Setting Mitigation Goals for Sectoral Programs: A Preliminary Case Study of Mexico’s Cement and Oil Refining Sectors

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Although the study has been carried out with support from the European Commission, the views expressed do not necessarily represent the opinion of the EC.

In addition, although this analysis has been reviewed by various government and industry officials in Mexico, the views expressed and the sectoral goals proposed here do not represent the official position of the Government of Mexico.

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I. Introduction

Paragraph 1(b) of the Bali Action Plan calls for enhancing mitigation action with respect to climate change through consideration of “\textit{nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner.}”

The forms that these nationally appropriate mitigation actions (NAMAs) can take must still be defined, but discussion is centering around three general classes of NAMAs:

- **Unilateral NAMAs** – NAMAs that a country intends to implement completely on its own but for which recognition of this effort is desired.

- **Conditional NAMAs** – NAMAs, or portions of NAMAs, that will only be implemented with the help of international assistance, in the form of financing, technology transfer and/or capacity building. Such a NAMA could represent a more ambitious version of one of the unilateral NAMAs, for which assistance is needed for the incremental effort, or it could be completely unrelated to the proposed unilateral NAMAs; in either case, the necessary support would also have to be specified.

- **Carbon Market NAMAs** – NAMAs that are eligible for support through full or partial crediting in the carbon market.

The process by which a developing country would officially declare its NAMAs has yet to be determined, but it has been proposed that each developing country put forward a climate plan or low-carbon growth strategy\textsuperscript{1} that describes the NAMAs that it intends to implement. Sectoral programs, categorized in the Bali Action Plan as \textit{“cooperative sectoral approaches and sector-specific actions,”} could be a part of the developing country’s plan or strategy. These types of programs allow a developing country to continue to grow their industries, but in a more climate-friendly manner and without compromising the country’s sustainable development.

A sectoral program could consist of a single NAMA or a group of associated NAMAs designed to achieve a sectoral goal. Under the sectoral approach assumed in this policy brief, the sectoral goal would include both a unilateral component – the sectoral goal that the country will adopt if it receives no international assistance – and a more ambitious, “no-lose” goal that the country will pursue under specific provisions of international assistance. If the country does not reach its no-lose goal, no penalties would accrue; however, if it beats this goal, the excess emission reductions would be eligible for sale in the carbon market.

\textsuperscript{1} The latter has been proposed by the European Commission in its “Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Towards a comprehensive climate change agreement in Copenhagen,” January, 2009 (available at \url{http://ec.europa.eu/environment/climat/future_action.htm}).


To implement such a sectoral program, a country must be able to determine unilateral and no-lose goals that are ambitious but which it considers to be fair and feasible to achieve. In theory, setting such goals under a sectoral program can basically be viewed as a four-step process:

1. Develop a business-as-usual emissions baseline;
2. Evaluate the emissions reduction potential and implementation costs for mitigation options in the sector;
3. Determine the barriers to implementation of each mitigation option; and
4. Utilize the information from the first three steps to devise reasonable goals for the sector in terms of:
   a. Unilateral effort (barriers to implementation of the required mitigation options can be completely overcome without international assistance); and
   b. A conditional, no-lose goal and the assistance needed to achieve this mitigation level, in terms of finance, technology or capacity-building.

Of course, the final and most important stage of any sectoral program is implementation. This involves developing a plan for the country to achieve the goals set for any given sector – determining the policies, programs or other enabling activities that must be put in place to allow the country to reach its sectoral goals.

In reality, this sectoral goal-setting process could prove to be quite complicated. Some industries may span a broad range of practices, and substantial variations may be present within and across countries. Data quality and completeness may vary widely, and issues of competition and antitrust may make some desired data unavailable. It may indeed be the case that “one size fits all” is unattainable. Conceivably, in some situations it may even be the case that no size fits.

In an effort to advance the state of knowledge of sectoral programs, the Center for Clean Air Policy – Europe (CCAP) is leading a consortium of partners and consultants in a “proof-of-concept” study, funded primarily by the European Commission, of sectoral programs in energy-intensive sectors in China, Mexico and Brazil. Some of the key questions being addressed by this Sectoral Study are:

- What impact can sectoral programs have on greenhouse gas emissions, both globally and for individual developing countries?
- What data is available for the sectors being analyzed in each country?
- Is this data sufficient to perform the analysis needed to set sectoral goals and determine the need for international support?

As part of the Sectoral Study, the project team is undertaking the initial efforts to determine potential sectoral goals for specific sectors in Mexico and China. However, before moving on to a discussion of the details of sectoral goal-setting, it is important to introduce two critical aspects of sectoral programs that the Sectoral Study has helped to

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2 The study partners are the Centre for European Policy Studies (CEPS, Brussels), Climate Change Capital (CCC, London), the Center for European Economic Research (ZEW, Mannheim, Germany), and the Institute for Sustainable Development and International Relations (Iddri, Paris).
illuminate – the types of sectoral goals that could be adopted and the need for flexibility in developing sectoral goals.

At the initiation of the Sectoral Study, emissions intensity goals were thought to be the most practical option for a developing country because these allow for growth in the sector but require that growth to proceed in a more climate-friendly manner. However, consultations with Chinese officials led to the development of an alternative type of sectoral goal – the technology-deployment goal. This type of goal would specify the extent to which an emissions reduction technology or practice is deployed within a sector by a given date. Under many circumstances, such a goal would be more straightforward to implement and the progress toward the goal would likely be easier to monitor, report and verify. If the goal is met and exceeded, the emissions impacts could still be quantified, and CERs could be awarded for the excess emission reduction. The Sectoral Study is now considering the potential for both emissions-intensity and technology-deployment goals as the associated analysis of each sector is performed.

In addition, flexibility is important in setting sectoral goals. Countries should be permitted to design a sectoral program to suit their needs, taking into account their national circumstances and data availability. For example, sector boundaries should be allowed to be expanded beyond some base boundary specification, as long as data is collected and emissions are reported and monitored in a manner consistent with both the base boundary conditions and the newly proposed boundaries.

Each of these issues is discussed further in this policy brief, which presents two important components of our Sectoral Study work to date – a first attempt to develop sectoral goals for Mexico’s cement and oil refining industries and some of the lessons learned along the way. In the following sections, each of the four steps of the sectoral goal-setting procedure is discussed more fully, and the process of developing preliminary goals for these sectors in Mexico is described. The focus here is on a general discussion of the analytical work because many of the data and/or quantitative results remain confidential. Readers that are primarily interested in the general lessons learned during the Sectoral Study can skip to Section VII.

II. Business-as-Usual Baselines

Business-as-usual (BAU) baselines can be determined in either a bottom-up or top-down fashion. If plant-specific historical data is available, this can be extrapolated and summed to produce the aggregate emissions of the sector, taking into account expected plant retirements, plant retrofits and new builds. Alternatively, sector-wide historical data on fuel use, production, and other parameters can be similarly used to calculate the baseline. The latter method is generally much simpler and just as accurate, as long as it can account for changes in the structure of the sector over time (plant retirement and construction, natural improvements in production technologies and processes, etc.).
In determining business-as-usual (BAU) baselines, the behavior of a number of variables must be considered for the period of interest. These include:

- Production levels of final, and potentially intermediate, products;
- Emissions mitigation efforts already planned, including CDM projects;
- Production capacity, including the construction of new facilities, retrofitting of existing facilities, and retirement of existing facilities;
- Production technologies, processes and practices employed;
- Fuel use by fuel type; and
- Electricity use.

Ideally, this data would be available at the unit or plant level to allow the most accurate determination of potential sectoral goals. Estimates or extrapolations will be required if the data is more aggregate in nature.

II.A The Cement Sector in Mexico

For the Mexico cement industry, the historical data needed to calculate the BAU baseline was generally not provided by the industry itself but was acquired through a variety of publicly accessible resources. In this manner, some plant-level data was acquired for CEMEX cement plants (slightly more than half of the cement production in Mexico), but none were available for other facilities in the sector. The basic data and assumptions that went into the baseline projections were:

- **Production:** 38.8 Mt cement in 2007 and assumed to smoothly increase at the average growth rate exhibited from 2000-2007 (2.93% per year).³
- **Clinker fraction of cement:** 80.19% in 2006, the average clinker fraction of all cement plants in Mexico, except those owned by Holcim Apasco,⁴ and assumed to remain constant at this level.
- **Production capacity:** 52.85 Mt cement in 2007,⁵ which is sufficient to meet clinker demand through 2020. Since the Mexico cement industry is relatively young, no cement plants were therefore expected to be constructed or retired before 2020. This may be an unrealistic expectation, but no information was available that would indicate when a new facility would be needed or built prior to that time. We are currently trying to gain more insight into this issue.
- **Energy intensity of clinker production:** 3.515 GJ/t clinker in 2007, the average value for all CEMEX cement plants,⁶ which agrees with values presented by the

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⁶ Calculated from data in spreadsheet accompanying CDM Project Design Document, 2007. “Project 1356: Reducing the Average Clinker Content in Cement at CEMEX Mexico Operations” (available at [http://cdm.unfccc.int/Projects/DB/SGS-UKL1190380419.97/view](http://cdm.unfccc.int/Projects/DB/SGS-UKL1190380419.97/view)).
IEA; because this is the second most energy-efficient cement production in the world, behind only that of Japan, and since no new cement plants were assumed to be needed before 2020 (see the previous bullet point), this energy intensity was assumed to remain constant.

- **Alternative fuel use:** No data was available for alternative fuel use, so tires were assumed to make up 1.5% of the fuel mix. We are continuing to research the use of alternative fuels in Mexico’s cement kilns because we have anecdotal evidence that their consumption is significantly greater than this. However, this evidence also suggests that a large fraction of these alternative fuels are sludges and similar wastes with very high carbon content, so the emissions benefit of their use is expected to be small.

- **Fuel mix:** The fuel mix was calculated from the fuel use in 2006, after incorporating the consumption of alternative fuels.

- **Emissions factors (EFs):** Fuel EFs were taken from the IPCC, and an EF of 87.3 tCO$_2$/TJ was used for tires.

- **Emissions intensity of electricity use for cement production:** 0.06167 tCO$_2$/t cement in 2007 and assumed to remain constant at this level.

- **Emissions intensity of calcination (process emissions):** 0.528 tCO$_2$/t clinker and assumed to remain constant at this level.

Using this data, the emissions baseline for the Mexico cement sector was calculated in the following manner:

- **Clinker production** = (cement production) x (clinker fraction)
- **Energy use** = (clinker production) x (energy intensity of clinker production)
- For each fuel type, fuel energy = (energy use) x (percentage of fuel mix)
- For each fuel type, CO$_2$ emissions from fuel use = (fuel energy) x (fuel EF)
- CO$_2$ emissions from electricity use = (emissions intensity of electricity use for cement production) x (cement production)
- Process CO$_2$ emissions = (emissions intensity of calcination) x (clinker production)
- Total CO$_2$ emissions = CO$_2$ emissions from fuel use + CO$_2$ emissions from electricity use + process CO$_2$ emissions

The final BAU baseline for the Mexico cement sector shows CO$_2$ emissions rising by approximately 49% between 2006 and 2020.

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9 2006 IPCC Revised Guidelines: Chapter 2. Stationary Combustion; Table 2.3
11 Ibid.
II.B The Oil Refining Sector in Mexico

The methodology used to develop the emissions baseline for the oil refining sector was quite different than that adopted for the cement sector. Here, emissions were derived from a widely-used energy intensity metric developed by Solomon Associates, a firm that has determined benchmarks for the performance of oil refineries and a relative index that allows efficiency comparisons to be made among oil refineries of similar types and characteristics. These diagnostics are confidential but are used by nearly all major oil companies around the world to assess and track the performance of their refineries. For our work in Mexico, the Solomon Energy Intensity Index (EII) has been used as the metric for each refinery’s energy efficiency.

Of course, the Solomon EII is a measure of energy efficiency, not GHG intensity. GHG intensity can vary not only with the quality of the crude oil input, but also with the slate of outputs produced and the various environmental controls installed. By using the Solomon EII as a proxy for GHG intensity, we capture the energy-related changes in GHG intensity but may miss some opportunities resulting from changes to the input and/or output mixes.

For this sector, most of the data came directly from PEMEX, the national oil company in Mexico, which provided the following data/information:

- Actual CO\(_2\) emissions for each refinery in 2007
- Quantity of crude oil input for each refinery in 2007
- Solomon EII of each refinery in 2007
- Solomon EII for its refineries as a group in 2007
- Projected crude oil input for each refinery for 2008-2012 (including the impacts of a reconfiguration of their Minatitlan refinery in 2009)
- Emissions reduction estimates for retrofit projects planned for implementation from 2008-2012
- Approximate schedules for refinery upgrades, construction of a new refinery, and the introduction of low-sulfur transportation fuels
- A general plan for retrofit projects from 2012-2017

The procedure for estimating the BAU baseline of the Mexico oil refining sector was then as follows:

- CO\(_2\) emissions were assumed to scale with crude oil input.
- Because the overall Solomon EII for Mexico’s refineries appeared to be an emissions-weighted sum of the EII’s of the individual refineries, the Solomon EII was assumed to scale with CO\(_2\) emissions.
- Because there were only small fluctuations in the annual crude oil input projections for each refinery from 2010-2012, the annual input from 2013-2020 was assumed to be the same as that in 2012.
- Projected crude oil inputs were used to derive CO\(_2\) emissions projections. The final emissions baseline resulted after adjusting the initial projections for:
  - The emissions reductions from projects planned for implementation from 2008-2012;
The production of low-sulfur fuels (assumed to occur in 2012 and cause a 20% increase in CO₂ emissions beginning in that year);
- The new refinery (assumed to come on-line in 2013, with an annual crude oil input of 300,000 barrels per day and a Solomon EII of 100); and
- Upgrades at two other refineries (which were assumed to increase capacity by 30,000 barrels per day in 2015 with not impact on the Solomon EII).

For oil refining in Mexico, the BAU baseline developed here projects that CO₂ emissions will grow by about 58% between 2007 and 2020.

### III. Mitigation Options

In considering mitigation options that could be adopted under a sectoral program, it is important to evaluate as broad a set of options as possible, particularly if international assistance is requested. This allows the proposed mitigation goal to be fairly evaluated by the international community and provides greater assurance that there is no “low-hanging fruit” that could be used to achieve a sectoral goal more easily than indicated under the proposed program.

Given the data available for the Mexico cement and oil refining sectors, we could not evaluate as detailed or comprehensive a set of mitigation options as we would have liked for either sector. However, our analysis and discussions with Mexican stakeholders led us to conclude that, out of the universe of mitigation options, many resulted in small emissions reductions and/or were high in costs, and a small number of actions stood out as the high-value opportunities. For this preliminary attempt at the development of sectoral goals, we concentrated our analysis upon such opportunities, but we expect to incorporate a wider range of mitigation options in future versions of this work.

#### III.A The Mexico Cement Sector

For the initial analysis of the Mexico cement sector, the following mitigation options were considered:
- Increased cement blending
- Improved energy efficiency of cement production
- Reduced use of electricity per ton of cement produced
- Offsetting electricity used for cement production with electricity generated from renewable resources
- Increased use of alternative fuels (tires only)

For the second phase of this goal-setting exercise, we will expand the list of mitigation options included in the cement sector analysis. As discussed above, the availability and use of various types of alternative fuels will be a particular focus here, but we intend to add fuel switching and carbon capture and sequestration (CCS) as well.
III.A.1  Mitigation Potentials

To determine the emissions reductions that could be achieved with each mitigation option listed above, we first estimated how far each of these options could be feasibly implemented in the Mexico cement industry between 2013 and 2020. The maximum deployment levels that we adopted were:

- Energy efficiency (EE) of 3.0 GJ/t clinker (similar to the best in the world)
- Clinker percentage of 72.3% (blending proposed in CEMEX CDM PDD\textsuperscript{12})
- Electricity intensity (EI) of 80 kWh/t cement (approximately 2/3 of the difference between the current level and industry best practice\textsuperscript{13})
- Complete offset of electricity use with electricity produced by wind power
- Alternative fuel use increasing to 50% of fuel mix

These deployment scenarios produced the mitigation potentials shown in Table 1. Note that the first entry in this table (Scenario 0) shows the BAU baseline emissions level.

Table 1. Mitigation results for maximum deployment mitigation scenarios

<table>
<thead>
<tr>
<th>Scenario Number</th>
<th>2020 Mitigation Scenario</th>
<th>Emissions (MtCO\textsubscript{2})</th>
<th>Reduction from BAU</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Baseline (BAU)</td>
<td>41.63</td>
<td>0.00</td>
</tr>
<tr>
<td>1</td>
<td>EE = 3.0 GJ/t clinker</td>
<td>39.54</td>
<td>2.09</td>
</tr>
<tr>
<td>2</td>
<td>Clinker fraction = 0.723</td>
<td>37.87</td>
<td>3.76</td>
</tr>
<tr>
<td>3</td>
<td>EI = 80 kWh/t cement</td>
<td>40.52</td>
<td>1.11</td>
</tr>
<tr>
<td>4</td>
<td>Electricity 100% offset by RE</td>
<td>38.15</td>
<td>3.48</td>
</tr>
<tr>
<td>5</td>
<td>Alternative fuels (tires) = 50%</td>
<td>40.69</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Two of the mitigation scenarios in Table 1 were not considered further as potential sectoral options. Scenario 3, an improvement in the electricity intensity of cement production was omitted because achieving this scenario (1) would produce relatively modest emissions reductions in 2020, (2) would be very difficult to achieve, and (3) would be more costly and less appealing to the Mexican cement industry than Scenario 4, which also addresses CO\textsubscript{2} emissions from electricity use. In addition, since a very large increase in the use of alternative fuel, in the form of tires, did not produce a significant decrease in emissions in 2020, this mitigation option was not considered further (but it is important to note that this option may have more potential than estimated here; we will be able to evaluate this more fully when more data and a wider selection of alternative fuels is included in our future work).

This left energy efficiency, wind power, and cement blending as the promising options to consider in setting sectoral goals for the Mexican cement sector.

\textsuperscript{12} CDM Project Design Document, 2007. “Project 1356: Reducing the Average Clinker Content in Cement at CEMEX Mexico Operations” (see \url{http://cdm.unfccc.int/Projects/DB/SGS-UKL1190380419.97/view}).

### III.A.2 Mitigation Costs

Determining the emissions reduction in 2020 for a mitigation option only requires full implementation by 2020, without concern for the manner in which this implementation occurs. However, determining the net present value (NPV) of the cost of adopting that option requires knowledge of the implementation schedule and lifetime of the measure. For each of the three promising mitigation options in Table 1, the NPV of the cost of full implementation was calculated in the following manner, assuming a smooth, linear deployment of each option from 2012 through 2020 and a lifetime of 20 years:

- **Scenario 1:** On average, the energy efficiency of a CEMEX cement plant in 2006 was approximately equal to that of a kiln fitted with a 3-stage preheater but no precalciner.\(^{14}\) Worrell et al. (2008) show that adding a precalciner to a dry kiln with preheaters will improve energy efficiency by an average of 0.43 GJ/t clinker at an average cost of $18.70 per ton of cement capacity.\(^{15}\) It was assumed that this type of measure represented the average upgrade required for a cement kiln in Mexico to achieve Scenario 1 in Table 1. Fuel savings (and associated emissions reductions) were assumed to come from petcoke having an energy content of 7775 kcal/kg and a price of $58/ton.

- **Scenario 2:** Increasing the degree of cement blending was assumed to cost $1.5 million per cement plant in up-front capital costs.\(^{16}\) Blending materials were assumed to cost $22.50 per ton\(^ {17}\) and require transport of 501.44 km\(^ {18}\) at a cost of $0.06 per ton per km.\(^ {19}\) Fuel savings (from reduced clinker production) were calculated in the same manner described for Scenario 1.

- **Scenario 4:** The renewable energy option was assumed to be profitable, given that CEMEX is already pursuing such projects under the CDM and quotes an IRR of 11.76% on an investment of $395 million for a 249 MW wind farm.\(^ {20}\)

The overall result of this cost analysis was that Scenario 1 is extremely expensive, Scenario 2 has modest cost, and Scenario 3 is likely profitable (although the rate of return remains somewhat uncertain).

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\(^{14}\) FL Smidth, 2006. *Cement Plant Pyro-Technology* (as cited by the Centro Mario Molina in a report prepared for CCAP).


III.B  *The Mexico Oil Refining Sector*

A comprehensive analysis of the available mitigation options for oil refining in Mexico was beyond the scope of the *Sectoral Study* to date. However, since the country’s oil refineries are not particularly energy efficient (as measured by the Solomon EII), the most promising mitigation options were expected to be energy-efficiency measures. These could range from relatively small, individual projects to the most significant energy efficiency option, energy integration. The latter involves an extensive examination of the energy use at a refinery and leads to a reconfiguration of the refinery in a manner that allows the energy to be more fully utilized through better integration of the operations so that energy lost in one step of the refining process can be recycled and used in some other part of the refinery.

The other significant mitigation option that PEMEX has great interest in pursuing is co-generation. PEMEX is currently constructing a 300 MW co-generation facility, CPG Nuevo Pemex, but has the capacity to build a total of about 3100 MW. Such facilities allow PEMEX to more efficiently produce the steam that it needs for its operations and to also generate electricity in a cleaner manner than the typical power plant in Mexico.

III.B.1  *Mitigation Potentials*

PEMEX is in the process of developing a strategy for its refining operations through 2017 that includes a number of energy efficiency projects. Although this plan is still confidential, the overall impact of the planned projects on the sector’s Solomon EII in 2017 is approximately known and implies an emissions reduction of about 1.18 MtCO$_2$ in that year (3.3% of BAU). The mitigation potential for energy integration has initially been estimated to be 1.72 MtCO$_2$ per year (more than 4% of BAU in 2020) by the World Bank as part of its MEDEC study.\(^\text{21}\)

Based upon the emissions reductions expected from the CPG Nuevo Pemex facility, installing the full 3100 MW of co-generation would prevent the emission of 9.7 MtCO$_2$ annually; this would be 23% of the estimated BAU emissions from oil refining in 2020.

III.B.2  *Mitigation Costs*

The mitigation costs for the individual, post-2012 energy efficiency projects were not provided by PEMEX and were not calculated here. Instead, these were assumed to be similar to the costs for energy efficiency projects that PEMEX plans to implement prior to 2012. Thus, it was assumed that PEMEX would not need any type of financial or other support to undertake these efforts. On the other hand, the cost of performing energy integration at each refinery in Mexico, taken from a draft version of the MEDEC study performed by the World Bank,\(^\text{22}\) is substantial.

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\(^{22}\) Ibid.
For co-generation, the net costs of implementation are uncertain because these depend upon the price that PEMEX would be paid for its excess electricity generation. However, these operations appear to be highly profitable if PEMEX can get a reasonable rate from the national utility for the surplus electricity that it supplies to the grid.\textsuperscript{23}

\textbf{IV. Barrier Analysis}

A developing country is often unable to implement (or more fully implement) important mitigation options because the associated costs are prohibitive. However, in most developing countries, there are also mitigation options available that appear to be cost-effective or profitable but which are not being adopted. This is generally due to some specific domestic barrier to implementation, such as an overly restrictive legal framework or non-cost financing constraints. To develop a feasible strategy for implementing a sectoral program, it is critical to determine the actual barriers to implementation for each of the promising mitigation options so that the proper policy and incentive structure can be developed and the associated need for international assistance assessed.

\textit{IV.A The Mexico Cement Sector}

In Mexico, the barriers to implementation of the three promising mitigation options in the cement sector are the following:

- **Scenario 1:** Cost is the primary barrier. Making the cement kilns more energy efficient is expensive and would therefore not be a normal business practice.

- **Scenario 2:** Both cost and an insufficient supply of blending materials are potential barriers for this option. However, the primary barrier discussed by CEMEX in their CDM PDD was the need for scientific laboratory research to determine exactly how to perform the blending process so that the fraction of clinker can be reduced while retaining the structural integrity of the cement.

- **Scenario 4:** There are a number of potential impediments to the construction of renewable energy facilities. First, the up-front capital costs are a likely barrier. If this is the only barrier, then pursuing this option may simply require loans that are paid back through revenue generated from electricity sales – such loans could be (1) provided through direct international assistance, or (2) enabled through capacity building or the establishment of specific entities to help Mexican banks make such loans. Second, the revenue stream could be insufficient to make these ventures profitable over the long term or to make them attractive to investors. For example, the CEMEX PDD argues that its wind farms will be profitable but that the rate of return is insufficient to attract the necessary investment, so this may present an additional financial hurdle to overcome. Since the IRR is dependent upon the price that CFE, Mexico’s national electricity utility, is allowed to pay for electricity (it is required by law to purchase at least cost), it’s not clear that the international community would

\textsuperscript{23} Ibid.
be willing to provide financial resources to support this option; it may instead expect Mexico to reform its electricity pricing laws, and in fact, Mexico recently passed a new law that allows CFE to consider the costs of externalities in determining “least cost.” The rules for incorporating externalities into the pricing structure have not yet been developed, but these new rules are likely to make renewable energy projects more attractive to investors without any type of additional incentive (such as CDM CERs).

IV.B The Mexico Oil Refining Sector

The primary barrier to implementing mitigation options at any PEMEX facility is the manner in which its budget is determined. PEMEX is publicly owned, and the high taxes and royalties that it pays are the major source of revenue for the Mexican government. Until recently, PEMEX has not been allowed to enter into joint ventures with private-sector companies, so its funding has been restricted to what is provided in its annual budget by the Finance Ministry. The size of this budget is much less than the revenue that PEMEX provides to the government, and the budget is also very specific in terms of where the allocated funds can be spent. For funding considerations, energy efficiency projects tend to get low priority for two reasons. First, because PEMEX is such an important source of revenue for the government, it is critical to keep its oil production from falling. However, production from its existing fields is diminishing, so exploration for new sources of oil is its top priority, and its budget is therefore heavily weighted toward these efforts. Energy efficiency projects, on the other hand, are generally viewed as simple maintenance projects and are thus considered to be much less important. Second, there is a general perception among PEMEX officials that the company would not reap the benefits of cost-saving projects – there is no real incentive to make energy efficiency projects a higher priority because the savings in fuel costs would accrue to the government, not to PEMEX itself. The fear is that these cost savings would actually lead to future budget cuts for PEMEX, as its operating costs would decrease.

For co-generation, an apparently profitable venture, there are two primary barriers to implementation. The first is similar to that described for energy efficiency projects – making co-generation a high enough priority to obtain the needed capital funding through the PEMEX budgetary process. The second relates to the legal structure of the electricity sector in Mexico. Electricity producers in Mexico that are not a part of CFE or Luz y Fuerza del Centro, the supplier for Mexico City, can be classified as independent power producers (IPPs), self-suppliers, co-generators, and small suppliers. Specific rules and regulations apply to each of these types of producers. The CPG Nuevo Pemex facility will not quite produce sufficient electricity to supply all PEMEX operations with their power needs, so in this case, PEMEX’s electricity costs decline significantly because it only pays CFE a small fee for transmission of the portion of its electricity production that is used at sites other than the generation site. However, the next co-generation facility that PEMEX builds will produce enough electricity to supply the remainder that PEMEX needs plus a significant excess. Under these circumstances, CFE has the option but not an obligation to purchase this excess generation, and it is only required to pay the least short-term cost, a very low price, for the electricity that it would buy from PEMEX.
Thus, additional PEMEX cogeneration facilities face significant cost barriers that CPG Nuevo Pemex did not. PEMEX could potentially spin off an entity to produce electricity as an independent power producer, but it is not clear whether this is truly feasible or helpful, for a variety of reasons. For example, independent power producers must guarantee a specific generation capacity be available to CFE on demand, but it would be difficult for PEMEX to make such a guarantee. Since the steam production needed by PEMEX must be assured but will vary over time, its power generation will also fluctuate, so the supply of electricity that it would be could guarantee to CFE is uncertain. Both the feasibility and profitability of PEMEX cogeneration under an IPP requires further study.

V. Goal-Setting

After determination of the most promising mitigation options, calculation of their implementation costs, and identification of any non-cost barriers to their adoption, sectoral goals can be developed and proposed. As mentioned previously, this should include the consideration of different types of goals, both emissions-intensity and technology-deployment goals, for each sector being analyzed.

V.A The Mexico Cement Sector

For Mexico’s cement sector, the initial proposal for the unilateral emissions-intensity goal for 2020 was based upon full deployment of Scenario 2 (cement blending), as this option can be implemented at a reasonable cost to the industry and does not face significant additional barriers to implementation. Reaching this goal would reduce CO\textsubscript{2} emissions in 2020 by about 2.1 Mt (5.0%) from BAU.

For the sectoral no-lose goal, we proposed an emissions intensity that was equivalent to full implementation of all three promising mitigation options. Financial assistance would be requested from the international community to help Mexico implement Scenario 1, the energy efficiency upgrades, and in return, Mexico would agree to implement the cement blending and renewable energy measures to the full extent described in Table 1. If this goal is achieved, CO\textsubscript{2} emissions in 2020 would fall by about 9.2 Mt (22.1%) from BAU.

The estimated BAU emissions for the cement sector in Mexico are shown in Figure 1, as are the emissions pathways corresponding to a gradual progression toward the proposed unilateral and no-lose goals. These proposed sectoral goals (and the methodology used in their development) have also been shared with the Mexican cement industry. Based upon the valuable feedback received from this group, the sectoral goals are in the process of being revised.
V.B The Mexico Oil Refining Sector

For oil refining, it was apparent that separate goals should be established for energy efficiency and co-generation, since these are represented by different metrics, and co-generation has the capacity to produce emissions reductions far in excess of those needed to offset the emissions associated with the electricity used by PEMEX.

For energy efficiency, it was assumed that the projects that make up the PEMEX strategy through 2017 would be part of the sector’s unilateral goal, as PEMEX expects to be able to obtain funding for these. Since projects beyond these would likely be more expensive but probably not excessively so, the oil refining unilateral goal was set by (1) assuming that the trend in energy efficiency improvement expected from 2012-2017 would continue to 2020, and then (2) pushing this effort slightly further. Achieving this goal would reduce emissions in 2020 by about 2.6 MtCO$_2$ (10.5%) from BAU.

The final proposed no-lose goal was set at the efficiency level that is the ultimate goal of PEMEX (and which is confidential). This goal could potentially be achieved through energy integration because the expected emissions reductions from this measure are approximately the same as the difference between the proposed unilateral and no-lose goals; however, this would be costly. There may also be other measures that were not considered here that will allow the no-lose goal to be met. Meeting this goal would produce emissions reductions of approximately 4.5 MtCO$_2$ (19%) from BAU in 2020.
Figure 2 presents the estimated emissions from Mexico’s oil refining industry if the proposed goals are achieved.

![Figure 2. CO\textsubscript{2} Emissions in the Mexico oil refining sector for the BAU baseline and for the proposed unilateral and no-lose goals.](image)

For co-generation, the proposed sectoral goal was technology-based, rather than being emissions-based, and was dependent upon whether the price that PEMEX can garner for the electricity that it generates is high enough to allow these ventures to be profitable. If it is, then it was proposed that PEMEX would commit to the full 3100 MW of co-generation but would request international assistance, in the form of loans, to cover some portion of the up-front capital costs and to accelerate the construction of these facilities (given that the government, under the current PEMEX budgetary process, would likely need to stretch the funding for these projects over a very extended timeframe). However, if PEMEX cannot get a profit-making price for its electricity, then it would instead pledge to construct only a fraction of the full co-generation potential, again supported by international loans. Emissions reductions produced by co-generation that is deployed by PEMEX beyond this initial pledge would be eligible for sale in the carbon market. If necessary, the international community could make the provision of the loans contingent upon policy reform in Mexico that provides PEMEX a sufficient price for its generated electricity to allow it to use the revenues from its electricity sales to repay the loans.

**VI. Implementation**

Mexico has chosen a trans-sector cap-and-trade system plus policy reform to reach its sectoral goals. The cap-and-trade system will initially include the oil and electricity
sectors (with cement and iron and steel to be added later), and the goal is to have this system operational by 2011. In addition, Mexico has adopted new laws that (1) give PEMEX more flexibility in the use of its budget and its pursuit of joint ventures with private entities, and (2) allow CFE to include the costs of externalities in its definition of the “lowest-cost” electricity.

A future step in the analytical process described here is to determine the best way to convert the proposed sectoral goals into sectoral caps for a cap-and-trade system. Emissions-intensity goals, for example, can easily be converted into caps under the assumed BAU scenarios for cement production and oil refining, but a system will need to be put in place to adjust these caps over time to account for differences between actual production and BAU expectations. In addition, the proposed goals will need to be reexamined and revised because they assume that each sector is pursuing mitigation opportunities in isolation. Under a trans-sector cap-and-trade program, a determination will need to be made regarding overlap between some of the promising mitigation options for the oil refining and cement sectors – cogeneration and wind energy, respectively – and the power sector. Such projects will either need to be carved out of the electricity sector’s boundaries, or they will need to be covered under the electricity sector cap. The best ways to address these types of issues requires further analysis.

VII. General Lessons Learned

As mentioned previously, CCAP undertook this exercise to develop proposals for sectoral goals for Mexico as part of a “proof-of-concept” study of sectoral programs. The key objective was to see if it was feasible to determine acceptable sectoral goals from the existing data. During this process, many lessons have been learned, and the most important of these are discussed here.

**Lesson 1:** Significant data gaps exist. The general lack of unit-level or plant-level data and cost data, and concerns about confidentiality means that we cannot create intensity goals based on extensive plant-specific data. Instead we’ve had to build the targets using data from a variety of sources, making informed estimates to fill the data gaps, and adopting general rules of thumb for mitigation potentials and costs, based upon existing research into technology benchmarks and performance levels. This is not surprising, as the EU faced similar circumstances in the pilot phase of their Emissions Trading System, when data on industry emissions and mitigation costs was lacking.

**Lesson 2:** There is no substitute for in-depth bottom-up analysis and consistent data. Capacity building for developing countries needs to begin immediately to help them to systematically acquire the data needed to perform the analysis required to set sectoral goals and justify any request for international support.

**Lesson 3:** As the exercise described in this paper shows, even when data is limited, reasonable sectoral goals can potentially be determined. Setting such goals with incomplete data can also stimulate greater interaction, cooperation and feedback from the...
affected industries, as they want to assure that the sectoral goals are equitable and feasible to achieve.

**Lesson 4:** Goals should not be rigidly limited to sector-wide emissions-intensity goals. As we found from the analysis of oil refining, an energy-intensity metric was a satisfactory proxy for the GHG emissions intensity. Technology-based goals can be more effective in some settings, are generally easier to implement, and can serve as transitional goals while data capacity is built. However, determining the emissions credits to be earned from beating a technology-deployment goal is obviously less straightforward and could be more uncertain than for emissions-intensity goals.

**Lesson 5:** Flexibility is important in setting sectoral goals; these should take into account national circumstances and data availability. For example, in Mexico, using atypical sector boundaries for cement production and oil refining can allow a greater suite of mitigation options to be accessed. Use of both emissions-intensity and technology-deployment goals may do the same for some sectors in some countries.

**Lesson 6:** Energy efficiency does not always imply a lack of mitigation opportunities. For example, even though Mexico’s cement industry is the second most energy efficient in the world, it still has some significant potential for emissions reductions through blending and other measures.

**Lesson 7:** Bottom-up analysis of the barriers to cost-effective options can uncover the need for tailored incentives (e.g., Mexico barriers to co-generation) and needed links to policy reform. Such barriers are not evident from a simple depiction of a McKinsey cost curve, for example. For measures that appear to be cost-effective but face other barriers to their adoption, support can be made contingent on policy reform that removes these roadblocks.

**Lesson 8:** The key to any sectoral program is implementation – what policies and measures will a country adopt to achieve its sectoral goals?

**Lesson 9:** Setting sectoral goals in developing countries will be similar to setting caps in Annex I countries – it will be both a policy and political negotiation process.

**VIII. Future Work**

The *Sectoral Study* extends through March of 2010, and the upcoming phase of work will involve revising the cement and oil refining sectoral goals for Mexico, as well as working to develop similar types of goals for the electricity, iron and steel, and non-refining oil sectors. CCAP will also continue to perform this type of goal-setting exercise for Mexico after the conclusion of the *Sectoral Study*. In China, our in-country analysts at Tsinghua University have produced initial case studies of the energy-intensive sectors there and are now focusing on the determination of technology deployment goals for China’s cement, iron and steel, and electricity sectors. An update of the Mexico and China target-setting exercises will be presented at future UNFCCC meetings in 2009 and 2010.