. The Guatemala Congress attempted to promote private investment through the Renewable Energy Law of 1986. This law granted tax-exempt status for renewable energy projects. Several bagasse cogeneration and hydro projects, and some geothermal projects, were registered under this incentive law, but the law proved to be ineffective in attracting large-scale private investment. By 1990, 92% of electricity was still generated by state-owned facilities.

In the early 1990s, the system had reached its generation limits and daily blackouts were common. International agencies joined in support of a new electricity regulatory framework. As consultations on developing a new structure dragged on, the energy crisis deepened. INDE began to offer extremely generous purchasing conditions to private sector companies willing to invest immediately in electricity generation. Between 1993 and 1996 private generators entered into power purchase agreements (PPAs) with INDE, opening electricity generation to private investment. Thirteen generation contracts were signed, including 178 MW of renewable energy projects (small hydro and bagasse co-generators) and 201 MW of fossil fuel projects. Due to the energy crisis and the high risks for investment in Guatemala, INDE was allowed to enter into long-term (15-year) PPAs without meeting requirements for competitive pricing (Fundación Solar, 2002).

In October 1996, the Congress of Guatemala passed the General Electricity Law. The law defined a new structure for the country’s energy sector and further reformed the electric power market, allowing the private sector to participate in all sectors of the energy market. The law gave private companies unrestricted direct access to the power grid, distributors, and wholesale customers, and provided for a general unbundling of generation, transmission, and distribution. It created the new regulatory commission and defined the wholesale power market. Privatization of state-owned electric companies began with the selling off of INDE and the state distribution company, EEGSA. The state, however, retained ownership of the transmission company.

Between 1997 and 2002, 569 MW were added to the national grid (AMM, 2003a). Only 80 MW of this additional capacity were from renewable energy projects. The privatization of power supply in Guatemala resulted in a sharp increase in the use of large reciprocating engines burning heavy fuel oil, whereas prior to that, the bulk of the power serving the Guatemalan main grid was from hydro stations. This is a common phenomenon when private entities begin to invest in generation, since private investors will seek to minimize their risk by constructing plants with low capital costs and short construction lead times. In addition, existing combined heat and power (CHP) facilities in the sugar industry began to generate excess electricity for sale to the grid. These facilities burn bagasse when it is available and heavy fuel oil for supplying power to the grid when bagasse stocks are exhausted. Figure 1 depicts how rapidly capacity was installed after the introduction of the PPAs and, again, with the 1996 power sector restructuring. It also makes clear the dramatic fuel shifts that occurred with the influx of new investments.

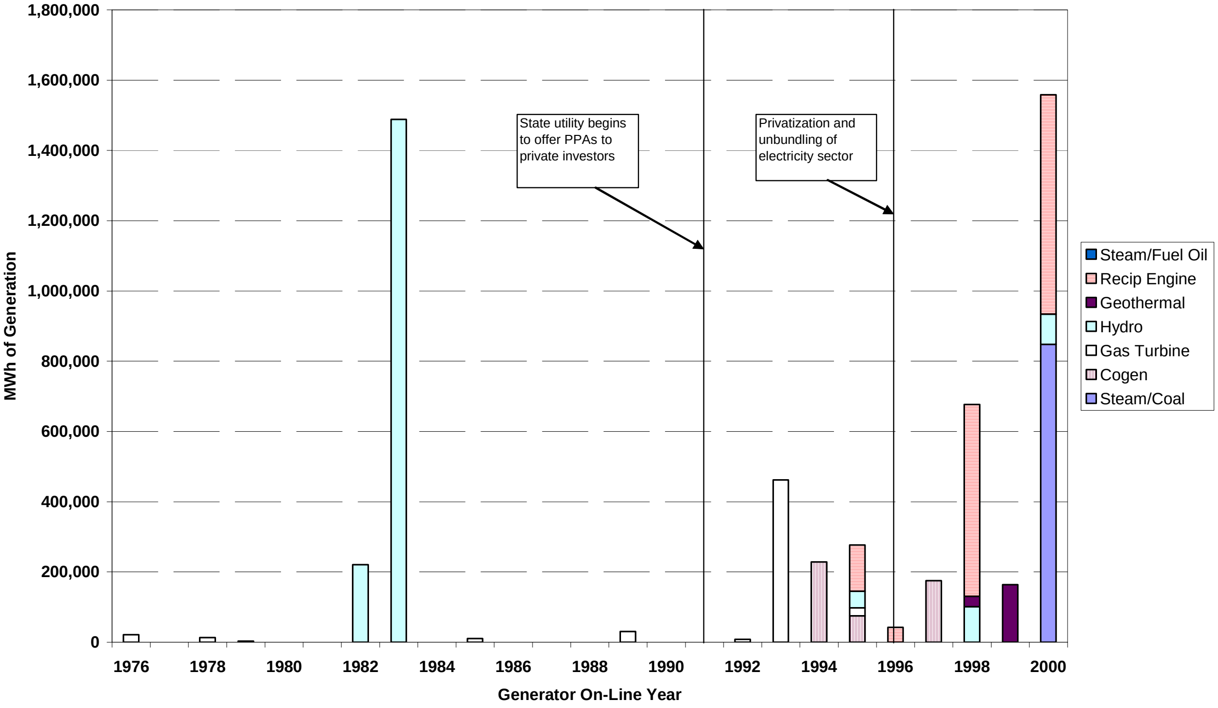

Figure 1. Generation in Guatemala in 2001, by Generation Type and On-line Year

Data on the net generation and fuel consumption for all plants that were operational for the full year during 2001 were used to construct performance standards for the Guatemala grid. The plant-specific fuel consumption data were confidential data provided by the Guatemala Ministry of Energy and Mines (MEM). Data for the fuel oil consumed for electricity delivered to the grid by cogeneration facilities were provided by the Guatemala Cogenerators' Association. The final data set consists of 37 plants. These plants were separated into baseload and load following units based on their capacity utilization factors, supplemented with detailed dispatch information from Guatemala’s Major Market Administrator (AMM, 2003b).

3.3 MBase Results for the Guatemala Grid

The Electricity Law of 1996 constitutes a clear break point for Guatemala’s grid, since it has had such a profound impact on the recent and continuing development of capacity additions. Of the 37 plants operational in 2001, 13 went online between 1996 and 2000. We used these plants to calculate the baseload and load-following build margins. For the hydro plants, detailed daily dispatch curves were examined in addition to capacity utilization to see how the plants were actually dispatched throughout the day. Based on the criteria established to classify the plants, only three plants (one hydro and two reciprocating engine plants) were designated as load-following plants. The ten plants constituting the baseload reference set are a diverse mix of coal, hydro, geothermal, bagasse, and heavy fuel oil cogen, and reciprocating engines burning heavy fuel oil.

Table 2. Performance Standards (kgCO_2/kWh) for the Main Guatemala Grid Using a Five-Year Build Margin

Type of Performance Standard	Weighted Average	Top 25th Percentile	Top 10th Percentile
Baseload Build Margin	.702	.643	.507
Load-Following Build Margin	.567	N/A	N/A
Combined Build Margin	.689	.633	.510
Operating Margin	.735	N/A	N/A

Table 2 lists all of the sector-wide performance standards generated by MBase. The baseload build margins represent the average characteristics of the baseload plants built in recent years. The large drop from the 25th to the 10th percentile is due to the performance of the best cogenerating stations, which burned significant amounts of bagasse. Since only three load-following plants were constructed during this period, there were not enough reference points to calculate meaningful percentile performance standards for load-following plants. The weighted average of the load-following plants is much lower than the average for the baseload plants, due to the inclusion of the coal plant and even the more carbon intensive cogenerating stations that burned mostly fuel oil for grid-delivered power. Since many offset programs may not differentiate between baseload and load-following projects, we also present the combined build margins of all thirteen plants. It is weighted more heavily toward the baseload build margin as a result of the greater number and capacity of baseload units.

The operating margin consists of the average emissions rate of all the thermal plants whose generation is relatively responsive to changes in the system load. These plants consist of the two fossil-fuel burning load-following plants that were recently built, as well as all of the diesel-burning gas turbines (which are all used at very low capacity factors), some of the older reciprocating engines, and a couple of older oil-burning steam turbines. The inefficiency of the older plants and the infrequency of their operation lead to very high emissions rates, which explains the high figure for the operating margin.

3.4 Comparison of MBase Results to Two Previous Studies

Two previous studies have also provided estimates of avoided CO_2 emissions due to additional renewable energy projects in Guatemala (Friedman, 2000; PCF, 2003a). Data limitations hindered the calculation of baselines for an unpublished report for the U.S. EPA (Friedman, 2000). Assumptions about operating efficiencies for some plants had to be made since the author of this report was not able to obtain actual fuel consumption data. This report also does not distinguish between baseload and load-following build margins. It found a combined build margin of plants built over the same five-year period as our study (1996–2000) of 0.750 kgCO_2/kWh. This is about 10% higher than the combined build margin we calculated but, given the limited data used for the EPA report, a difference of this magnitude could be expected. The EPA report also does not treat operating margins per se, but it does discuss some characteristics of the wet and dry season dispatch curves. As a rough approximation of the operating margin, an average emissions rate of 0.900 kgCO_2/kWh is given based on the average efficiency of the oil-fired generators. This figure is significantly higher than our calculation, but the exact calculation for the EPA report is not given. Thus, this discrepancy cannot be explained.

A baseline study for a project seeking support from the Prototype Carbon Fund (PCF) in Guatemala for a small hydro project assumes that the station will only have an impact on the operating margin (PCF, 2003a).[9] The baselines method assumes that power from the hydro plant is equally likely to have an impact on any of the plants that operate on the margin on the main Guatemala grid, which they define as all heavy and distillate fuel oil plants. Their method weights the existing plants by capacity, not actual generation, and thus overstates role of some of the older turbines, which are run at very low capacity factors. The figure derived from this calculation is 0.810 kgCO_2/kWh, roughly 10% higher than the operating margin calculated by MBase. The MBase operating margin, however, is weighted by the actual generation of the units, which should more closely approximate the impact of reduced demand for marginal generation throughout the year.

3.5 Discussion

As shown in Figure 1, the introduction of private investment to Guatemala's power sector had a profound impact on its total generating capacity as well as its fuel mix. This breakpoint event set a bound on the vintage of plants that one would include in the set of reference plants, since plants constructed before the breakpoint are no longer representative of the types of plants likely to be constructed in the near future. Two other events may constitute a breakpoint that will affect future performance standards. One is the completion of the San Jose coal-fired power plant, the first in Guatemala, in 2000. Since Guatemala has no indigenous coal supply, it must import the coal it uses for this station. In order to do so, special receiving facilities had to be constructed at Puerto Quetzal (TWG, 2003). Presumably, now that facilities have been established to receive and process coal, it is more likely that coal-fired power plants may be constructed in the future. This may represent a significant fuel mix break point that leads to higher GHG performance standards from 2000 on. Similarly, a planned regional transmission line (known as SIEPAC) would constitute a market integration break point since new power for distribution in Guatemala could come from any of the other five participating Central American countries, broadening the resource base for future power needs. However, it is uncertain when this project will be completed (PCF 2003b).

4. Cement Sector Results

4.1 Central America's Cement Sector

The cement industry contributes annually about 5% to CO_2 emissions globally, making it an important industry for CO_2 mitigation projects. In addition to its large contribution to global CO_2

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[9] It is interesting to note that the final Project Description Document (PCF 2003b) for the project baseline study cited in PCF 2003a asserts the project's additionality on the basis of coal-fired generation being the least-cost alternative for capacity expansion but uses the operating margin from the baseline study to estimate emissions reductions. Thus, the argument for additionality rests on the assumption of a build margin effect, whereas the estimated emissions reductions are based on an operating margin effect. This contradiction is not explained in the project proposal.

emissions, the cement industry has many opportunities for efficiency improvements (Worrell et al., 2001; Worrell and Galitsky, 2004; Worrell et al., 2004). Like many developing regions, Central America has seen growth in the cement industry in the last decade. Thus, mitigation projects are likely to emerge in Central America in the near future. Unlike the electricity sector, only one cement plant is currently operated in Guatemala. This fact, combined with the presence of regional trade in cement, implies the need to use a broader geographic region. For these reasons, all plants in Central America were used to set the performance standards.

The cement sector has been changing rapidly over the past decade in Central America, with three major foreign companies — Holcim Ltd, CEMEX S.A. and Lafarge S.A. — now owning most of the plants in the region. This has changed from 1996, when these three companies owned only 6 of the 12 plants in operation at that time. Table 3 shows the current distribution of plants and their ownership as well as ownership circa 1996 (when the last complete set of data from Cembureau was published). Today, there are ten cement plants in Central America and one grinding plant (Cembureau, 1996; Gutiérrez, 2003; Holcim, 2004). One of the plants operational in 1996 has been shut down.

Figure 2 shows the production of cement in Central America from 1993 to 2001. Because data sources were incomplete for later years, some individual plant production data were approximated based on previous years to obtain a total for 2001. Through our contacts with the industry, we were able to obtain more accurate and up-to-date data for the Holcim plants in Central America. These data are shown in Figure 3. Both Figures 2 and 3 show that production of cement has increased in the last decade. Holcim has shown an 80% increase from 1993 to 2002 for four plants in the region.

Table 3. Cement Industry Overview

Country	Company	Plant	Owner/s	Previous Owner/s
Costa Rica	Industria Nacional de Cemento SA (INCSA)	Aguacaliente	Holcim	Holcim
	Cementos del Pacifico SA	Colorado	CEMEX, 80%	CEMEX, 80%
	Cementos del Pacifico SA	Patarrá	CEMEX	CEMEX
El Savador	Cemento Maya SA	Cantón Tecomapa	Holcim	CESSA
	Cementos de El Salvador SA (CESSA)	El Ronco	Holcim	Partly by 450 El Salvadorans, partly by Holcim
Guatemala	Cementos Progreso, SA	San Miguel	Holcim	family owned
	Cementos Progreso, SA	La Pedrera	N/A*	family owned
Honduras	Cementos del Norte SA de C.V.	Rio Bijao	Holcim	Holcim
	Industria Cementera Hondureña SA (INCEHSA)	Pedras Azules	Lafarge	Lafarge
Nicaragua	Compania Nacional Productora de Cemento SA (CANAL)	San Rafael Del Sur	State owned, CEMEX operated	State owned, CEMEX operated
Panama	Cemento Panama SA	Quebrancha	Holcim	Corporación Incem
	Cemento Bayano	Calzada Larga	CEMEX	CEMEX (95%), employees (5%)

Source: Cembureau, 1996; Gutiérrez, 2003; Holcim, 2004.
*No longer in operation.

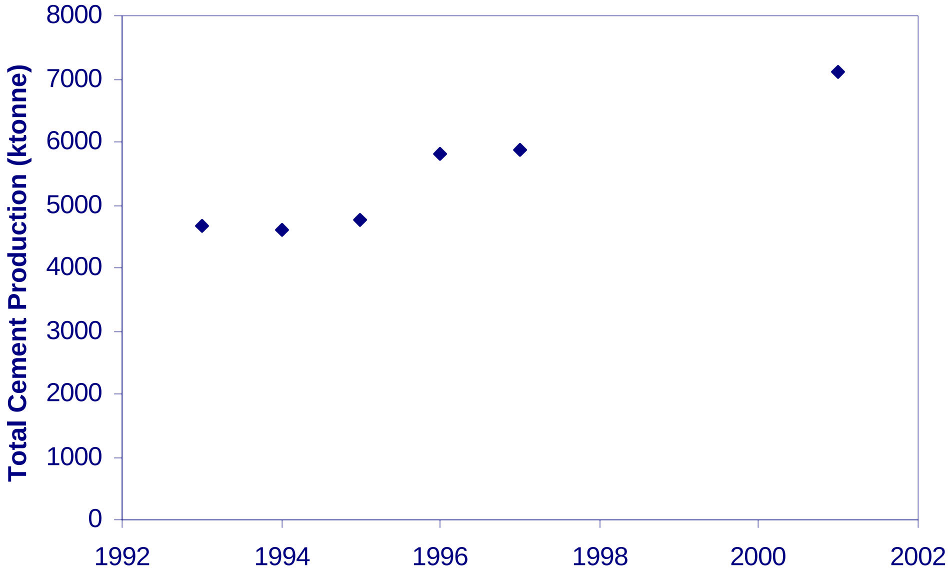

Figure 2. Total Production of Cement in Central America from 1993 to 2001

Source: Cembureau, 1996; Gutiérrez, 2003.

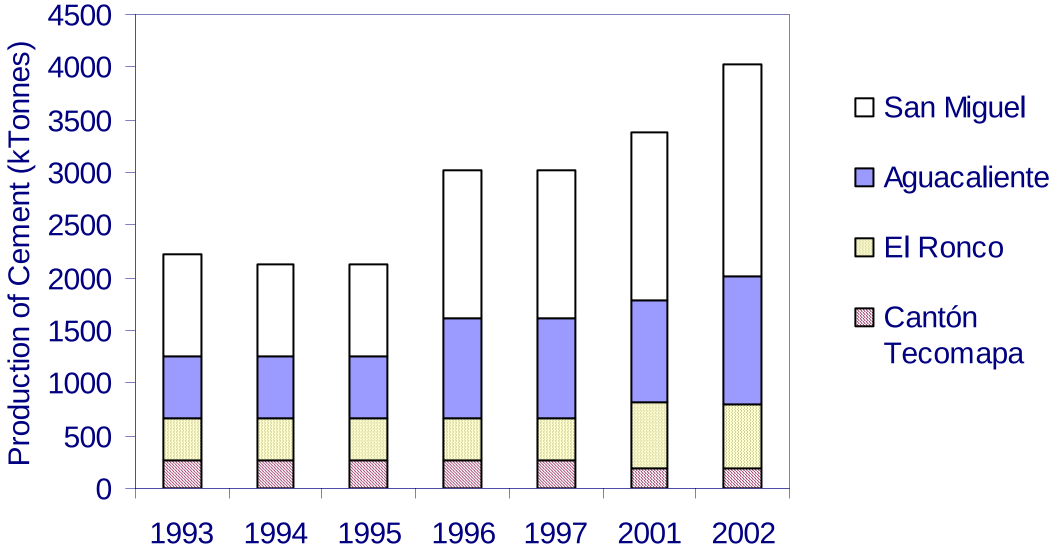

Figure 3. Production of Cement by Holcim Plants in Central America from 1993 to 2002

Source: Cembureau,1996; Gutiérrez, 2003.

Clean Development mechanism (CDM) and Activities Implemented Jointly (AIJ) projects have already been proposed for this region. For example, Cemento de El Salvador, S.A. (CESSA) participated in an AIJ CO_2 reduction project that resulted in replacement of its wet kiln with a new, larger, dry kiln, eliminating about 0.19 tonne of CO_2 per tonne of clinker (UNFCCC, 2004). In this project, the current plant was used as the baseline. The development and use of MBase for cement allows for the use of a multiproject baseline for a more transparent, consistent, and less costly comparison where data are available.

4.2 Methodology for the Cement Sector

In addition to the questions posed above in Section 2, in the development of any industrial sector performance standards, it also is necessary to determine which process steps are to be included, and whether or not to include process emissions in the calculations of total carbon emission reductions, where applicable.[10]

The first version of MBase Cement was developed for a study of projects based in China and Brazil (Sathaye et al., 2002). In this version, three stages of production were included in the model: grinding and homogenizing raw materials, kiln operation for clinker production (or pyro-processing), and finish grinding of the final cement product. Process-based emissions from the calcination of limestone were not included in this first model. The current version of MBase

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[10] In cement production, the calcination of lime produces CO_2 as a byproduct. However, most industries do not produce process-based emissions.

Cement incorporates processed-based emissions as well as two additional energy-consuming process steps.

Blended cements are cements that use a higher ratio of blended materials than the 5% used in the most common type of cement, known as Portland cement. By reducing the clinker to cement ratio—increasing the amount of additives used in cement—the CO_2 intensity (CO_2 per tonne of cement) is also reduced, not only by decreasing energy requirements, but also by reducing process-based emissions.

In the current version of MBase, two sets of emission reductions are calculated instead of just one: emission reductions based solely on energy efficiency upgrades (as in the original version of MBase Cement), and emission reductions that combine reductions from energy efficiency upgrades with process-based emission reductions prompted by increasing the amount of blended components used. Process-based emissions are calculated based on the clinker to cement ratio. Actual calculations in the new version of MBase use the clinker to cement ratio of the baseline set and of the project to determine the process emission reductions from using more blended materials.

Two process steps have been added to MBase Cement. The first step was added to account for the fuels required for drying any additives used in blended cements. This seemed a necessary addition once process-based emissions were included (see above). This step is only applicable to some cement production because not all additives are dried.[11] The second addition was made to the clinker production stage. In the first version of MBase, this stage included the fuels required to operate the kiln, but it did not include any electricity requirements for kiln operation. In the current version of MBase, both fuel and electricity requirements are included in the model for this step.

4.3 Central America Cement Case Study

Similar to the electricity sector, one goal for the cement industry project was to create a baseline, given appropriate data for plants in the Central American region. Based on contacts with industry and the workshop held in Antigua, Guatemala (April, 2003), we were able to collect data on four plants in the region—all owned by Holcim. Unfortunately, due to the lack of plant data for the remaining six plants in the region, we were unable to construct a credible baseline for the entire industry in Central America.

In lieu of creating an actual baseline for the region, we composed a set of hypothetical plants based on a reasonable representative set of recently built plants in the region in order to illustrate the MBase features. Just as in an actual baseline data set, our baseline plants were "chosen" based on vintage (1971–2001), geographical scope (Central America) and fuel specificity (all fuels). Two hypothetical projects were also created. The first project (project #1) was a retrofit of a kiln to a new highly efficient one. The second project (project #2) implemented the same energy-efficient kiln but also incorporated blended cements at the plant (at a clinker to cement ratio of 80%, versus 95% for project #1). Total carbon emissions for the two projects as well as

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[11] Portland cements, e.g., generally only use pozzolans as additives, which do not need to be dried. Only blast-furnace slag generally needs to be dried prior to use in cement making.

the baseline plants were calculated (at varying levels of stringency), taking into account process emissions from the calcination process. These results are shown in Figure 4.

Both projects reduce emissions when compared to the least stringent baseline (a weighted average). However, because process emissions are included in the calculations for carbon emissions, project #2 shows a reduction in carbon emissions at each stringency level, whereas project #1 only reduces emissions at the weighted-average stringency.

In order to evaluate actual cement carbon emission reduction projects for Central America, more data are needed for construction of the baseline. For those companies or regions that have access to data that will permit a calculation of the baseline, MBase Cement can be used as an evaluation tool for carbon emission reduction projects in the cement industry.

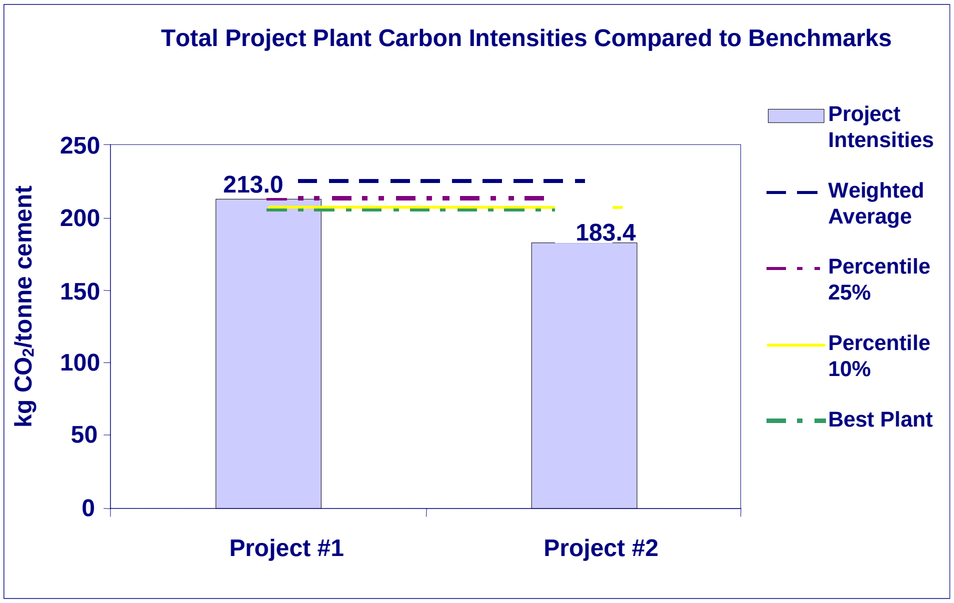

Figure 4. Carbon Intensities for Two Hypothetical Plants Compared to Estimated Baselines for the Central American Region

4.4 Discussion

Due to the lack of plant data, we were unable to create a real set of performance standards for the Central American region. In order to have successful data collection efforts in the future, it will be vital to involve companies from the start of a project and engage them on the development of the model. Working with the cement industry attendees at the Guatemala workshop allowed us to explain and verify the manner of calculating carbon emission reductions and energy efficiency in the model, as well as to make the tool more useful for their companies by presenting the data in a manner that was consistent with industry norms. For example, including process emissions in this version of MBase Cement was well received at the workshop by the cement industry. By seeing the usefulness of our model, they were more willing to work with us to obtain the data that were needed to create a baseline for their industry. In the end, the workshop attendees were the source for all of the detailed data examined in this study.

5. Conclusions

This study has shown that using MBase, or a similar multiproject method, is a viable approach for calculating baselines for the Guatemala power sector. Using performance standards may facilitate the evaluation of GHG mitigation projects in Central America, where projects under consideration have tended to be smaller renewable energy projects. In recent years, there has been sufficient capacity expansion to produce meaningful results for build margins. The results of this study were found to agree, approximately, with those of two previous studies (Friedman, 2000; PCF, 2003a). However, the current study used a more complete data set to derive its marginal emissions rates. There were not enough load-following plants constructed during the period examined to yield results for various stringencies other than the weighted average. For the baseload and combined build margins, the higher stringencies had a marked effect on lowering the performance standards. The level of stringency a program administrator ultimately chooses may depend on local circumstances that are likely to affect the carbon intensity of future sources of generation.

This study has also shown that using MBase, or a similar multiproject method, is a viable approach for calculating baselines for the cement industry. However, because it was not possible to collect data for a sufficient number of plants in the Central America region to create a reliable baseline, a hypothetical baseline had to be created. Access to more data would enable the creation of a baseline and would provide a relatively inexpensive, transparent, and consistent alternative for evaluating GHG mitigation projects in the Central American cement industry.

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