Mexico AND Emerging Carbon Markets

Investment Opportunities for Small
and Medium-size Companies
and the Global Climate Agenda

Commission for Environmental Cooperation

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ISBN: 2-922305-57-0

Legal Deposit-Bibliothèque nationale du Québec, 2001
Legal Deposit-Bibliothèque nationale du Canada, 2001

Disponible en français - ISBN: 2-922305-59-7
Disponible en español - ISBN: 2-922305-58-9

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Acknowledgements

This report has been prepared by several individuals and organizations. The research initiative in Mexico was led by Cathleen Kelly, Senior Policy Analyst, Center for Clean Air Policy together with Edmundo de Alba of Consultor Ambiental Internacional, Edward A. Hoyt, Director General, EIC Consultores de México, S.A. de C.V., and Miguel Breceda. From the Commission Secretariat, the report was prepared by Scott Vaughan, Chantal Line Carpentier and Zachary Patterson of the Environment, Economy and Trade program. The authors are grateful to Barbara Ouimet for editing and proofing this report.

Views expressed in this report do not necessarily reflect those of the parties to the Commission for Environmental Cooperation, or of the Secretariat. Any errors are those of the authors of the CEC Secretariat.

Preface

When the environmental agenda began to take shape, many feared that countries that adopted high levels of environmental standards would find themselves at a competitive disadvantage. Although the echoes of this debate between strong economic performance or high levels of environmental protection continue, there is a very strong body of empirical evidence suggesting that such a dichotomy between either a strong economy or a strong level of environmental protection is not valid. More and more companies are adopting different kinds of environmental targets and benchmarks within their operations. They are doing this not simply because it makes environmental sense, but because it makes business sense as well.

Among the most exciting areas in which the green agenda is affecting business perceptions and practices is in the financial services sector. Although the traditional focus of environmental policy has been on pollution-intensive sectors alone, there is a growing body of evidence suggesting that financial markets—and the array of actors within those markets, from commercial banks to venture capitalists, from equity investors to insurers, from large portfolio investors to producers who support "green" or sustainable objectives—are paying more attention to environmental issues, and are positively affecting the environmental agenda in the process.

Perhaps no single environmental policy challenge is as great as climate change. The purpose of this report—the first in a series of reports intended to provide information to the financial services sector on key environmental issues in North America—is to identify potential financing opportunities in Mexico related to the climate agenda. It is my firm belief that by engaging the private sector in the environmental agenda, in defining cooperative approaches that combine regulatory measures with incentive-based and market-led approaches, innovative and cost effective solutions will be found that meet our shared demand for the highest levels of environmental quality.

Janine Ferretti, Executive Director, CEC

Executive Summary

Over the past decade, progress has been made in identifying environmental policies that are effective in ensuring high levels of environmental quality, as well as cost effective. There is growing recognition that a "menu" of policy approaches—one that weaves command-and-control regulations with the use of various incentives and market-based instruments—can be highly effective in meeting environmental challenges.

Nowhere is this search for a combination of approaches more evident than in international efforts to address climate change. As a global environmental problem, climate change has spawned intensive work to define and codify approaches combining domestic measures to address the problem, with efforts designed to facilitate cooperation at the international level.

The logic behind the use of various "flexible" mechanisms at the international level to address climate change is widely recognized. Differences in the marginal costs of reducing greenhouse gases (GHG) emissions vary significantly between countries. In particular, marginal costs differ between industrialized countries—the source of the majority of GHG emissions—and economies in transition or developing countries. By way of illustration, some estimates show that the cost per ton of carbon [emissions] that is reduced in industrialized countries is in the vicinity of US$35–50 per metric ton. In contrast, the estimated cost to reduce a metric ton of carbon [emissions] in developing countries is in the range of US$10 ton or less.

Since 1997, an enormous amount of work has focused on elaborating how the Kyoto Protocol is likely to proceed. At the time of this report's publication, the operating details of the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC), despite domestic setbacks in the United States, awaits the resumption of the Sixth Conference of the Parties, to be held in Berlin in mid-2001.

Discussion of any legal matters related to the UNFCCC lies entirely outside of the scope of this report. Rather, the purpose here is to identify in broad terms the potential investment opportunities within Mexico in the context of what appears to be an emerging global market in which the buying or selling of tons of carbon (emissions, or their equivalent) continues. The jury remains out on exactly how large this international market already is, what its near-term growth potential will be, what rules will define how the market will function, or what the equilibrium price of a ton of carbon will likely be. However, while international negotiations to clarify administrative rules and procedures continue, considerable efforts are already underway by the private sector in addressing climate change. Indeed, companies on a growing list have decided that the challenge of climate change is real, that the solution will rely partly on the leadership from the private sector,

and that an international market related to climate change is quickly evolving and is likely to reward front-runners on the climate agenda. For example, some estimates suggest that under the Clean Development Mechanism (CDM)—the mechanism under the Kyoto Protocol by which Annex 1 countries and non-Annex 1 countries can undertake cooperative climate-related policies—the potential market for carbon-offset policies could be between US$5 billion and US$17 billion per year by 2010 (Austin et al., 1999). Other estimates suggest a carbon-offset market of more than US$20 billion per year (UNCTAD, 1998). Clearly, estimates of the likely value of carbon markets will depend on the assumed value of a cost per ton. As in any market, price volatility has to be assumed at the outset. At the same time, a benchmark price range that seems to be gaining consensus is between US$10 to US$20 per ton of carbon. [The World Bank's Climate Investment Fund, launched in late 1999, refers to a price per metric ton of carbon of US$20. Other estimates, including one by the Intergovernmental Panel on Climate Change dealing with costs of carbon sequestration related to land use, land-use change and forestry, suggest a price that is significantly less than US$10 per ton (IPCC 2000b).] Clearly, depending upon the project, and the realized value of carbon credits, there will be opportunities for arbitrage in these credits and a potential for high returns.

Obviously, questions about the magnitude, operation, predictability and assumed price range of carbon-related markets will be deeply affected by legal negotiations currently underway under the UNFCCC. Following the suspension of the Sixth Conference of the Parties to the UNFCCC in The Hague in late 2000, attention of various stakeholders has shifted back to the Article 4 Commitments contained in the (1992) UNFCCC. In particular, some are examining the operational implications of Article 4 (2) (a), which notes in part:

> "The developed country Parties and other Parties included in Annex 1 commit themselves specifically as provided for in the following:
>
> a) Each of these Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs. These policies and measures will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention, recognizing that the return by the end of the present decade to earlier levels of anthropogenic emissions or carbon dioxide and other greenhouse gases not controlled under the Montreal Protocol would contribute to such modification, and taking into account the differences in these Parties' starting points and approaches, economic structures and resource bases, the need to maintain strong and sustainable economic growth, available technologies and other individual circumstances, as well as the need for equitable and appropriate contributions by each of these Parties to the global effort regarding

> that objective. *These Parties may implement such policies and measures jointly with other Parties and may assist other Parties in contributing to that achievement of the objective of the Convention* and, in particular, that of this subparagraph …" (emphasis added).

It remains unclear how climate-related measures undertaken "jointly" will translate into project-based climate initiatives involving two or more countries. However, given the extent of pilot projects and voluntary measures already underway or being considered, coupled with significant cost differentials among countries, it seems inevitable that the highly dynamic and quickly evolving international carbon market will continue.

The purpose of this report is to identify potential investment opportunities arising from possible carbon offset projects in Mexico. It is important to stress that as a non-Annex 1 country, Mexico is not obliged to meet domestic GHG emission reduction targets. At the same time, given the increasingly strong economic links between Mexico and its other NAFTA partners—Canada and the United States—one scenario is for investment transfers linked to climate change to follow existing international investment and trade patterns. This assumption reflects the observation of von Moltke that as international efforts to address climate change expand, the distinction between climate-related project investment and other types of investment flows will become increasingly blurred.

Three sectors in Mexico are examined in this report, in order to evaluate their potential for carbon reduction: (a) electric power generation; (b) steel production; and (c) land-use change and forestry. This report does not attempt to provide a comprehensive inventory or baseline of total GHG emissions or potential carbon offsets within these three sectors. Rather, it pays particular attention to carbon-related opportunities involving small and medium-size enterprises (SMEs) within these three sectors.

Particular attention is paid to SMEs, in Mexico, for several reasons. First, evidence already suggests that larger companies are better positioned to examine opportunities related to the international climate agenda. For example, companies as diverse as TransAlta, Edison Electric, Arizona Public Service, Niagara Mohawk, Beyond Petroleum (formerly BP-Amoco), Suncorp, Sumitomo and dozens of others have been engaged in different aspects of the international carbon market. Leadership continues both by these companies operating alone, as well as partnering with such organizations as Environmental Defense, the World Resources Institute or the World Bank in demonstrating that climate-related initiatives can make environmental as well as sound business sense.

By contrast, SMEs in general face several obstacles in identifying and taking advantage of climate-related projects and associated investment opportunities. Difficulties include higher entry and transaction costs, difficulty in accessing capital markets—in particular, external capital markets—difficulty in estimating individual baselines and inventories, and other barriers. It is worth noting that some of these difficulties are generic to SMEs in general, while others (such as the calculation of inventories) are unique to the climate agenda. It is also worth noting that barriers to SMEs in developing countries participating in international joint initiatives are even greater than those that exist in industrialized countries.

Despite these obstacles, among the conclusions of this report is that SMEs in Mexico in a number of areas present potentially attractive investment opportunities. What follows are the key findings for the three different industry sectors considered.

Electricity

- The Mexican electric power sector continues to initiate or undergo profound changes. (For readers interested in the changing electricity sector, the CEC will release an Article 13 report—Environmental Challenges and Opportunities in the Evolving *North America Electricity Market*—in early 2002. For interim reports in relation to this initiative, please see <www.cec.org/electricity>.)
- The most significant carbon-related opportunities in Mexico's electricity sector are closely tied to the planned expansion of natural gas use. According to the most recent estimates by Mexico's Energy Secretariat, the sector will use more than twice as much natural gas as oil in its primary energy inputs in the near term (*Secretaría de Energía* 1999b).
- In addition to overall gains from the proposed switch from oil to natural gas, the single greatest area of carbon-reduction potential involving SMEs is found in such demand-side opportunities as energy efficiency and fuel switching. Distributor-supplied users represent a group of considerable potential, comprising SMEs and residential consumers. Such users will receive a bundled service, consisting of delivery and the final sale of electricity. Among the initiatives underway in Mexico relating to the demand-side is the promotion of super-efficient residential lighting, promising to increase efficiency by more than 50 percent over current lighting fixtures. Given the fact that residential electricity supply continues to grow at a rate higher than that for the commercial/manufacturing sector, focusing policies on demand-side gains could lead to considerable reductions in tons of carbon.[1]
- Potential diseconomies of scale that may arise in the calculation/accounting process may present problems in arranging deals involving demand-side residential lighting.
- However, a back-of-the-envelope estimate suggests that total sales in 1999 in the residential sector were 33 TWh (terawatt hours), the generation of which produced approximately 0.75 million metric tons of CO_2 per TWh. A conservative estimate for the growth rate in residential electricity demand is five

1 In 2001, the CEC will release the results of a survey of electricity users in Mexico, measuring their interest in and willingness to pay for renewable electricity as part of their total electricity portfolio. Results can be found on <www.cec.org>, under the "Green Goods and Services" area.

percent. Assuming that electricity efficiencies could reduce this demand by 20 percent over the decade 1999–2009, electricity demand could be reduced by 4.2 TWh, representing a savings of 3.1 million metric tons of CO_2 (assuming no changes in CO_2 production per unit of electricity). This would be worth approximately US$31 million (using a proxy market value of US$10/metric ton for carbon).

Steel Production

- A series of case studies and surveys was prepared for this report, including surveying 13 large and medium-size steel producing companies in Mexico. Among the results of the company questionnaires were the following: nearly three-quarters of those surveyed said that they were aware of energy-savings potential in their operations, and more than half were already running, or had plans to run, energy-savings components. Translating energy-saving gains into potential certified emission credits is complex, and is the topic of intensive ongoing work, which is outside of the scope and mandate of this report.
- Comparing existing furnace technologies with the application of best-available technologies, detailed information is provided on specified areas of inefficiency such as in maintenance, preheating systems, incompatibilities between molding and fusion capacities and management, and pretreatment controls. Findings for the 13 production units surveyed indicate a total potential carbon emissions reduction of just under 121,000 tons of carbon. Using US$10/metric ton as a proxy price for carbon, the potential market value arising from these gains is approximately US$1.2 million.
- The quantity of carbon emissions from steel production in Mexico has declined steadily over the period 1986 to 1996, from 0.50 metric tons of carbon emitted per ton of steel produced in 1986, to approximately 0.40 tons in 1996. While this is obviously good news from all points of view, this trend of decoupling total tons of steel from tons of carbon emitted narrows somewhat the carbon offset opportunities in the sector.

Land-use Change and Forestry

- Among the most difficult issues in the climate change debate remains the extent to which carbon sequestration can be calculated, related to land use, land-use change and forestry.
- This study suggests that the climate agenda can contribute to changing Mexican forests from their current state of being a net source of greenhouse gas emissions, to becoming a significant carbon sink. Despite numerous gaps in information and analysis in forwarding these estimates,

including the absence of information on total land cover, rates of deforestation, inventories of aboveground biomass, and carbon densities of forests, different carbon offset scenarios are presented for Mexico's forests. Under one scenario, a range of 2.3 to 3.0 billion metric tons of carbon is identified as the total possible carbon offset. Under a second scenario—accelerated adoption of new technologies—an estimated range of 4.2 to 5.1 billion metric tons between 1990 and 2030 is suggested as possible.

- Among the lessons of the forestry sector—characterized by small-scale landholders and farmers—is the need to identify various non-carbon benefits that can be of immediate relevance to small-scale farmers and their communities.
- Strategies for shifting Mexico's forests from a net source of greenhouse gas emissions to an important carbon sink are varied and include: improved management within protected areas, improved forestry management generally, more efficient wood-burning stoves, reduced rates of forest fires and better forest-fire management, and a range of carbon sink enhancement actions such as reforestation, energy-biomass sources and agroforestry.
- Using the proxy market value of US$10 per metric ton, a rough calculation of the potential market value of carbon-related investment opportunities identified in this report is approximately US$23 million at the low end, and US$51 million at the higher end for the Mexican land use, land-use change and forestry (LULUCF) sector.

1 Introduction: Finance and the Environment

It has often been assumed that high levels of environmental protection do not easily fit with business interests. Some have argued that countries or companies that adopted strict environmental standards stood to lose markets, because of assumed drag in competitiveness often associated with environmental standards.

While this debate will inevitably continue, there is a growing body of empirical evidence that companies that adopt high levels of environmental standards are also well managed and highly competitive companies. Conversely, companies that ignore or attempt to circumvent environmental standards also tend to have various management, business planning and other problems.

The responsiveness of companies to the environmental agenda is reflected in a host of initiatives, from the ISO 14,000 series to corporate environmental reporting. A McKinsey survey of 400 corporate executives worldwide found that over 90 percent agreed that the capacity of the private sector to integrate environmental priorities will be a key business challenge of this century (cited in US EPA 2000).

A key question of relevance to the climate debate centers on identifying the drivers that encourage companies to adopt environmental policies and pay more attention to the environmental agenda. While it has broadly been assumed that companies will respond only to direct regulations (in place or being proposed), it is now clear that other factors—in addition to mandatory regulations—affect a company's environmental profile. For example, as markets become increasingly global, companies must pay attention simultaneously to home and host country regulations. There is also evidence suggesting a relationship between export intensity and the adoption of higher levels of environmental standards within companies. Other factors that have been identified as affecting the likelihood of a company adopting an environmental policy include the views of customers, the role of communities, and the ownership structure of the company itself. In turn, a number of studies have shown a positive correlation between the improved environmental performance of a company and the value of the firm, expressed for instance in shareholder value (Wisner and Epstein, draft, 2001).

Given the evidence that environmental policies are becoming an important part of corporate planning and policies, it is little wonder that the financial services sector is paying more attention to the environmental agenda. Although there are several points of intersection between financing and the environment, two broad types tend to dominate this relationship:

a) *Risk Assessment and Risk Management:* Environmental risk has been at the center of environmental policies since their formulation. Environment-related risk is to some extent being weighed by the financial community as one factor that can help overall business risk. Tools to determine, and where possible quantify environment related risk, vary by sub-sector within the financial services sector. Risk tools also differ depending on whether the financial exposure is debt, equity, joint venture, mergers and acquisition or other types of financing. Moreover, the insurance sector—particularly European-based insurers—have made impressive strides forward in identifying and quantifying specific types of risk, including real estate-related risk, as well as indirect risks, such as financial risks associated with the impacts of climate change.
b) *Green Investment Opportunities:* The other way of looking at business risk is by measuring the financial performance of companies. The Environmental Capital Markets Committee, established by the US Environmental Protection Agency (EPA), continues to study the environment-finance link, and has made a number of recommendations to improve indicators capable of measuring this interface (US EPA 2000). Environmental considerations continue to affect different kinds of investments, including so-called "green" companies that market products or services that are relatively cleaner or more sustainable than other products or services within a similar category. The relatively small size of the so-called environmental industry, coupled with sporadic evidence that environmentally sensitive firms perform marginally better, suggests that the market share for green goods and services will remain roughly constant in the short term, but that as international policies move into place to constrain future carbon emissions, investments related to the climate agenda will expand.

1.1 Environmental Issues and Risk Management

One example of the importance of environmental issues to investors is found in the results of a 1999 survey of 50 of the leading financial institutions in the United Kingdom. The survey found that 35 of these institutions (or 70 percent) had developed an external environmental statement, an increase from 52 percent in 1998. Another survey, conducted by PricewaterhouseCoopers of over 150 signatories to UNEP's *Statement by Commercial Banks on the Environment* (a list that includes, from North America, Salomon Inc., Royal Bank Financial Group, Republic National Bank, Community Capital Bank), found that:

- 90 percent have some form of dedicated environmental management function;
- 74 percent of those polled have environmental policies covering corporate credit; 63 percent covering investment; and 53 percent covering investment banking;
- 60 percent of institutions surveyed have initiated or have in place steps to integrate environmental considerations into core credit decisions, while many fewer—20 percent—have policies covering portfolio management;
- 60 percent of institutions have developed various types of "green" financial products (UNEP 1999a).

Among the clearest areas of overlap between financial and environmental management involves the assessment and management of risk. How environmental issues affect investments, assessments of risk, and actual risk management tools obviously varies by industry segment. Commercial banks often consider environmental issues when evaluating the risk associated with an investment in a particular company since, for example, repeated reports of environmental non-compliance could lead not only to fines and penalties, but also to consumer opposition to the company—as seen for example in the consumer boycotts of Shell—or even to the borrower or financier itself. Studies already show that shareholder value declines on average by one to two percent when an environment-related lawsuit is pending, and that capital markets generally respond to the public disclosure of environmental performance such as the Commission for Environmental Cooperation's *Taking Stock*, which compares pollution emissions among firms. Conversely, evidence shows that the market value of a firm increases by, on average, slightly less than one percent in shareholder value when firms are recognized for strong environmental performance (Lanoie et al., 1997).

Other environmental risks can include industrial accidents, the discovery of hazardous or toxic waste sites, and the opposition of communities to new waste management siting. Less frequently, risks to banks can entail more direct lender-liability issues. Since the Fleet Factors case of the early 1990s, efforts by banks, the American Banker's Association, the US Environmental Protection Agency and others have focused on clarifying liability exposure, including shielding borrowers against the deep pocket syndrome. At the same time, the distant prospect of lender liability has been a major catalyst within the banking sector to track and manage environmental risk, especially properly-related environmental risks.

Risk management tools used by commercial banks are generally tied to capital-intensive project finance, with risk tools applied to reduce potential liabilities over a period of 10 to 15 years. Environmental due diligence procedures, especially those tied to loans for which real estate is used as primary collateral, are now applied regularly by many commercial banks in North America. Led by the Bank of America, the Royal Bank Financial Group and others in the early 1990s, environmental due diligence generally includes Phase I, on-site environmental audits involving checklists. Similar tools are used by investment banks, which, in the course of preparing for the initial public offering, examine the extent of environmental liability exposure. This generally includes procedures for the disclosure of environmental exposure, and the application of due diligence procedures, particularly for pollution-intensive industries.

Environmental and associated financial risks are now regularly examined by the insurance sector. Like banking risks, insurance risks include industrial accidents related to catastrophic events such as large spills, or cleanup costs of abandoned toxic or hazardous landfill sites. Where the two liability segments diverge is in the area of climate change. Over the past two decades, insurers have been calculating the business costs of a four-fold increase in natural disasters such as storms and coastal flooding. For example, according to estimates by the insurance sector, the number of natural and man-made disasters increased significantly in the late 1980s and early 1990s. What is more, in 1998, insured losses arising from natural disasters exceeded US$17 billion; an increase of nearly 40 percent since 1995 (UNEP 1999b). Total economic losses from such events are estimated to exceed US$90 billion. A senior executive of Swiss Reinsurance Company recently warned that if three hurricanes comparable in size to Hurricane Andrew were to reach the United States in one season, it would likely lead to the collapse of the US insurance sector because of high and "unforeseeable" economic losses (Knoepfl 1999).

While the tools differ within industry segments, what risk management approaches share is the consideration of a probable increase or decrease in asset values over time because of environmental issues. The time element is important: risk management is not only about identifying current financial risks, but also about estimating likely shifts in an initial price offering or asset value over time. Time horizons differ, but as noted for commercial banks as well as the insurance, pension fund and other sectors, a time horizon of 10 to15 years is fairly standard. The future orientation of financial risk management helps explain why so many large energy companies today are acting as if the climate agenda is already underway.

1.2 Environmental Investment Opportunities

While risk management remains the main area of convergence between the financial sector and the environment, so-called green investment represents the other side of the issue. Numerous examples exist which point to emerging business opportunities tied to the environmental agenda, coupled with an increased valuation of environmental information across financial services.

The main channel for environment-related investments is mutual funds. After commercial credit, mutual funds and pension funds together represent the single greatest source of investment capital. For example, an estimated 6,500 mutual funds exist worldwide, with a capitalization of US$4.5 trillion.

Green funds are generally categorized within socially responsible funds, examples of which include Domini Social Equity, Fidelity Select Environmental Service, Hudson Investors Fund, Calvert Managed Growth, Storebrand-Sudder Environmental Vale Fund and Dreyfus Third-Century Fund, as well as others. Socially responsible funds have an estimated total market value of approximately US$4 billion. Thus, green investment funds make up only a small fraction of all mutual funds and, hence, of total investment.

The fact that green investment funds make up such a small fraction of overall mutual funds should not be perceived as a strike against green investing, but rather as an indication of a segment of the mutual fund market with good growth potential, since there are good reasons to make environmental investments. The first is that there is convincing evidence that environment-related investments pay in terms of current performance. Consider the performance of the Dow Jones Group and SAM Sustainability Group of the Dow Jones Sustainability Group Index, launched in October 1999. The Index—drawn from the larger Dow Jones Index of 3,000 companies—provides information on the link between environmental performance and the financial performance of over 200 companies worldwide. Market capitalization of the Index exceeds US$4.3 trillion. Yet the real news is not how many companies are on the list now, but where they and companies like them are going. Many financial analysts, including Dow Jones itself, are convinced that sustainability-driven companies will outperform the competition, because they look at long-term challenges. Already, a series of empirical studies shows that beyond compliance, corporate environmental investment increases financial performance and shareholder value.

While interest in environmental issues by the financial sector over the past decade has primarily involved risk management and its implications for credit policy, the last 16–18 months has seen a shift in emphasis towards investment-related opportunities. This shift can be explained by the change in perceptions about environment-related business opportunities and, more importantly, by the track record of environmental investments. With the rise in eco-efficiency funds since 1997, a track record now exists which proves that the performance of green funds *meets or* *exceeds that of standard industry funds*. For example, a growing body of quantitative data comparing portfolios of sustainably-driven companies with industry averages like the Standard and Poor's 500 Index and the TSE 300 show the former outperforming the latter by an average of over three percent per year.

Another reason that companies are making environmental investments is the fact that there has been a shift in industry perception of these investments. A recent report by World Resources Institute (WRI) notes that, whereas companies had previously made environmental investments reluctantly as a matter of regulatory compliance, now companies are beginning to move beyond minimum compliance as part of good business practices. The increase in eco-efficiency, the adoption of internal environmental codes of conduct and company targets, and the increasing adoption of voluntary environmental standards like the ISO 14000 series, are examples of this shift. In addition WRI notes:

> Companies have even made a changing regulatory framework into a source of competitive advantage by pre-empting environmental regulations and voluntarily going beyond compliance on their own terms, knowing that rivals will likely be compelled to react later (Repetto and Austin 2000).

Recent examples of such investment include giants such as General Motors, IBM, Interface, Johnson and Johnson, Pitney Bowes and others forming the Green Power market Development Group, committing their companies to accelerate the use of environmentally-preferable power by 2010. Already, BP has announced it will invest over US$1 billion on wind and solar energy in the next decade, while Royal Dutch Shell will spend roughly US$500 million on renewable energy. When it comes to energy policy and the challenges of implementing the Kyoto Protocol, it is not simply that the Global Climate Coalition—the industry group that worked to oppose climate change policies—is defunct. The real story is that more and more companies are not waiting to see what happens with environmental regulations. They are moving ahead now, over and above minimum compliance.

From the preceding, the role that the environment plays in investment decisions should be relatively clear. The question remains, however, as to just how large the environmental industry is.

1.3 Defining Environmental Expenditures

The trickiest issue with understanding the size of the "environment industry" is assigning an exact dollar figure to total environmental expenditures. This, in turn, reflects the absence of a clear definition of what exactly, if anything, constitutes the "green sector." Unlike familiar and well-defined economic sectors such as mining or telecommunications, environmental expenditures, by definition, cut across a wide range of sectors, from pollution-intensive industrial sectors to energy, transportation and agriculture as well as various service sectors, such as tourism.

Various efforts have been made to classify and measure environmental expenditures. Rather than isolating a green "sector" per se, it has been argued that total transactions should be measured by the transformation of environmental considerations into normal business activities as opposed to a specialized activity of "environmental experts." One expert in this field has argued that environmental investments should include all goods and services that improve the state of the environment, either by reducing the wasteful use of natural resources (e.g., eco-efficiency or related production techniques), or by reducing emissions (Gentry 1995).

Table 1 provides some concrete examples of environmental expenditures—based on the preceding definition—divided into three categories: (a) equipment, (b) services and (c) resources, with dollar values (1997 estimates):

Table 1: **Estimated Environmental Expenditures**

	US INDUSTRY (BILLIONS OF US$)	GLOBAL INDUSTRY (BILLIONS OF US$)
EQUIPMENT		
Water equipment and chemicals	13.5	34.0
Air pollution control	11.7	25.8
Instruments and information systems	2.9	4.6
Waste management equipment	11.2	26.7
Process and prevention technology	0.8	2.0
SERVICES		
Solid waste management	31.0	88.3
Hazardous waste management	6.4	16.7
Consulting and engineering	15.3	26.5
Remediation/industrial services	8.6	14.7
Analytical services	1.6	3.1
Water treatment works	25.7	62.1
RESOURCES		
Water utilities	24.2	64.9
Resource recovery	15.4	34.6
Environmental energy	2.2	4.4
TOTAL	**170.5**	**408.4**

Source: Ferrier 1996.

The above table gives a snapshot of environmental expenditures. What is most important here is the relative size of this industry. At US$170.5 billion, it makes up about two percent of US GDP, and approximately 0.7 percent of world GDP. While this is actually quite a large portion of US GDP for one industry, there is still growth potential. What is more interesting is the much smaller share of world GDP that the industry makes up, suggesting even greater opportunities outside of the United States.

2 The Climate Agenda

Among the most intensive areas of work currently underway at the international level to address a global environmental problem is that related to climate change. While considerable attention continues to focus on the future steps that governments will take in implementing the UNFCCC and its Kyoto Protocol, action is already underway within the market to address climate change. To take just one of numerous examples of action underway, during the 1990s, DuPont invested over US$50 million to reduce GHG emissions in their worldwide operations by a target of 45 percent. In 1999, DuPont further committed itself to reducing GHG emissions by 65 percent by the year 2010. It also committed to allocating ten percent of its global energy use to renewable energy by 2010.

While some marginal debate lingers regarding the scientific validity of the global warming theory, overwhelming evidence shows that the global climate is changing. In December 1995, the *Second Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC)—a consensus-based report that draws upon the largest gathering ever of scientists and other experts to address a single issue—shifted forever the debate about climate change. It concluded that since the end of the 19th century, global mean surface air temperature has risen by approximately 0.3 to 0.6 degrees Celsius, and that "the balance of evidence suggests that there is a discernible human influence on global climate." An updated version of this report is currently under governmental review.

The chair of the IPCC, in his report to the November 2000 Conference of the Parties (COP VI), noted that current projections suggest an increase in global mean surface temperatures in the range of 1.5°C–6°C by 2100 (roughly double the 1995 IPCC predictions). In May 2000, the Intergovernmental Panel on Climate Change (Working Group III) released the *Special Report on Emission Scenarios: Summary for Policymakers* (Intergovernmental Panel on Climate Change 2000). It notes that future GHG emission trajectories are complex, given that emissions vary in response to demographic change, social and economic development, and the rate and nature of technological change. The IPCC report makes use of four future emission scenarios:

- Scenario A1, characterized by very rapid economic growth, global population that peaks in 2050, and the rapid introduction of more efficient technologies. Other assumptions include a convergence in per capita income between regions, capacity building and increased cultural interactions. This scenario outlines three alternative directions in technological change: fossil fuel-intensive, non-fossil fuel sources, and a balance across all sources.
- Scenario A2, characterized by a very heterogeneous world, including self-reliance of countries, very slow convergence in fertility rates among countries resulting in very high global population growth, and differences in per capita income and technological change between countries.
- Scenario B1, characterized by a peaking of global population growth in mid-century (as in Scenario A1), rapid changes in economic structures towards services and information-based economies, the reduction in material intensity, and the introduction of clean and highly efficient technologies. In this scenario the emphasis is on global solutions to economic, social, environmental and other challenges.
- Scenario B2, characterized by continually increasing global population (lower than A2 scenario), intermediate levels of economic development, and less rapid and diverse technological change than in Scenarios B1 and A1.

2.1 The Kyoto Mechanisms

The Kyoto Protocol was launched at the Third Conference of the Parties to the UN Framework Convention on Climate Change held in Kyoto in December 1997. Among the main outcomes of that agreement is the commitment by all Annex I countries to lower their emissions of six greenhouse gases—CO_2, CH_4, N_2O, HFCs, PFCs and SF_6—by at least five percent below 1990 levels, with a target date between 2008 and 2012.

Reduction commitments within the Annex I Group of industrialized countries are not uniform. The member states of the European Union, the Czech

Republic, Bulgaria, Estonia, Romania, Poland, Slovakia and Switzerland will reduce their total greenhouse gas (GHG) emissions by eight percent each. The United States will lower its total emissions by seven percent. Canada and Japan will reduce theirs by six percent. Some other countries are allowed to increase their emissions above the 1990 levels: these include Australia (eight percent), Iceland (ten percent) and Norway (one percent).

Three flexible market-based mechanisms are identified in the Kyoto Protocol: Annex I Joint Implementation (JI), the Clean Development Mechanism (CDM), and International Emissions Trading (IET).[2] (A fourth approach, based on the "bubble" concept, is also allowed in the Kyoto Protocol.)

These flexible mechanisms allow Annex I countries to meet a part of their GHG emission limitation targets through various types of international cooperation mechanisms. The logic of cooperating internationally in such efforts is well recognized, and includes the achievement of environmental objectives at lower costs than would otherwise be possible if each country were to set about reducing GHG emissions independently. By introducing greater flexibility and cost savings, various international mechanisms allow for sharing of reduction costs between countries, and mobilization of private capital.

The principle flexible mechanisms outlined in the Protocol are:

- *Joint Implementation*, which provides for transfer of emission reduction units (ERUs) tied to the implementation of specified projects. These projects can be implemented between Annex I Parties.[3]
- *Clean Development Mechanism* enables non-Annex I Parties to host projects that contribute to their sustainable development goals and reduce greenhouse gas emissions, and allows Annex I Parties to use the certified emission reductions resulting from the project to meet part of their commitment.
- *International Emissions Trading* allows for transfers of assigned amount units (AAUs) among Annex I Parties. A party's assigned amount is its net GHG emission budget based on its emission reduction commitment under the Kyoto Protocol.
- *Bubbles* A bubble is a regulatory concept whereby two or more emission sources are treated as if they were a single source. This creates flexibility to apply pollution control technologies to whichever source under the bubble has the most cost-effective pollution control options, while ensuring the total amount of emissions under the bubble meets the environmental requirements for the entity.

Extensive work continues in determining the rules of each of these mechanisms, to ensure that rules are transparent, equitable, and provide clarity and predictability to the private sector and governments. Although the mechanisms differ, they share the commodification of a metric ton of carbon, or its equivalent (one ton of carbon is

2 Annex I JI is outlined in Article 6, the CDM in Article 12, and IET in Article 17. See UNFCCC (1997).
3 When ERUs are generated by one Party and sold to another Party, the seller Party subtracts the ERUs from its assigned amount, and the buyer Party adds the ERUs to its assigned amount. A Party's assigned amount is its net GHG emission budget based on its commitment under the Kyoto Protocol.

equivalent to 3.67 tons of carbon dioxide). This report concentrates on possible CDM-eligible projects in Mexico, reflecting the unique trilateral (Canada, the United States and Mexico) composition of the Commission for Environmental Cooperation.

2.2 The Role of Small and Medium-size Firms for Flexible Mechanism Projects: Challenges and Opportunities

The particular focus of this report is climate-related project-opportunities involving small and medium-size enterprises (SMEs) in Mexico. This issue is especially important given the importance of SMEs in the Mexican economy in terms of the total amount of capital invested, jobs created, and products manufactured.

By way of illustration, Mexico's agricultural sector comprises a large number of farmers working small plots of land on the one hand, and larger, irrigated plots on the other (World Trade Organization 1997). These enterprises tend to be non-dominant players within the markets they occupy.

In terms of geographical location, roughly half of Mexican micro-enterprises are concentrated in seven states. Small firms tend to be located in the center of the country and the metropolitan area of Mexico City, medium-size enterprises are dispersed and big enterprises tend to be concentrated in the North.

SMEs can play a role in the evolving international climate change agenda in two ways. First, to the extent that they are engaged in production activities themselves, they can do so by undertaking measures that reduce GHG emissions or sequester carbon. These measures include: improving process efficiencies or installing technologies to reduce energy consumption, switching to less carbon-intensive fuels, planting trees or improving forest management to sequester carbon, and others. Second, to the extent that SMEs provide services that enable clients to achieve greater levels of efficiency (e.g., energy service enterprises), they can support trends toward greater efficiency.

Put another way, SMEs can be just as involved in international efforts to reduce the impact of climate change as larger companies. The difference is not the type of activity eligible for SME-based projects. The difference relates to the greater hurdles SMEs must face in: gaining knowledge of flexible mechanisms under the UNFCCC or the Kyoto Protocol; meeting flexible mechanism accounting requirements, including relatively high levels of informational and technical difficulties in calculating baselines and levels of additionality and affording third-party certified emission reduction certification; generic difficulties in attracting external capital for climate-related investments; and other entry barriers including relatively high transaction costs, all of which may make SME activities appear less attractive than those of larger entities.

Despite these difficulties, it is argued that considerable investment opportunities exist in Mexico's SME sector Examples noted below cover the electricity, steel and forestry sectors. Indeed, the purpose of the rest of this paper is to give examples of SME opportunities in Mexico that show promise for flexible mechanism-related investment.

3 The Electric Power Generation Sector: Demand- and Supply-side Opportunities

3.1 Introduction

The electric power sector represents opportunities and unique challenges for SMEs in Mexico to participate in the evolving flexible mechanism marketplace. The greatest opportunities for SME involvement in energy efficiency are twofold.

First, SMEs in the industrial, commercial, and residential sectors can develop energy efficiency or fuel switching projects that will offset power-grid emissions. With the increased revenue generated by certified emission reductions, energy efficiency projects will have a shorter payback period than they would in the absence of the flexible mechanism. In addition to providing economic returns, energy efficiency projects can improve the productivity of the SMEs and enhance their competitiveness in their respective markets.

Second, SMEs can take advantage of the potential business opportunities made available by operational flexible mechanisms. The profitability of energy efficiency measures is likely to expand the current market for energy efficiency technologies, products, and services. While energy services companies and energy-efficient equipment suppliers may not benefit directly from the certified emission reductions , these companies can take advantage of an indirect benefit; expanded market opportunities.

Because of the status of the energy sector and the current regulatory framework, flexible mechanism opportunities in the power generation sector are limited. Additional barriers specific to SMEs limit flexible mechanism opportunities for the power generation sector. However, the current regulatory structure is under review. If proposals to increase private sector participation in the energy sector are accepted, then opportunities for SME participation on the supply-side could increase. At this time, the outcomes of discussions on power sector reform, as well as on the time frame for reform are uncertain, although the new Fox administration has reiterated its commitment to restructuring.

This section begins with an overview of Mexico's power sector and trends in supply and demand. Second, an overview of GHG emissions from the power sector provides context for the potential for certified emission reductions. Mexico's experience with energy projects in the AIJ Pilot Phase is then highlighted. Third, the current and potential role of SMEs in the power sector, whether as end-users or service providers and investors, is reviewed. A discussion of the most promising segments in the power generation and energy efficiency markets follows. And lastly, the limitations imposed by Mexico's energy regulatory framework are outlined. The section begins with a review of the power sector and the opportunities for private investment.

3.2 Structure of the Mexican Electric Industry

3.2.1 Supply

According to 1998 data, the total effective electricity generation capacity in Mexico is 38,502 MW. Of this, some 90 percent originates from the *Comisión Federal de Electricidad* (CFE) and 2.2 percent from *Luz y Fuerza del Centro* (LFC): *Sistema Eléctrico Nacional* (SEN) companies. The state-owned corporation *Petróleos Mexicanos* (Pemex) accounts for 4.4 percent of the total, and the private sector for three to four percent (*Secretaría de Energía* 1999b:45, 95 and CFE 1999a:12). In terms of supply, Mexico's electricity market is thus thoroughly dominated by the SEN (combined capacity of 35,256 MW).

At present, the CFE and LFC meet slightly over 93 percent of the country's total electricity demand of 147.1 terawatt-hours (TWh). For 1998, direct electricity sales were 110.7 TWh (75 percent of the total) by the CFE and 26.7 TWh (18 percent) by LFC, which serves the Federal District (Mexico City) and some municipalities of Mexico, Puebla, Morelos and Hidalgo states. This latter company, it should be noted, generates less than eight percent of the power it sells, getting the rest from the CFE (Ibid. and CFE, no date: 4).

The two member companies of the SEN thus serve as the public electricity utilities. The current level of territorial coverage is around 95 percent. LFC covers the one-fourth of the country's population of close to 100 million living in the center of the country, while the remainder is served by the CFE.

The installed capacity of the private sector, authorized by the applicable legislation, is 6,756.5 MW. In 1998, private sources only generated 5.93 TWh or 3.5 percent of the total gross power output in the country. Pemex generated 5.42 TWh (3.2 percent) (*Secretaría de Energía* 1999a: 45).

The SEN plants break down by generation technology as follows: 79 hydroelectric units; 36 gas turbine; 29 steam; eight internal combustion; seven combined cycle; five geothermal; two coal-fired; one nuclear; one dual (fuel oil and coal) and one wind-powered. In other words, Mexico's power production is largely driven by fossil fuels (66.4 percent based on hydrocarbons, 10.5 on coal, for a subtotal of 77 percent). Of the remainder, 14.4 percent derives from hydroelectric, 5.4 percent from nuclear and 3.3 percent from geothermal and wind sources (*Secretaría de Energía* 1999b: 62 and CFE 1998: 12). According to CFE data, the remaining useful life of the installed plant ensures that electricity can be generated under the current conditions and operating levels for the next 19 years (CFE 1999a: 34). In recent years, the electric industry's productivity and efficiency indicators have improved markedly (Table 2).

Table 2: Productivity and Efficiency in the Electric industry

YEAR	CFE Interruption time (min/user)	CFE Power sold per operations employee (GWh/employee)	LFC Interruption time (min/user)	LFC Power sold per operations employee (GWh/employee)
1988	802	1.124	487	0.640
1989	567	1.299	447	0.669
1990	536	1.295	373	0.821
1991	495	1.319	414	0.828
1992	375	1.355	437	0.862
1993	447	1.447	408	0.906
1994	251	1.585	373	1.152
1995	242	1.654	401	1.140
1996	203	1.771	377	1.165
1997	236	1.853	352	1.382
1998	224.8	1.933	374	1.630

Source: Ministry of Energy web site.

Despite significant efforts to raise the productivity and efficiency of the two companies, some specialists believe that these two companies are overstaffed. In 1999, the 108,543 Mexican electricity sector workers (73,302 for CFE and 35,241 for LFC) produced average annual sales of 1.33 gigawatt-hours (GWh) per worker—a very low figure compared with other countries, especially those of North America.

Although the CFE's economic efficiency may indeed be debatable, its own financial and management indicators show this to be a healthy company with a "sound financial structure" (CFE 1999a: 32). This is not the case for LFC, which, according to some observers, received an indirect subsidy equivalent to $2.4 billion in 1999 (Dessomes 1999).

In terms of future supply, an estimated 22,248 MW of additional installed capacity will be required by 2008—the equivalent of 80 percent of Norway's current installed capacity, for example (Table 3). This represents 2,225 MW of new capacity per year until then. The CFE has already taken steps within its investment program to commission 6,444 MW of capacity in the coming years. The capacity gap of 15,804 MW, a little less than half the country's current capacity, thus constitutes the area of opportunity for the private sector in the Mexican electric industry.

Table 3: Capacity and Demand, 1998–2008

(MW)

1998		2008			1999–2008	
Effective Capacity	Maximum Demand	Effective Capacity	Maximum Demand Capacity	Total Additional	Capacity developed by CFE	Capacity open to private sector
35.256	28.571	57.504	48.014	22.248	6.444	15.804

Source: Based on Secretaría de Energía *2000.*

3.2.2 Transmission

The SEN currently (1999) possesses an electricity transmission grid surpassing 600,000 kilometers in length. This includes 34,079 of high voltage lines, 38,844 of secondary transmission lines, and 528,107 kilometers of distribution lines (CFE 1999b:16).

The time horizon for the current program of investment in the grid is 2003, since beyond that year it is difficult to forecast the physical location of new plants. Between 1999 and 2003, 20,237 kilometers of new transmission lines are expected to be added, and between 2004 and 2008, an additional 12,273 kilometers (*Secretaría de Energía* 1999b:118).

At present, the independent producers are permitted to build transmission lines for their own use; alternatively, they may access the SEN's transmission grid through payment of charges established and published in the Official Gazette of the Federation (*Diario Oficial de la Federación*—DOF) on 24 November 1994 and amended on 15 May 1998 (Ibid: 120).

3.2.3 Demand

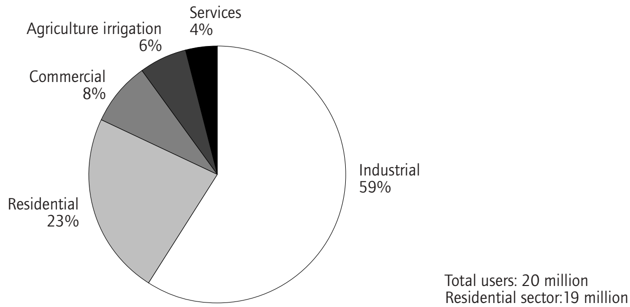
The supply forecasts and plans discussed above come in response to consumer demand that has grown consistently since 1965, if not earlier. In that period, domestic electricity sales grew at an average annual rate of eight percent, much faster than Mexico's economy as a whole.

In the last 10 years, sales have grown by five percent per annum; the figure is more than six percent for residential and medium-size business consumers. According to some Ministry of Energy estimates, demand growth in the year 2000 has returned to the historical average near eight percent.

In 1998, gross generation by the SEN amounted to approximately 171 TWh, 80 percent (137.3 TWh) of which was sold domestically. The market value of electricity sales was $6.9 billion[4] and as indicated above, electrification has reached nearly every one of the country's residents.

The largest electricity consumer, absorbing 60 percent of the total, is the industrial sector. It is followed by the residential sector with 23.1 percent; the commercial sector with 7.7 percent; agricultural irrigation with 5.6 percent and services with 3.8 percent (*Secretaría de Energía* 1999b: 40). The total number of users (accounts with the CFE or LFC) is greater than 22 million, more than 19 million of them residential (see Figure 1).

Figure 1: Electricity Consumption by Sector (1998)



In the last few years, the largest increase in electricity demand occurred in the residential sector. From 1989 to 1998, sales to this sector grew by an average 6.5 percent per annum (Table 4). However, the industrial sector, especially medium-size businesses, promises the fastest growth for the foreseeable future.

4 The data on sales revenues are taken from CFE, *Estadísticas por Entidad Federativa* 1998, p. 12. The exchange rate used (9.150160 = 1 dollar) is taken from CFE, *Precios Internos y Externos de Referencia de los Principales Energéticos*, 10th edition 1999, Figure A.1.

Table 4: **Average Annual Growth of Electricity Sales (CFE and LFC) (%)**

Sector	1989–1998	1999–2008	80% confidence intervals
Residential	6.5	5.0	4.5–5.5
Commercial (1)	3.7	4.8	4.0–5.5
Services	1.5	4.7	3.5–5.8
Industrial (2)	5.8	6.3	6.0–6.6
Agricultural	1.9	0.9	-0.1–1.8
Total (excluding exports)	**5.3**	**5.6**	**5.4–5.8**

(1) Users charged general low-voltage rates, primarily commercial, service and micro-industrial establishments.
(2) Users charged general high-voltage rates (large industrial units) and medium-voltage rates (primarily medium-size and small industrial establishments as well as retail businesses and large service establishments).

Source: Secretaría de Energía *2000, p. 88.*

Mexican demand will continue to grow by an estimated total of 72 percent in the next 10 years. To meet this new demand, the country's energy planners call for an expansion of the installed capacity by 63 percent. Under a scenario of normal economic growth,[5] sales are expected to rise from the current 140 TWh annually to 236 TWh in 2008.

The SEN has organized the task by dividing the country into nine geographical areas: Northwest, North, Northeast, West, Central, East, Peninsular, Baja California and Baja California Sur. In the last decade, top sales growth occurred in Baja California and Baja California Sur, with annual averages of 8.2 and 7.2 percent, respectively (Table 5). The largest overall consumers remained the Western region, taking up 23 percent, and the Central and Northeastern regions with approximately 19 percent each.

Map 1 shows past growth and projected average annual growth of electricity sales in Mexico under three hypothetical economic growth scenarios devised by the Federal Government and applied by the CFE for the period 2001–2010. The "high" scenario assumes average annual GDP growth of 5.8 percent; the "planning" scenario assumes 5.2 percent and the "moderate" scenario assumes 3.8 percent. Pratically all market forecasts issued to date by Mexican government planners, including those at CFE, have adopted the "planning" GDP assumptions. Thus, with an anticipated GDP average growth of 5.2 percent per annum, electricity demand will grow by 5.5 percent per annum from 2001–2010 (see Map 1).

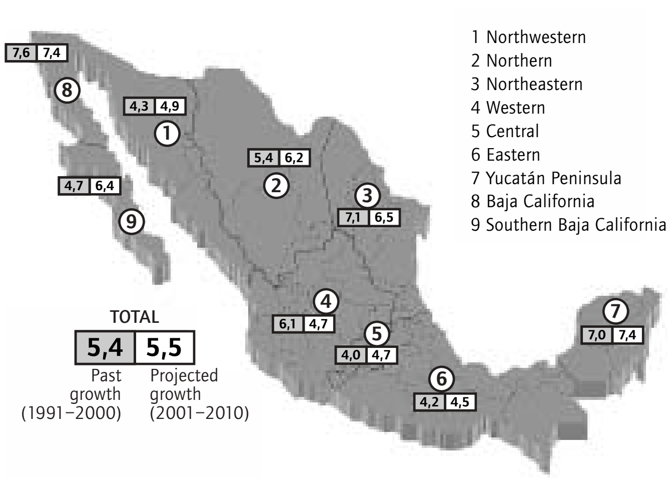
5 The CFE planners made their power demand projections by considering three possible scenarios: the "Moderate," with average GDP growth of 3.8% from 1999 to 2008; "Planning" with 5.2% and "High" with 5.5%. CFE no date. *Desarrollo del Mercado Eléctrico* 1994–2008, p. 11.

Table 5: SEN Planning Regions: Sales, Capacity and Demand

Area1989 sales	1998 sales (GWh)	2008 sales (GWh)	Growth (GWh)	Growth 1989–1998 (%)	1998–2008 (%)
1 Northwest	6.796	10.020	16.681	47	67
2 North	7.280	11.113	20.098	53	80
3 Northeast	13.479	23.746	43.943	76	85
4 West	16.966	29.724	54.028	75	82
5 Central	22.062	29.026	44.310	32	53
6 East	15.584	22.337	34.138	43	53
7 Peninsular	2.073	3.961	7.738	91	95
8 Baja California	3.640	6.347	13.595	74	114
9 Baja California Sur	610	863	1.569	42	82
Small systems	47	71	119	51	68
Total	**88.537**	**137.208**	**236.219**	**55**	**72**

Source: Extrapolated from data in Secretaría de Energía *1999b.*

Map 1: Past and Projected Regional Electricity Sales in Mexico (1991–2010)



Source: CFE no date pp. 11, 23.

3.3 Balance of Trade

Electricity supply and demand data include imports and exports. In the last 10 years, the balance of trade has varied somewhat erratically, but there was a general trend of declining exports and increasing imports. A total 562 GWh were imported and 1931 GWh were exported in 1989, rendering a favorable balance of 1369 GWh; but by 1998, the trade balance had turned negative by 1,434 GWh because imports had increased to 1,510 GWh while exports dwindled to 77 GWh. The projections include minimal exports for the next few years.

3.4 Energy Savings and Efficiency

Energy savings and efficiency plans implemented mainly by government agencies such as the National Energy Efficiency Commission (*Comisión Nacional para el Ahorro de Energía*—Conae) and the Electrical Energy Savings Trust (*Fideicomiso de Apoyo al Programa de Ahorro de Energía del Sector Eléctrica*—Fide) may significantly augment energy savings so that some new capacity creation can be postponed. Conae's programs in particular may diminish new power plant requirements by 7,531 MW or 13 percent of the total capacity required for 2008, as well as reducing the amount of electricity sales by 25,754 GWh or 11 percent of sales for that year. Yet, although profusely discussed in the *Secretaría de Energía*'s *Prospectiva del Sector Eléctrico* 1999–2008 (Outlook for the Electric Industry, 1999–2008), this energy efficiency potential is not factored into the planning calculations, perhaps because the actual results of any given efficiency program are hard to predict.

3.4.1 Rates

In 1962, shortly after the nationalization of the electric industry, the government set the pricing policy that would remain in effect to this day. In a coarsely drawn, highly schematic classification, the CFE and smaller affiliated companies divided their customers into 13 different rate categories by business and individual consumer type. After 1988, the number of categories was increased to 31. The price of electricity to the consumer is now set "as a function of power volume demanded, voltage, temperature [of the user's zone of residence], type of user and guarantee of service" (*Secretaría de Energía* 1999b:44)

The current rate structure consists of the following sectors (CFE no date:14).:

Residential

Users paying rates 1, 1A, 1B, 1C, 1D and 1E for domestic service.

Commercial

Users paying rates 2 and 3 for general low-voltage service; these are primarily commercial, service and micro-industrial establishments.

Service

Users paying rates 5, 6 and 7 for public lighting, wastewater and drinking water pumping and temporary service.

Industrial

(Includes medium-size and large business users)

> *Medium-size business:* Users paying rates O-M and H-M for general medium-voltage service; these are primarily medium-size and small industrial establishments, as well as commercial and large service establishments.
> *Large industry:* Users paying rates H-S, HSL and HTL for general high-voltage service; these are essentially large industrial establishments and major water supply systems.

Agricultural

Users paying rates 9 and 9M for agricultural irrigation pumping.

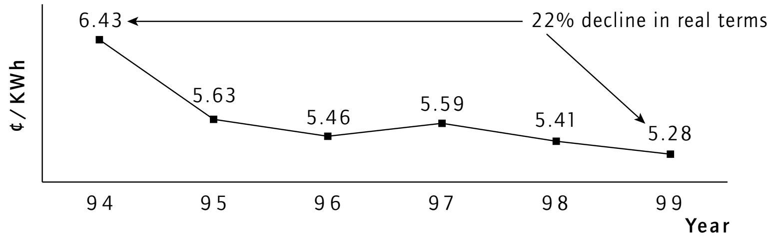
Exports

These consist of sales to US and Belizean companies.

The rate structure is gradually being adapted to reflect the complexity of the productive apparatus and the various consumer types, including residential, service and industrial consumers. The last group can opt for hourly rates: this makes for more efficient administration of demand and streamlining of peak demand management for the provider.

Historically in Mexico, electricity prices, especially for domestic ratepayers, have tended to lag behind the cost of production. Sharp real rate increases in the early 1990s constituted an effort to bring rates in line with costs, but rates fell almost 22 percent in constant currency from 1994 to 1999, with the aggregate average price[6] declining steadily from 6.43¢ to 5.28¢ per kWh (Figure 2).[7]

Figure 2: **Aggregate Average Price per kWh (1994–1999)**



6 The aggregate average price includes maintenance charges, but does not take account of the LFC sale prices or the value-added tax (VAT).

7 CFE, Annual Report, p. 20. The exchange rate applied is 9.56 pesos to the dollar according to Bank of Mexico data.

Fluctuation in the price/cost ratio has been an ongoing preoccupation in defining the country's rate policies. The authorities have tried to apply policies in such a way that average price tracks cost more closely, and periods of disparity are shortened.

From 1997 on, almost all rates were automatically indexed on a monthly basis for inflation in the cost of basic inputs into production, transmission and distribution. The affected rates are those applicable to the commercial sector (rates 2 and 3 for general low-voltage service), the service sector (rate 7 only, temporary service), and the industrial sector, as well as the so-called "Interruptible service" rates (I-15 and I-30).

The indexing formula for all voltages is a function of the average Producer Price Index (PPI) for "Machinery and Equipment" (IPPME), "Raw Metals" (IPPMB)[8] and "Other Manufacturing Industries" (IPPOM). In addition, the high- and medium-voltage rates are indexed to international fuel prices (fuel oil, diesel, coal and natural gas) using an index called ICC (*ibid*). In calculation of the index factor for medium-voltage rates, the change in the average of the three PPI is assigned a weight of 71 percent and the ICC is weighted 29 percent; the corresponding weighting for the high-voltage rates is 59–41 percent.

Indexing has rendered pricing more transparent, and it is now possible to extrapolate price scenarios for the future from inflationary trends in various inputs, including fuel. These scenarios are fundamental to the design of private investment projects in the electric sector.

In order to make comparisons with alternative investment projects, the private sector needs to know the production costs incurred by the CFE per kWh. As various Mexican electricity analysts point out, the true figures are a well-kept secret. The publicized average costs exhibit distortions due to the inclusion of financial expenses and the aggregation of generation, transmission and distribution costs. In short, they do not provide accurate information about the net costs of power generation.

Evidently, spot estimates of generation costs are laborious and complex, given the dimensions and complexity of the CFE's installed facilities. Considerable efforts to establish the marginal short- and long-term costs of generation have been made over several years, but the results have not been made public.

In 1999, CFE sales revenues stood at approximately US$8.223 billion[9] for total costs slightly over $7 billion. The aggregate average cost per kWh delivered was reported as $0.047, and the aggregate average cost of generation was US$0.033/kWh.[10] These figures do not strictly reflect the true cost of production, though, since they include all manner of government transfers and subsidies. After all, the price-cost ratios given in the income statements in the Commission's 1998 and 1999 annual reports were 0.75 and 0.73, respectively, meaning that the average revenues fetched by the CFE for its products are currently 25 percent short of its costs. Thus, the operating surpluses habitually reported

8 *Prospectiva*, p. 46. For more details, see: http://www.cfe.go.mx/gercom/tarif100/ti.chtml.
9 Figures taken from CFE, 1999 Annual Report and converted to dollars (1 dollar = 9.56 pesos).
10 Assuming that the cost of generation is equivalent to 70% of the aggregate average cost.

by the company are due to a wide range of government subsidies and to various sui generis accounting practices.

Moreover, the aggregate costs are estimated by a cumbersome and complex calculation of financial and operating costs. The complexity is due to the wide range of power plants at different stages in their useful lives, using a variety of technologies and having disparate levels of amortization or depreciation, among other factors.

3.4.2 Rate-setting Policy

According to recent information, except for those rates applied to the residential and agricultural sectors, all rates were sufficient to cover the average cost of production. For rates applied to the industrial sector, the largest power consumer, the price/cost ratio is approximately equal to 1.

Normally, all rates are composed of fixed charges corresponding to the type and quality of service requested, plus variable charges for power consumption volume.

For the residential sector, which consumes 23 percent of power, the price of power is subsidized on the order of 58 percent since the current price/cost ratio for this sector is 42 percent. The fiscal cost to the federal government due to this subsidy is estimated at approximately US$2.4 billion in 1999. For the agricultural sector (irrigation pumping), the rate subsidy amounts to almost 70 percent, but it should be added that this sector only represents six percent of the national market.[11]

Rate-setting policy is not established by the CFE but rather by the Secretariat of Budget and Public Credit (*Secretaría de Hacienda y Crédito Público*) authorities. The decision to eliminate subsidies is, in the final analysis, a political one, and the improvement of the price/cost ratio in both sectors depends on economic policy decisions in the immediate future.

As of January 1 of 2000, a Ministry of Finance order authorizing new rate adjustments and modifications goes into force. For 2000, rates for residential use, agricultural irrigation (rates 9 and 9M), public lighting (rates 5 and 5A) and wastewater and water supply pumping (rate 6) were expected to rise by 0.08 percent per month. The aim of these adjustments is to raise the price/cost ratio for these rates, as stated in the document in question: "the rate-setting proposal [...] aims to narrow the gap between these rates and the real cost."[12]

In the last ten years, electricity prices in Mexico have remained almost invariant in real terms. Despite some fluctuations, the median price for these years (the weighted average of all rates) remains stable, and the rates applicable to the industrial sector in particular show average annual growth of -2.1 percent while the other rates increased (Table 6).

11 Estimates produced from database of Gutiérrez Santos, 1999:47.
12 On CFE web site, section "*Gerencia Comercial*," http://www.cfe.gob.Mexico.

Table 6: **Electricity Rate Trends 1989–1998 (1998 Constant Cents/kWh)**

Year	Commercial	Industrial	Lighting	Residential	Agricultural	Average Price
1989	10.46	4.82	8.47	4.80	1.15	5.39
1990	11.05	4.86	11.77	5.57	1.35	5.85
1991	13.01	5.55	13.53	6.89	2.62	6.92
1992	14.94	5.59	14.92	7.68	3.60	7.71
1993	15.56	5.4	15.62	7.79	4.42	7.81
1994	14.85	4.52	14.54	7.41	4.04	7.04
1995	9.80	2.82	9.40	4.68	2.19	4.35
1996	10.29	3.37	10.25	4.97	2.27	4.70
1997	11.57	4.21	11.32	5.50	2.50	5.45
1998	11.28	3.98	11.96	5.49	2.47	5.25
Average annual growth in %	0.8	-2.1	3.9	1.5	8.9	-0.29

Source: CFE 1999a, domestic electricity price table (no page number).

Short-term projections (5–10 years) of Mexican electricity prices are only valid if done by consumer sector, since the sectors obey different parameters. Residential rates are set basically as a function of economic policy criteria. The key question is to determine the speed at which the authorities intend to rectify the price/cost ratio.

For industrial rates, the methodology is defined and the foreseeable price trends may be plotted by taking account of trends in the producer price indexes and in forecasts of the price of fuels used for power generation.

3.5 Overview of Emissions from Power Generation

Mexico's electricity generation capacity is dominated by thermal power plants. Thermal power generation accounts for approximately 65 percent of total generation, the majority of which is from oil-fired plants. Coal, gas, and diesel plants supply the remaining thermal generation. Hydroelectric capacity provides the next largest contribution to overall power generation, approximately 29 percent. The remaining 6 percent of installed capacity is met by nuclear, geothermal, and wind capacity. Table 7 (below) provides a summary of the country's generation capacity by fuel type and region.

Carbon dioxide emissions from the power sector comprise a significant part of Mexico's total contribution to global greenhouse gas emissions. According to the most recent national communication by Mexico on its emissions inventory, the electric sector contributed approximately one-quarter of total emissions, or about 108,500 billion metric tons of CO_2 (INE 1999). This emission estimate does not include CO_2 emissions from fossil fuel combustion for electricity generation in the industrial, residential, or commercial sectors of the economy.

Expansion plans for Mexico's generation capacity through to the year 2007 favor additions of natural gas-fired capacity, complemented by some hydroelectric, geothermal and coal-fired facilities. Based on the latest version of CFE's expansion plan, the overall increase in generation capacity will be on the order of 21.5 GW, with about 70 percent, or some 15 GW, provided by natural gas-fired facilities, mostly combined cycle plants. Table 8 provides a summary of planned capacity additions (further detail is provided in Annex A).

The increased proportion of natural gas in the fuel mix used for electricity generation will likely decrease the overall carbon intensity of the power generation sector (i.e., kg CO_2/kWh). As noted, natural gas has a lower carbon content, and thus emits less CO_2 per unit of energy, when compared to either oil or coal. The extent to which this decline in carbon intensity on a per kWh basis occurs will depend on resource utilization patterns. In addition, while the carbon intensity of the sector will decrease, the overall CO_2 emissions from power generation activities will increase due to the necessary increase in production.

The ability for flexible mechanism projects to generate certified emission reduction credits will depend on its ability to reduce emissions compared to what would have happened in the absence of the flexible mechanism. Baselines and benchmarks are important tools for measuring these emission reductions. The level at which the baselines are set will determine the amount of certified emission reductions a given project can achieve and the additional revenue flexible mechanism participation is likely to afford. For example, if natural gas-fired, combined-cycle plants are the typical plant that is installed, in order to generate certified emission reductions, flexible mechanism projects must have emissions lower than such a plant. Such a baseline would provide Certified Emission Reduction credits for renewable energy technologies and energy efficiency measures.

Table 7: Installed Generation Capacity, as of December 1997

Thermal Generation

Area	Hydro and wind	Fuel Oil	Combined Cycle	Gas Turbine	Diesel[2]	Dual Fuel[3]	Coal	Geothermal	Nuclear	Total
Northwest	941	2,162		130						3,233
North	28	1,074	200	253						1,555
Northeast	118	1,715	378	170			2,600			4,981
Western	1,797	3,466	218			2,100		88		7,669
Central	1,902	2,474	482	374						5,232
Eastern	5,250	2,217	452	43				40	1,309	9,311
Peninsular		442	212	328	1					1,083
Baja California		620		177	2			620		1,419
Baja California South		113		96	75					284
Isolated Systems					47					47
Total	**10,036**	**14,283**	**1,942**	**1 671**	**125**	**2,100**	**2,600**	**748**	**1,309**	**34,814**
	28,8 %	41 %	5,6 %	4,8 %	0,4 %	6,0 %	7,5 %	2,1%	3,8%	100.0%

[1] Wind capacity is 1.6 MW installed at La Venta, Oaxaca.
[2] Internal combustion.
[3] Generally runs on fuel oil and natural gas or fuel oil and diesel (Eastern Subdivision).

Source : Secretaría de Energía, 2000.

Table 8: **Summary of Planned Evolution of Electricity Generation Capacity, 1997–2007**

	Existing 1995	Existing 1997	Planned 1997–2007	Total 2007	Percent Increase
Geothermal	753	748	215	963	29
Hydroelectric	9,331	10,036	2,465	12,501	25
Combined Cycle	1,890	1,942	14,703	16,645	757
Coal	2,250	2,600	2,700	5,300	104
CITD	129	125	131	256	104
Gas Turbine	1,682	1,671	1,154	2,825	69
Conventional (with CC and Dual)	15,695	16,383	150	16,533	1
Nuclear	1,309	1,309	-	1,309	0
Total	**33,037**	**34,815**	**21,518**	**56,332**	**62**

Note: Due to technology mix at several proposed projects and name changes at some plants, classification may not be precise.

Source: CFE 1999a, domestic electricity price table (no page number).

3.6 Power Generation and Energy Efficiency Projects under AIJ

Mexico's portfolio of JI/AIJ projects has only recently been expanded to include energy projects. This reflects the initial reluctance of the Secretariat of Energy and other parts of the Mexican government to support projects in the energy sector, due to concerns about the implications of such projects for Mexico's energy sector, given its contribution to the country's GHG emissions. Some energy sector officials expressed concerns that issuing credits for projects in the energy sector might limit the country's ability to reduce emissions at some point in the future. In effect, some officials have counseled that Mexico's energy sector reserve potential emission reductions to meet any future targets Mexico may face. Early in the history of Mexico's JI/AIJ program, the National Ecology Institute (*Instituto Nacional de Ecología*) signaled its preference for forestry projects, and indeed the first three projects to receive registration in Mexico's *Reto Voluntario y Registro de Acciones* (RVRA) were alternative agriculture and forestry projects.[13]

3.6.1 Past Lessons with JI/AIJ Projects in the Electric Power Sector

Mexico has been involved in both power generation and energy efficiency JI/AIJ projects. With the approval by the San Juanico wind generation facility as a JI project in 1999, Mexico acquired its first energy sector JI project registered with the US Initiative on Joint Implementation. On the demand-side, the ILUMEX project in the Mexican states of Nuevo Leon and Jalisco developed under the

13 These are Proyecto Salicornia (alternative agriculture, 1996), Scolel Té (forestry, 1997), Sierra Gorda de Querétaro (reforestation, 1998), and Sierra Norte de Oaxaca (forestry, 1997).

World Bank's AIJ Pilot Program, reduces grid emissions through a high efficiency lighting project.

The San Juanico wind generation project dates back to a commitment made by Arizona Public Service (APS) under the US Climate Challenge to reduce emissions below 1990 levels, together with a transaction between APS and Niagara-Mohawk Power Company (NMPC) involving a swap of SO_2 emissions permits and CO_2 reductions. As part of the transaction, APS acquired the commitment to invest in an emissions reduction project, and chose to work with CFE in Mexico.[14]

The San Juanico project involves the replacement of a diesel-fired generation station at San Juanico that provided electricity for an isolated grid in the town for about three hours a day with a 117-kW system powered by 100 kW of wind turbine generators and 17 kW of solar panel capacity, with an upgraded 80-kW diesel unit providing back-up power. The key to the system is a 70kW power processor that balances power from the two renewable resources, and a bank of batteries providing power storage capacity.

The project cost a total of about US$1 million, of which APS and NMPC provided US$300,000, government agencies another US$250,000, and the governments of Baja California Sur state and the town of San Juanico another US$260,000. The municipal government contributed land and local villagers provided labor. The villagers recognized the economic potential of the system and as a result agreed to move from the old system in which they paid a flat rate of 50 pesos a month for electricity to a system of metered billing. According to the project's developers, a fish processing plant in the town was not operating before the project was completed, but could do so afterwards. This would permit the fisherman to store and preserve fish in the event that prices are unacceptably low, substantially improving the revenue potential of their catch. Previously, fishermen were obliged to sell their fish at the going price or lose it to spoilage.

The GHG emission reductions from the project are limited, however. According to APS, the estimated reduction in emissions is about 350 tons of CO_2 a year, or some 10,000 tons of CO_2 during the lifetime of the project. Given the sizeable investment in the project, the cost per ton of the carbon reductions generated by San Juanico is about US$100 per metric ton. The costs of carbon offsets from these projects are not publicly available, but the price offered and, in the case of the USIJI forestry project Scolel Té, paid for carbon credits from these projects has normally been US$10 per metric ton of carbon. Clearly, this cost is substantially more competitive than the cost associated with the reductions achieved at San Juanico, again confirming the initial assessment that the capital costs associated with San Juanico were comparatively high.

The project was implemented under a cooperative agreement between APS and CFE. According to the APS team responsible for the project, CFE's involvement and in-kind support for the project was crucial to its success. However, other

14 Personal communication from C.V. Mathai, APS project manager, October 1999.

agencies also played a part in implementation, and it is likely that it would not have been completed without their support. USAID and the US Department of Energy's Sandia National Laboratory both contributed additional funding to the project.

3.6.2 Other Pilot Projects

Since the San Juanico project (which is of limited usefulness as a model for subsequent projects because of cost and time involved), several energy efficiency projects have been submitted to INE and USIJI for registration. These include a series of demand-side management projects implemented by a Mexican energy services company submitted for registration by financial advisors Econergy International Corporation (EIC). These projects have been implemented on a commercial basis, with almost commercially-priced financing, and could provide an example of flexible mechanism projects as viable investments. At present, these projects are under review by USIJI and INE.

3.7 SME Market in the Power Generation and Energy Efficiency Sectors

This section seeks to characterize the SMEs that are involved in the power generation and energy efficiency sectors in Mexico, and the opportunities for new entrants in these markets in the future. While the ability of SMEs to participate in the generation sector, in particular, has been limited in the past, the regulatory changes that seem likely in the next several years could alter the market environment substantially. On the other hand, in the energy efficiency sector, most of the companies currently involved are SMEs, and the opportunities for new entrants are probably greatest for larger, established firms from overseas, especially energy service companies.

3.7.1 Energy Efficiency Sector

The energy efficiency sector in Mexico is made up of a large number of SMEs, and an increasing number of larger, international firms. No formal, publicly available registry of companies exists, and efforts to characterize the sector in detail have been limited to date. The assessment presented in this paper is based largely on anecdotal evidence and observation.

In recent industry meetings organized for the energy efficiency and energy services company sectors in Mexico, the companies present were exclusively small engineering firms with between five and 20 employees. However, larger foreign energy services companies have also been active in the market, especially in the last five years, and it seems unlikely that the group in attendance at the recent meeting in Mexico was representative of these newer players.

The presence of larger firms is likely due to the wave of US investment in Mexico resulting from NAFTA. Larger energy services companies from the United States have followed their larger clients into Mexico to perform energy efficiency projects at Mexico-based facilities. More recently, with Fide's efforts to promote the energy efficiency sector in Mexico, there has been increased interest on the part of US and other international energy services companies in the Mexican market.

Regardless of the broader factors, however, the primary determinant for investor interest in the sector is the potential for identifying and implementing profitable projects. As energy costs edge higher and the need to become more competitive in international markets sharpens, companies with energy-intensive processes will look for cost-effective energy savings, and will employ external expertise to the extent that they lack this expertise in-house. As noted earlier, energy prices have moved quite dramatically higher since mid-1999, in part as a result of the increase in crude oil prices, but also due to the significant strength of the Mexican peso, which has appreciated by about 20 percent since late 1998. Together, these factors will increase the incentives for industrial and commercial energy users to reduce their energy costs.

3.7.2 Power Generation Sector

The scope of investment opportunities in flexible mechanism projects in Mexico's power generation sector will depend on the extent to which the regulatory structure is reformed. The current framework allows participation of the private sector under only four modalities. These modalities include independent power production (IPP) over 30 MW; cogeneration plants; small-scale production under 30 MW; and self-supply to service private needs. In any case, however, power generation projects have high capital requirements that may well exceed the resources and capabilities of SMEs, even when the additional revenues generated by certified emission reductions are taken into account. Based on the number of private sector projects that have been approved by the Energy Regulatory Commission (*Comisión Reguladora de Energía*, or CRE) for new project development, there appear to be relatively few SMEs currently involved in this sector.

- *Self-supply.* The average size of the generation facility for which self-supply permits have been issued is roughly 30 MW. This size represents substantially more capacity than the average small or medium-size company would be able to consume by itself. Also, at about US$30 million, this requires a substantially larger investment than most SMEs, with net assets in the neighborhood of $1 million to $10 million, would be able to finance. While possible, it does seem unlikely that a large enough group of SMEs would be able to agree on a project of this size. Even so, there may well be some smaller firms, especially in sectors where energy consumption is high, that have developed some of the smaller projects for which permits have been issued. Accordingly, of the project types open to private investment at present, the self-supply sector is probably the most attractive to SMEs.

- *Cogeneration*. The average size of the cogeneration facilities for which permits have been issued is substantially larger, about 75 MW. This confirms assertions that only a few cogeneration projects with favorable demand characteristics can actually be implemented, and suggests that these projects are even more clearly the province of larger firms, since the investment required would likely average about US$75 million. Given the technical complexity of cogeneration projects in general, this sector would appear to be a less attractive area of opportunity for SMEs in Mexico.
- *Import*. Import permits have been issued to companies that are mostly maquiladora subsidiaries of large, multinational corporations based in the United States or Asia. The list of import permit holders includes six permits totaling some 10 MW of transmission capacity, under the following names: Bose (consumer electronics); Minera Múzquiz (mining); Seihwa (probably electronics); Paulson Mexicana (unknown sector, but a foreign company); Hyo Seung de Mexico (probably electronics); and Mecox Resources (unknown sector, but a foreign company).

There are several explanations for the relatively low level of investment in private power, especially under the cogeneration, self-supply and small-scale production provisions of the energy law. Barriers to private sector involvement in the power sector that are applicable to both large and small companies are discussed later in this section. However, there are other issues that make it even more difficult for SMEs, as opposed to larger enterprises, to get involved in private power production:

- *Investment size relative to balance sheet assets of developers*. Power generation projects require substantial initial capital investments. This factor, together with the transaction costs involved with executing such projects, is perhaps the most important limitation on the participation of SMEs in the power sector. While the list of permits issued to date by the CRE contains the names of companies to which permits have been issued, it is difficult to discern whether relatively small companies have received permits. However, while this list does not provide detailed information on each company, anecdotal and empirical evidence does suggest that small companies are in the minority.
- *Transaction costs*. Conversations with Mexican enterprises that have considered developing generation facilities since 1993, and to a lesser extent since 1996,

reveal that the process of permitting and securing project permits, sales agreements, freighting arrangements with CFE, and obtaining gas supply contracts (previously with Pemex, a complicated process) have played a important part in slowing development, increasing costs and, ultimately, dampening the viability of the projects. However, there are changes underway in the market that could help reduce some of these transaction costs. Since gas transportation and distribution were opened to private companies in 1995, for example, private investment in this sector has increased, and numerous market entrants are developing large customer bases based on rapid conversion to natural gas from other fuels.

3.8 Opportunities for Power Grid Emission Reductions for SMEs

Mexico's rapid growth in electricity demand and consumption must be met by construction of new generation capacity, very likely complemented by increased investment in energy efficiency measures and demand controls. This need is compounded by the fact that some generation capacity, albeit a small segment, will be decommissioned in various areas of the country in the next several years. With adequate support from energy policy initiatives, private power, using cogeneration or renewable energy technologies, could play a significant role in meeting Mexico's capacity requirements in the next decade, especially in regions where access to natural gas will be limited because of considerations regarding the cost of infrastructure development or limited sales potential. More immediately, energy efficiency measures can play a role in reducing demand for electricity. In addition, these measures can offset carbon emissions by reducing power generation and the need for additional capacity.

While SMEs could ultimately play a part in both the power generation sector and the energy efficiency sector, both as end-users as well as project developers, it seems most likely that they could play a role in the development of the energy efficiency technology and services market. Their role as end-users of services provided by energy service companies offers the most potential. To the extent that SMEs do take part in the power generation and renewable energy market, the opportunities to do so may well include developing off-grid capacity. For example, taking advantage of renewable energy opportunities to displace current use of fossil fuels for thermal energy requirements in some production processes as well as space and water heating for commercial and tourism businesses. Other promising areas might include fuel switching to natural gas, and possibly the development of generation capability under a self-supply permit.

There are seven major market segments that are likely to emerge as significant markets for development of flexible mechanism projects in Mexico. It is important to note that the role of SMEs in most sectors (government is the exception) may be either as service providers (on a financed basis, as in performance contracting, or straight sales), or as service consumers (similarly, with varying contractual arrangements). Table 9 highlights the different types of energy projects that may be most attractive in each sector and the role that SMEs can potentially play.

The potential applications of energy technologies and the participation by SMEs are addressed in the following section. First, opportunities for both grid-connected as well as off-grid applications in the power generation sector are examined. Second, energy efficiency opportunities on both the demand side and supply side are discussed.

Table 9: Potential Flexible Mechanism Opportunities for SMEs by Market Segment

Market Segment	Energy Efficiency Opportunities	Power Generation Opportunities	Role of SME
National power supply	Generation Transmission Distribution	Renewable energy power sales	Limited, due to competition from larger firms Renewable energy equipment sales
Industrial and mining	Electricity Thermal energy use Fuel Switching	Renewable energy for self-supply generation Cogeneration Fuel Switching	End-user Energy services company
State, municipal and federal government buildings	Lighting Cooling Heating Pumping	Renewable energy for self-supply generation and thermal energy needs	Energy services company Energy engineering Equipment Sector
Commercial	Lighting Cooling Heating	Renewable energy for self-supply generation	Energy services company End-user
Hotels	Lighting Cooling	Renewable energy for self-supply generation and thermal energy needs	Energy services company End-user
Residential	Lighting Cooling Heating Hot Water	Renewable energy for electricity and thermal needs	Service providers

3.8.1 Energy Efficiency Sector

Energy efficiency projects offer significant opportunities for SMEs, especially in the nascent energy services company sector. There are numerous small firms specializing in energy engineering that have provided services to industrial and commercial clients, generally limited to fee-for-service contracts as opposed to performance contracting, which requires larger capital resources or access to financing, which has traditionally been lacking in Mexico.

The promotion of energy services company activity in Mexico is the focus of a major initiative by Fide, with support from the Interamerican Development Bank (IDB). Fide's multi-year *Programa de Eficiencia Energética* (PEE), which is funded through a US$23-million loan from the IDB, includes a range of activities intended to support the strengthening of energy services companies in Mexico. The Fide program is intended to help enhance the technical and business capabilities of Mexican companies that could become energy services companies, with technical training, development of contractual mechanisms, and efforts to create a certification system for energy service providers. Fide will also create a rebate program that will give end-user companies a greater incentive to participate in the program. In addition, a Decentralization Program funded by Banobras, also with resources from a US$400-million loan from the IDB, will provide resources for state and local governments to undertake a wide range of programs—which could include energy efficiency projects. To the extent that the program leads to the increase in demand for energy services company services, this program will complement the conditioning of the energy services company supply provided by Fide.

There is increasing awareness of the opportunities that energy efficiency investments offer—even if they are not utilized to the greatest extent possible. There is significant regional variation with regard to the receptivity and viability of energy efficiency projects. For example, several areas of the country boast climatic conditions and rapid energy demand growth that make energy efficiency investments a far easier proposition to sell to clients than in other regions. Several sectors have become targets for the development of an energy services company sector in Mexico:

– *Industry, commerce and hotels.* Industrial, commercial and hotel companies are becoming increasingly aware of the potential savings that may be generated by energy efficiency programs. This increased awareness is attributable to a large extent to the efforts of Fide and Conae, but is also due to tariff increases. The adjustments in electricity tariffs in the period following the 1994 devaluation, coupled with significant seasonal variations in tariffs in some regions of the country, have made the economic benefits of such projects clear.

  At the same time, industrial companies have limited their energy efficiency efforts to conducting energy audits. About 60 percent of companies polled by Fide indicated they had undertaken audits; of these, some 40 percent reported that energy consumption was higher than necessary. However, the scope of measures implemented by this segment seems to have been limited (IIEC et al. 1996). Tight budgets and numerous attractive non-energy-related investment opportunities tend to relegate energy efficiency investments to second- or third-tier priority—in spite of the potential savings. Accordingly, interest in performance contracting, or "outsourcing," has increased.

  Compared to the industrial sector, the commercial sector appears to have done far less in terms of identifying energy use patterns through audits

(32 percent in the Fide survey), and of these, 45 percent reported higher than necessary energy consumption. Lighting fixture changes and the installation of independent circuit breakers appear to be the most prevalent measures adopted (IIEC et al. 1996).

The economic returns on energy efficiency investments are greatest in regions where cooling requirements tend to be the greatest, which is typically in the regions of the country where demand growth is the fastest and, coincidentally, where the seasonal variation in energy and capacity charges are greatest. In other regions with more temperate climates, such as the Valley of Mexico and Guadalajara, the returns on such investments tend to be attractive in larger industrial and commercial facilities, and not so much in hotels.

Prior to the decline in the peso in August 1998, as of mid-1998, industrial tariffs nationwide averaged about 4.5¢/kWH, while commercial tariffs stood at 10.5¢/kWH. These levels are sufficiently high to make project economics attractive, even in more temperate regions if the consumption volumes are sufficiently high. Elsewhere, in the hotter northwestern and northern regions, as well as the tropical climates of the coastal regions, these rates are more than sufficient to make projects economically viable. Indeed, these areas often have higher than average tariffs as well: in Sonora, for example, an industrial facility faced summertime peak tariffs in the range of 9 to 11¢/kWH, and base period tariffs in winter as low as 2.3 to 2.8¢/kWH. As noted earlier, depreciation of the peso reduces the dollar value of these tariff rates for a short period, since the inflation component in the tariff escalator will permit tariffs to recover most, if not all the decline in dollar terms within a few months. In the current situation, in which the peso is much stronger, tariffs in dollar terms have increased, especially relative to tariffs imposed on the Mexican firms' competitors in the United States and elsewhere. This will only reinforce the desirability of implementing energy efficiency measures.

– *Municipal and state governments*. Local governments also offer attractive projects, especially in the area of efficient lighting. Fide has helped finance about $2 million in demonstration lighting and pumping efficiency projects for 135 municipal governments. Figures for these projects suggest an average repayment period of between one and two years, based on investments ranging from US$10,000 to US$20,000 (Torres 1998).

Based on these demonstrations, municipalities have financed similar projects using multilateral and private bank resources, the former channeled through Banobras (*Banco Nacional de Obras Públicas*). The total amount financed by Banobras is about US$24 million, covering another 100 municipalities. (Data on the amount of investment privately financed, in these municipalities, are not available.)

Fide estimates the current market for efficiency projects is made up of about 1,000 municipalities, each with a population of about 50,000 inhabitants, where projects have not yet been undertaken. A recent Fide study of this market's scope suggests the potential for 1.4 billion pesos of investment in 425 MW of capacity reductions and 1,800 GWH of energy savings.

In energy efficiency projects for municipalities, the issue of collection by energy services companies has been of greater concern than in the industrial projects. While lease contracts are generally signed in both project types, the potential for political change leading to cancellation of contracts is clearly greater at the local level. Some equipment suppliers/developers have addressed this situation by including clauses permitting the owner to remove equipment in the event of non-payment under public contracts. Given the political ramifications of having street lighting removed, incoming governments have tended to seek alternatives to canceling contracts that they do not wish to continue.[15]

– *Power supply.* Another major energy efficiency sector is that of the electric sector itself. CFE is only beginning to address the opportunities for supply-side efficiency measures. However, the field of competitors for CFE bids is large and dominated by major firms. It seems unlikely that SMEs can play a significant role here unless they provide a specialized technology, possibly one that offers an alternative to conventional equipment. This is extremely rare, and more likely to be the providence of a foreign firm rather than a domestic SME.

3.8.2 Power Generation Sector

There are opportunities for both grid-connected supply as well as off-grid applications in the power sector using cogeneration and renewable energy technologies. With respect to grid-connected applications, there are several major market segments that exhibit varying levels of development and activity. More limited opportunities are available in terms of off-grid applications due to the limited population not served by the grid. However, the prevalent use of diesel technologies does offer potential to reduce emissions that would occur in the absence of the any flexible mechanism.

For grid applications, there is significant variation between sectors in terms of sophistication and interest in private power projects, in addition to substantial regional variation. From a regional perspective, there is substantial variation in terms of the growth in demand and consumption of electricity and the availability of renewable energy resources. These are key factors in determining the demand for such services and technologies.

15 Personal communication, Esteban Torres (Municipal program director, Fide), 13 August 1998.

- *Cogeneration:* The National Commission for Energy Conservation (*Comisión Nacional para el Ahorro de Energía,* or Conae) has prepared an assessment of cogeneration potential in Mexico, but this assessment considers non-renewable energy applications primarily. It references a limited set of renewable energy opportunities in the country, especially in the sugar industry. Industrial cogeneration using natural gas has been extensively studied, and a significant amount of potential capacity has been identified. However, as noted earlier, the likelihood that cogeneration projects will be economically viable at a size that might be financially feasible for an SME or group of SMEs is limited, especially due to the transaction costs associated with developing, permitting and financing such projects.
- *Biomass:* In addition to the Conae work, a study by Winrock International assesses the viability of specific projects in the forest products and sugar industries (Conae 1998). In general, the opportunities for biomass cogeneration in the sugar sector are substantial, but they are hindered by the extremely poor financial condition of most sugar mills. Ever since their privatization in the early 1990s, the sugar mills have been burdened by large amounts of debt with little prospect of an improvement in prices to aid recovery. An additional barrier to project development is the fact that sugar is a controlled commodity in Mexico, and exports, especially to the United States, are controlled by a quota system. Furthermore, imports of high-fructose corn syrup have eroded the mills' market share in the important soft drinks sector.
- *Hydroelectric:* Conae has completed a study of small-scale hydroelectric potential in the Veracruz-Puebla region, including preliminary feasibility analyses for specific projects, and the CFE has extensive information on the broader potential for hydroelectric generation in the country (Conae 1997). CFE is very interested in finding ways to spin off the small hydroelectric facilities that it has throughout the central part of the country, but it can do little until the fate of the Zedillo Administration's restructuring proposal is clear.
- *Solar:* According to recent information provided by Conae, there is still a substantial amount of work to be done to characterize the solar resource. The institutional and technical infrastructure available is not sufficient to complete the characterization and to maintain substantially credible records. There appears to be substantial potential in this area, however. For example, CFE is in the midst of developing a major pilot solar-thermal generation station with World Bank and GEF funding.
  Solar thermal energy is also an abundant resource in Mexico. Recent studies performed by the Institute of Engineering at the UNAM suggest that widespread conversion of LPG-fired residential water heaters to solar water heaters is both technically feasible and financially attractive. The major limitation appears to be education and promotion of a conversion

program, combined with the provision of low-cost financing to low-income buyers of such equipment (Conae 1998).

- *Wind:* Wind power faces similar limitations as solar power. Basic research has been performed by the *Instituto de Investigaciones Eléctricas* (IIE) for the Tehuantepec Isthmus region, yielding very favorable results (IIE 1996). Still, IIE contends that further studies are required to adequately characterize the renewable energy resources of several regions, including: the Baja California Peninsula, the eastern coast of the Yucatán Peninsula, the northern *altiplano* (central highlands) including the area around Mexico City, the Gulf of Mexico and Pacific coastal regions, and the southern part of the Tehuantepec Isthmus.

The economic feasibility of projects in these various renewable energy subsectors is mixed. Even the most recent studies may need to be updated to reflect changing exchange rates and international market conditions. However, it appears that some of the sugar mill projects assessed in the Winrock study could be attractive investments, even under the changing financial conditions of the country. In the case of the Conae mini-hydroelectric study, the feasibility of certain projects looks equally promising, although further financial analysis is needed.

Mexico has a relatively high rate of grid-connection; about 95 percent. The rural population requiring off-grid electricity in Mexico is roughly 4.5 million (*Secretaría de Energía* 2000).[16] The opportunities for renewable energy projects for off-grid application are thus more limited. Of the rural population, some are served by community-based diesel-fired or other off-grid generation in mini-grids, while the remaining unserved population segment forms the core of the market for household-scale systems (e.g., solar home systems) and other small-scale renewable energy generation systems. The size of this unserved segment varies from state to state: as of late 1995 in the state of Sonora, for example, some 91,000 inhabitants, or about 5 percent of the state's total population of about 2 million, did not have access to electricity other than from batteries (INEGI 1996). Experience with such projects indicates that rural populations are keen to acquire renewable energy technologies, but may not understand the technical limitations of off-grid generation installations.

3.9 Energy Regulatory Framework

In accordance with the reforms to the Law on the Public Service of Electricity (*Ley del Servicio Público de Energía Eléctrica*, or LSPEE) passed in 1992 and implemented in 1993, private sector entities can build, own and operate power plants under four different "modalities" of private power activity. Private parties may also build and operate transmission lines as long as they are not interconnected with the national grid. The private sector activities permitted by the Energy Regulatory Commission (*Comisión Reguladora de Energía*—CRE) are as follows:

16 Mexico's population in 1995 was about 91.12 million.

– *Independent Power Production*. The CRE allows private companies to build, own, and operate plants over 30 MW and sell power to CFE under a long-term purchase power agreement. To date, these projects have necessarily been planned and initiated by CFE, with the private investors participating after responding to competitive bids for the long-term purchase power agreement. However, CFE is beginning to give private developers more leeway in choosing location, fuel supply and technology than it has in the past. For example, in a recently proposed bid, CFE will entertain proposals for new capacity for delivery near the border with the United States, either in the form of a new generating station, to be located in Mexico or the United States, or from electricity imported via a new cross-border high-voltage interconnection.
– *Cogeneration*. Under this option, cogeneration facilities can generate electricity for self-supply or sale to CFE under a long-term purchase power agreements. Since cogeneration plants are less likely to have been planned by CFE, it is more likely that cogeneration plants will be developed and operated for the purpose of self-supply than as independent power production facilities. However, this situation may change as CFE is becoming increasingly open to alternative proposals in response to its tenders for new generation capacity.
– *Small-scale production*. The CRE allows facilities under 30 MW to produce power for sale to CFE, either on a short-term basis or under a long-term purchase power agreement.
– *Self-supply*. The CRE allows a private company or group of companies to build, own, and operate a plant serving multiple clients, who are owner(s) of the plant. The owners of the plant are defined as nominal shareholders in the company. This requires that projects be developed by companies through a company specially created to serve their own needs. Projects may rely on the CFE's transmission and distribution infrastructure under a contract for freighting services, or must build their own lines and substations.

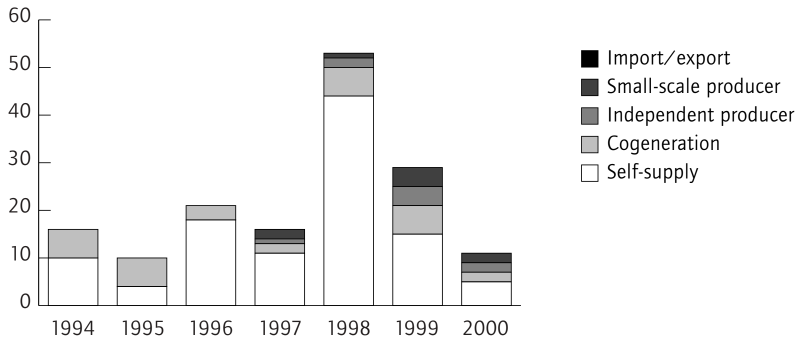
In order for private firms to participate in power sector supply and transmission, they must obtain a permit from the Energy Regulatory Commission (*Comisión Reguladora de Energía*, or CRE), the governmental body created in 1993 to regulate the energy sector. Although the CRE has nominal authority over the electric sector, its influence in practice is limited to reviewing applications for permits to generate, import or export electricity. Electricity tariffs are established by the *Secretaría de Hacienda y Crédito Público* (SHCP), based on recommendations provided by CFE with some input from CRE. As such, electricity tariffs remain a policy instrument for the government's macroeconomic policymakers.

Since the electric sector reforms of 1993, the CRE has been charged with issuing generation permits to private firms in accordance with the four modalities described above. However, only a relatively small number of permits have been issued since 1994. According to data from the CRE, 107 self-supply permits and 29 cogeneration permits have been issued. In addition, not all of the permitted projects have actually been built.[17] The Secretariat of Energy reported in 1999 that just 64 percent of the projects that received permits through March 1998 had been implemented and were in operation (*Secretaría de Energía 1999a*).

Of the total number of permits issued through April 2000, self-supply permits account for 70 percent, with cogeneration providing another 20 percent, independent production five percent and permits for power import and export accounting for less than five percent. Although one small-scale production permit was authorized, it is no longer in effect since the developer failed to build the proposed project within the period of validity of the permit.

Of the 9,500 MW in total capacity permitted, independent production and self-supply account for about 37 percent each, compared to 23 percent from cogeneration. Import and export account for only three percent. However, the permits do not reflect actual installed capacity due to the fact that not all projects permitted are implemented. For example, by March 1998, independent production projects amounting to 530 MW in new capacity were in operation, but permits for some 3,250 MW had been issued (*Secretaría de Energía 1999a*). The total independent production capacity permitted stood at 3,525 MW by April 2000. The number of independent power production projects issued per year has increased since 1997, and this segment of the private power market is expected to increase dramatically over the next several years as CFE accelerates its expansion program. (See Figure 3 for an analysis of the number of permits issued per year for each type.)

Figure 3: Permits Issued by CRE



Source: CRE, data through 6 April 2000.

Note: Only one small-scale production permit has been issued, and it has since been revoked due to failure to implement the project for which it was issued.

17 Many of those built were already in place before the permit was requested, as part of the CRE's effort to issue permits for hitherto unpermitted facilities.

3.9.1 Barriers to Private Sector Investment

While the pace of permit issuance may have quickened, as the Secretariat of Energy argues, many of the regulatory, economic and financial, and technical conditions that have been responsible for the low level of project development since 1993, especially through 1997, still remain, although there has been improvement in certain areas. Some key barriers to project implementation include:

- *Artificially low electricity tariffs.* Perhaps the most important deterrent to project development during the first years after the new power sector rules were promulgated was Mexico's artificially low electricity tariffs in the immediate aftermath of the peso devaluation. At the time, the tariffs did not include automatic adjustments for fuel cost and inflation, hence became artificially low (in dollar terms) at the lower exchange rates for the peso. Once a new tariff adjustment formula accounting for these factors took effect in 1996, tariff levels recovered in dollar terms. Since 1999, tariffs in dollar terms are likely to have increased still further in real terms because fuel prices have moved higher with the rebound in oil prices, and the peso has gained value versus the dollar. Tariffs vary by region, time of day and season. Although these tariffs in some regions in Mexico can be quite high by international standards, in other regions tariffs may be competitive with international rates. While it is too soon to determine whether this latest shift has entirely eliminated the price obstacle to project implementation, it seems likely that electricity costs that, until recently, had been comparatively low will increase. This tariff increase will make both private generation projects and energy efficiency projects comparatively more attractive.
- *Low purchase price for electricity by CFE.* The low purchase price for electricity offered by CFE—which is in effect a monopolist in the market for privately produced electricity fed into the grid—has been a deterrent for small-scale producers. The rates that CFE pays for capacity made available to the market are often inadequate for projects to reach an acceptable rate of return. In the case of renewable energy projects, especially wind, CFE capacity charges are limited due to concerns about the reliability of that capacity—a problem encountered by wind projects in other countries as well. Accordingly, the vast majority of permits issued, and investments that have actually reached completion, is composed of self-supply and cogeneration projects.
- *Technical requirements of cogeneration.* In order for cogeneration projects to be viable, of course, the technical requirements of the presence of a steam host, and adequately balanced steam and electricity loads within the industrial facility, must all be present. Since not all firms interested in such projects have facilities that meet these technical criteria, the set of

potential project sites is correspondingly small.

- *Legal restrictions on self-supply projects*. The restriction on self-supply projects that requires all purchasers of power to be equity participants in the plant reduces the set of potential projects.
- *Ongoing shortage of bank credit*. The relatively difficult financial and economic conditions prevailing in Mexico from 1995 to 1996 and the continuing shortage of bank credit have limited participation by investors. The credit drought is well documented, most notably by data that show Mexican bank lending dropping from 40 percent of GDP in 1994, before the peso crisis, to about 16 percent in 1999 (Economist 2000). This limitation affects small and medium-size firms more than larger entities, which make up a large part of the project permit holders.
- *High upfront capital investments and low rates of return*. Power generation projects require significant up-front capital investments. Furthermore, the stiff competition that has prevailed in the CFE-sponsored bids for independent power production projects appears to have driven down returns on investment for large-scale projects in the electric sector in the last two years. In a recent review of the bids received by CFE for power sales from independent power production projects, prices have ranged from a high of 2.94¢/kWH offered by Intergen at the Bajío plant to the 2.38¢/kWH offered by Iberdrola at Monterrey III (industry sources). In addition, high transaction costs in energy generation projects reduce the rate of return, limiting the profitability of projects, which has significant impact on small-scale projects.

3.10 Conclusions

The greatest opportunity for SME involvement lies in the energy efficiency sector, where SMEs can play a role in two potential capacities. First, SMEs in the industrial, commercial, and residential sectors can develop energy efficiency or fuel switching projects that will offset power-grid emissions. Second, SMEs can take advantage of the potential business opportunities made available by operational flexible mechanisms. Flexible mechanism opportunities in the power generation sector are limited due to the current energy sector and regulatory framework. Additional barriers specific to SMEs limit flexible mechanism opportunities in the power generation sector. However, the current regulatory structure is under review. If a proposal by the Zedillo Administration to increase private sector participation in the energy sector is accepted, the opportunities for SME participation in the supply-side could increase. At this time, the outcome of discussions on power sector reform, as well as the timeframe for reform are uncertain.

4 Flexible Mechanism Opportunities in the Steel Sector

4.1 Introduction

The steel industry is an energy-intensive industry: the largest industrial electricity and coke user and the second largest consumer of natural gas in Mexico. The steel sector industry in Mexico is a strategic economic sector, both in terms of the number of jobs it creates and its contribution to overall exports.

In the early 1990s, the steel industry in Mexico underwent privatization. The government sold *Altos Hornos de México* S.A. (AHMSA) and Siderúrgia Lázaro Cárdenas Las Truchas S.A. (Sicartsa) to the private sector, under conditions that incorporated additional measures to protect the environment. The new owners made important investments to improve the facilities and efficiency. At the sector level, investments in modernization over the last 10 years have totaled approximately US$4.9 billion. The steel producers' organization, *Cámara Nacional de la Industria del Hierro y del Acero* (Canacero), calculates that 24 percent of the modernization investments directly contributed to improved environmental protection, including GHG emission reductions.

The modernization process is relatively recent in comparison with other countries, and opportunities for further efficiency improvements remain, particularly in small and medium-sized enterprises. As a capital- and technology-intensive industry with a large amortization, further technological changes are unlikely, given current world steel markets and high energy costs. However, opportunities for cost-efficient improvements to small and medium-size enterprises may be available.

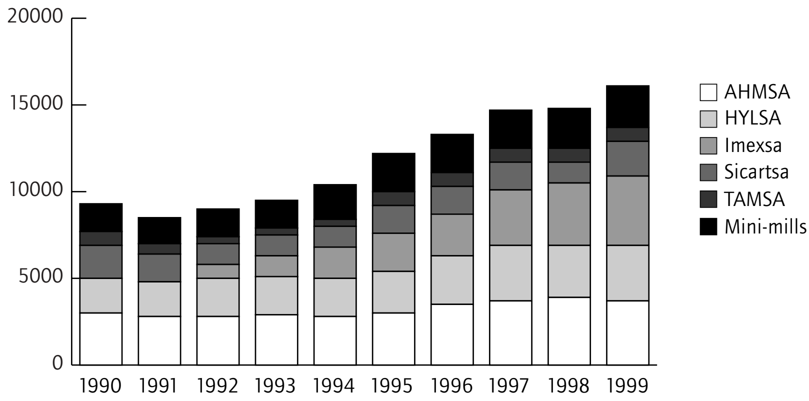
This section provides an overview of energy use and emissions in the steel sector, as well as information on opportunities for emission reductions at 24 enterprises. Special attention is given to the small and medium-size enterprises. For the purpose of initial estimation of GHG emission reduction potentials, close contact was established with Canacero.

4.2 Overview of GHG Emissions from the Steel Sector

As an energy-intensive industry, the steel sector contributes to GHG emissions, which are closely related to the amount of energy consumed and the mix of fossil fuels used. Total energy consumption in the steel sector is a function of the production volume (i.e., tons of steel produced), the process used and the efficiency of the production process, and the end-product mix.

As shown in Figure 4, from 1990 to 1999, Mexican iron and steel production increased annually by an average of 7.1 percent, reaching 15,299 thousand tons in 1999 (Canacero 2000). About 80 percent of steel production in Mexico is attributable to five enterprises: AHMSA, HYLSA, Imexsa, Sicartsa and TAMSA. Mini-mills represent the remaining 20 percent of production.

Figure 4: Steel Production by Company, 1990–1999

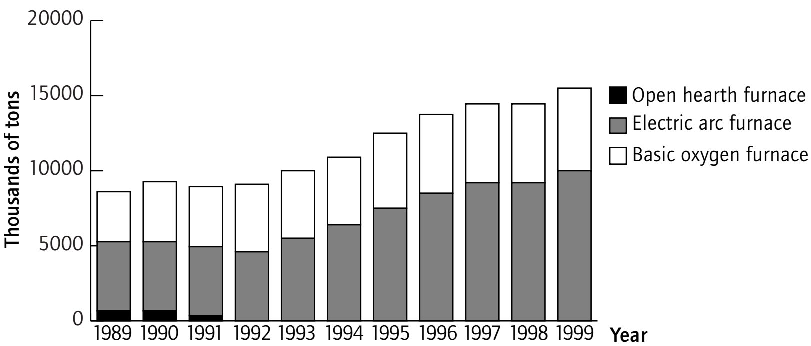


4.2.1 Technology Changes

Recent growth in Mexico's steel industry reflects in part its modernization. In iron making, pig iron production increased 32 percent, from 3,665 thousand tons in 1990 to 4,822 thousand tons in 1999. During those same years, use of newer technology to make sponge iron (also known as Direct Reduction Iron [DRI]) pushed its production up 140 percent, from 2,525 thousand tons to 6,070 thousand tons (Canacero 2000).

Technology has also changed the shares of primary steel production among the blast furnace (BF), open hearth furnace (OHF) and basic oxygen furnace (BOF) processes. In the early 1990s, OHF steel production disappeared completely and was replaced by BF/BOF production in the integrated plants. Similarly, production of secondary steel by the DRI, electric arc furnace (EAF) and scrap processes have also changed. Steel production by EAF has increased due to the growth of DRI production and to the expansion of the installed capacity of the scrap-based EAF secondary steel plants (Ozawa et al. no date, see Figure 5).

Figure 5: Steel Production by Process, 1989–1999



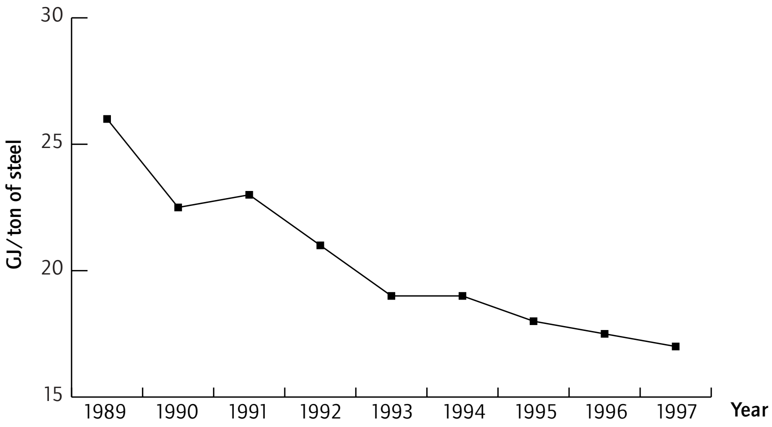
Similarly, in manufacturing semi-finished steel products, newer continuous casting technology has quickly replaced ingot casting. Since thinner sheets can be obtained using hot rolling, this production mode has increased, while cold rolling production has declined.

Most of the scrap consumed in the Mexican iron and steel industry must be imported. Due to the high cost of imported scrap, Mexico produces large quantities of DRI. Moreover, HYLSA developed its own technologies for DRI production: HYLI and HYLIII, which show reduced energy intensity compared to traditional processes (Ozawa et al. no date).

Energy Intensity and Energy Efficiency Measures

The rate of energy consumption by this sector has declined over the years, as measured by GJ/ton of steel. Energy intensity per ton of steel produced decreased 31 percent between 1989 and 1997, from 25.5 GJ/ton to 17.5 GJ/ton (see Figure 6). Efficiency gains are due to: closing of open hearth furnaces by 1992; increased use of continuous casting (from 9.8 percent in 1970 to 85 percent in 1996); and increased use of coke oven gas and blast furnace gas for electricity cogeneration in the integrated plants (Ozawa et al. no date). In addition, production of DRI in Mexico has increased and is carried out using the highly efficient HYL technology.

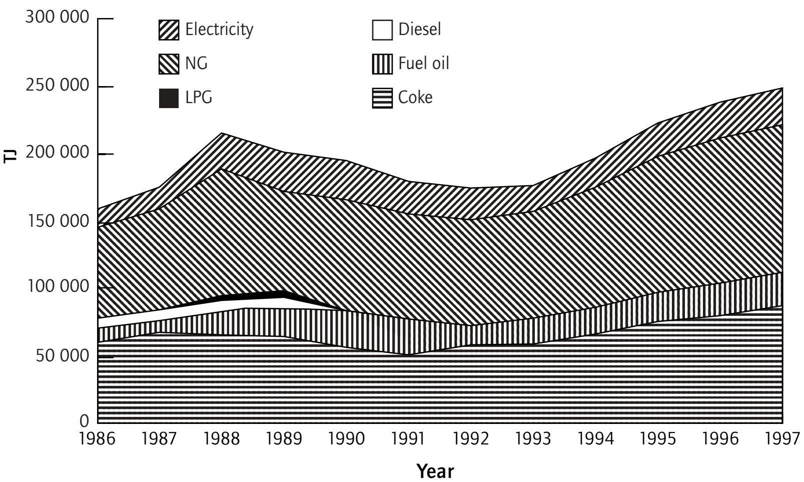
Figure 6: Trends in Energy Intensity (steel sector), 1989–1997



However, it has been estimated that the energy efficiency of the Mexican steel sector still has an important improvement potential [37.7 percent (Ozawa and Sheinbaum, no date)] in relation to best practices in 1995, including measures for energy saving at the different stages of the iron and steel making processes. At large integrated plants, the potential for energy conservation is high. At these plants, pellet, oxygen and nitrogen production, as well as water treatment are done on-site, hence increasing energy consumption compared to other facilities in which the corresponding energy is consumed off-site at the providers' plants.

Figure 7 suggests that the steel sector makes intensive use of many types of fuels. It is the largest industrial sector for electricity consumption, accounting for 11.1 percent of the total. This sector remains one of the country's two largest industrial consumers of natural gas, accounting for about 16.4 percent of the industrial national total—second only to the petrochemical industry. In 1997, the steel sector accounted for 10.5 percent of total Mexican industrial fuel oil consumption. And while steel making is a major consumer of coke, the increase of DRI production, which relies more on natural gas as an energy source, has tempered the growth in coke consumption (Canacero 1999).

Figure 7: **Energy Consumption by Fuel Type, 1986–1997**



4.2.2 Carbon Dioxide Emissions

Carbon dioxide emissions from the steel sector in Mexico have grown modestly in recent years, reaching 5,600 ktC in 1996 (see Figure 8). According to the National Greenhouse Gas Emissions Inventory (INE 1997), from 1987 to 1993 the iron and steel sector was the largest industrial source of CO_2 in Mexico, accounting for about 20 percent of total industrial emissions, which were in the neighborhood of 17,000 to 18,000 ktC during this period.

However, it is important to note that the carbon dioxide intensity (CO_2 emissions/ton steel produced) of the sector decreased by 37 percent, from 0.67 tC/ton of steel produced in 1988 to 0.43 in 1996. This decoupling of total outputs from GHG emissions (or carbon output per unit of overall output) is a result of the changes in the factors mentioned above, in particular, improvements in energy efficiency and the substitution of coke by natural gas due to the increase in DRI production.

Figure 8: **Steel Production and CO2 Emissions, 1986–1996**

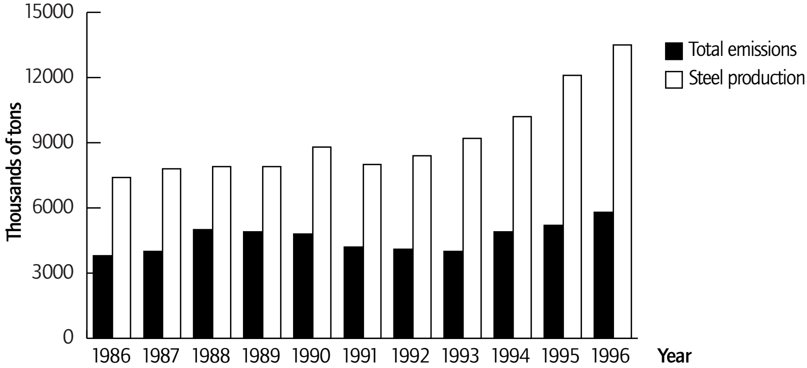
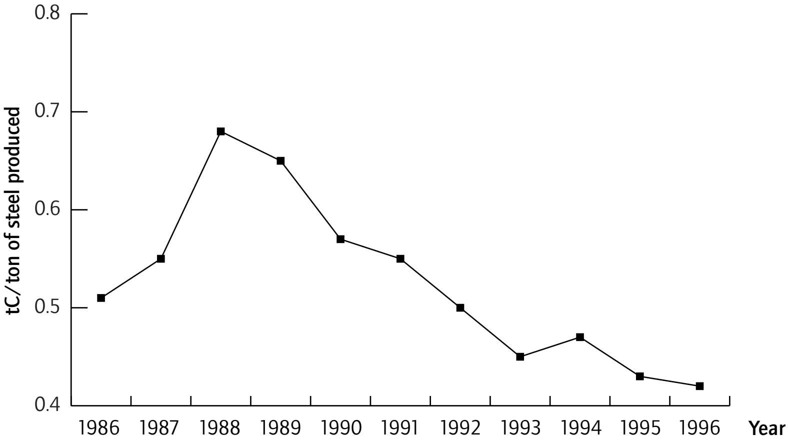


Figure 9: **Carbon Intensity of Steel Production, 1986–1996**



4.3 Characterization of Small/Medium-size (i.e., Non-dominant) Firms in the Steel Sector

Based on a survey and analysis undertaken for this report, assessing flexible mechanism project opportunities among small and medium-size companies of the Mexican steel sector entails the difficult task of gathering information on energy use and technology. There is very little awareness of climate change issues among companies (with the exception of the larger ones), but there is a general idea that climate change is a problem that could eventually mean large investments and stricter regulations for the steel industry rather than opportunities. In addition, data about energy consumption and technology at the company level is not readily available. This is partly a consequence of the small size and large number of small and medium-size industries in the Mexican steel sector.

In order to produce an in-depth analysis of opportunities for flexbile mechanism projects for non-dominant companies in this sector, it would be necessary to carry out a census and an effective climate change information campaign. Part of the activities of this study has been to inform some of the steel companies of the opportunities that could arise from flexible mechanisms. As a first step in this direction, questionnaires, together with background information on CDM, were distributed to Mexican Steel Chamber members, with the help of Canacero. Such efforts are likely to continue, since the Committee on Environment and Safety and the Environmental Office of the Mexican Steel Chamber are interested and aware of the opportunities that reducing greenhouse gas emissions could mean for its members. Therefore, in addition to providing information to potential investors, this the CEC project has helped raise awareness within the sector about potential opportunities and capacity-building needs related to flexible mechanisms, in general, and CDM, in particular.

4.3.1 Smelting Industry

In Mexico, the smelting industry provides employment for over 54,000, of which 79 percent are blue collar workers. An estimated 618 companies are in operation, of which information is available for only 250 companies, with an average production of 701,243 tons/year (CEC 1999). Fifty-one percent of the cast metal corresponds to gray iron smelting, 33 percent to nodular iron, three percent to steel, three percent to aluminum ingots and one percent to copper and alloys. Seventy percent of this production goes to the national market and the rest is exported.

4.4 Project Opportunities

Information on specific company data was collected from six different sources, listed below:

- CEC case study of a smelting company (CEC 1999),
- technical data for some Mexican electric-arc furnaces (*Iron and Steel Magazine* 2000),
- study by the *Centro de Producción más Limpia* (IPN 1998),
- Environmental Impact Assessments (Iron and Steel Magazine 2000),

- *Fideicomiso de Apoyo al Programa de Ahorro de Energía del Sector Eléctrico* (Fide) (Fide 2000), and
- results from questionnaire submitted as part of current study.

4.4.1 CEC Case Study of a Mexican Smelting Company

The 1999 CEC study entitled "Pollution Prevention in Steel Smelting Processes" identified pollution prevention opportunities at a Mexican smelting company. This case study represents a specific example of characteristic opportunities related to GHG emissions mitigation in small smelting companies.

The company studied has 80 workers; a small company by the Mexican industrial classification criteria. It smelts steel pieces up to 1350 kg and has a workshop for fabricating models, machines and tools. The company's ability to vary production by batch size, type of alloy, and shape enables it to reach a market that includes enterprises manufacturing equipment used in the steel, cement, petroleum, metal-mechanics, cellulose and paper sectors, as well as components for pumping equipment, valves, turbines and general machinery.

During visits to the plant, production data and the energy balances were collected. The 1999 production was 303 tons, about 70 percent of which was sold to exporting clients. According to data provided by the company, LPG consumption was 10,200 liters and electricity consumption was 47,280 kWh for the year of 1999. Total power demand for each stage of the process is shown in Table 10.

Table 10: Power Demand by Process Area, kW

Process Areas	kW
Lathes and millers	50.9
Model elaboration	16.1
Interior and exterior lighting	56.7
Finishing	279.2
Sand recovery	4.7
Fusion	210.3
Total	**617.9**

Using these data, potential environmental and economic savings were estimated. The study finds that the most significant GHG emission abatement would result from the installation of lids on the induction furnaces. Since none of the plant's furnaces are currently equipped with these lids, there is an energy loss during smelting due to heat radiation. The CEC study found that there is a loss of 0.5 kWh/kg of steel produced, which would mean a total of 545.2 GJ/year, for the year's production of 302.9 tons. The carbon emission savings associated with installation of lids on induction furnaces would be 28.2 tC/year.

Other measures that were considered in the pilot case that would lead to marginal GHG mitigation include:

- scrap storage,
- thermal treatment furnaces,
- using hot gases from the thermal treatment and the induction furnaces to preheat the pot,
- replacing standard motors with high-efficiency motors,
- optimizing the casting process, and
- developing a project to install an adequate electric system in the company.

Although the types of mitigation efforts will vary from plant to plant, the above list of measures, which would lead to a reduction in energy losses during smelting, should be of relevance to the other approximately 617 companies in Mexico.

4.4.2 GHG Mitigation Potential of EAFs Used by Selected Mexican Steel Companies

Potential GHG emissions mitigation opportunities were identified by comparing the energy intensity of 13 EAFs used by Mexican companies with that of the best available technology (see Table 11). Specifically, calculations were made comparing electricity consumption of the furnaces with a Specific Energy Consumption (SEC) of 308.6 kWh/ton of crude steel using best available technology. The electricity consumption per ton of steel produced could be reduced by an average of 162 kWh/ton of steel produced, or 34 percent using best available technology. In terms of emissions reductions, this would translate into mitigation levels of 30.2 kgC per ton of steel produced. Assuming that the EAF worked at full nominal capacity during the year, there would be a maximum total reduction of 120,674 tC/year. Using our estimate of US$10 per ton of carbon, this would translate to US$1.2 million in potential carbon credits.

4.4.3 The Mexican Center for Cleaner Production's Smelting Project

The Mexican Center for Cleaner Production (*Centro Mexicano para la Producción mās Limpia*) carried out a study on the environmental and production conditions at seven smelting companies. The study was done at the request of the State Governments of the Corridor México-Querétaro-San Luis Potosī, and with the support of INE and CANACINTRA. This study found 103 opportunities for cleaner production in the areas of energy efficiency, efficient use of materials and equipment, and labor risk reduction.

In relation to GHG emission abatements, the main opportunities were:

Table 11: Mitigation Potential at Selected EAFs

Company	No. of Furnaces	Start Date	Current SEC (kWh/t)	SEC Improvement Potential (kWh/t)	SEC Improvement Potential (%)	Annual Production (x103 ton)	Annual Carbon Emission Reductions (t C/year)
Ispat Mexicana, S.A. de C.V.	4	1988	660	352	53	717	46961.7
Siderúrgica de Tultitlán, S.A. de C.V.	1	1985	610	302	49	181	10198.7
Aceros D.M., S.A.	1	1993	490	182	37	331	11208.8
Aceros San Luis, S.A., Four 1	1	1973	470	162	34	80	2404.9
Aceros San Luis, S.A., Four 2	1	1979	470	162	34	80	2404.9
Aceros San Luis, S.A., Four 3	1	1986	470	162	34	80	2404.9
Tubos de Acero de México, S.A.	1	1987	470	162	34	762	22955.7
Aceros Corsa, S.A.	1	1988	461	153	33	122	3483.9
Talleres y Aceros, S.A. de C.V.	1	1993	460	152	33	254	7178.0
Siderúrgica de Yucatán, S.A., Four 1	1	1977	436	128	29	102	2417.1
Siderúrgica de Yucatán, S.A., Four 2	1	1977	436	128	29	102	2417.1
De Acero, S.A. de C.V., Saltillo	1	1986	345	37	11	435	2975.3
De Acero, S.A. de C.V., Celaya	1	1998	330	22	7	907	3663.0
Total							**120674.4**
INE's Environmental Impact Assessments							
Siderúrgica de California, S.A. de C.V.	1	1991	430	121,4	28	432	9756
Usine HYLSA du Nord du pays	1	1991	341	32	10	588	3545
Total							**13301**

Source : Technical information on EAFs was taken from Iron and Steel Magazine *1999.*

– preventive maintenance or redesign of EAF lids,
– improvement of the EAF doors,
– improvement of the pot preheating system, and
– automatic controls for fuel/air balance at the thermal treatment furnaces.

If the seven companies were to apply all the improvements recommended by the study, the *Centro Mexicano para la Producción mãs Limpia* calculates that the energy savings would add to 3,869,000 kWh/year, implying total emission reductions of 737 tC/year. By mid-1998, six months after the study, 42 percent of the 103 opportunities for improvement were implemented, 36 percent were in the process of implementation and the rest were programmed for the following months or were not to be implemented for technical or economic reasons.

4.4.4 INE's Environmental Impact Assessments

Based on the studies presented to INE for environmental impact assessments, data have been obtained for two steel companies:

– *Siderúrgica de Baja California* S.A. de C.V. in the State of Baja California, and
– HYLSA, North plant producing construction rods.
Both facilities together represent a total maximum reduction potential for GHG emissions associated with electric consumption of 13,300 tC/year.

4.4.5 Fide's Study on Electric Energy Saving for Four Smelting Companies

The Fideicomiso de Apoyo al Programa de Ahorro de Energía del Sector Eléctrico (Fide) carried out energy audits at four Mexican smelting companies to identify electric energy saving opportunities and energy efficiency opportunities. A profile of the energy consumption at each of the four companies is provided in Table 12.

Table 12: **Energy Profile of Four Mexican Smelting Companies**

Company	Products	Monthly Electricity Consumption (MWh)	Electric Energy (%)	LPG (%)	Natural Gas (%)	Oxygen (%)
1	Shafts	558	76.2	6.2		17.6
2	Iron parts for cars	239	85.4		14.6	
3	Shafts	99	100			
4	Valves and connections	32	96.2			

This study found 18 opportunities for energy savings and efficient use of materials and equipment, through measures that could be incorporated in the short and medium term. In relation to GHG emission abatement, the main opportunities were:

– preventive maintenance and management of EAF lids,
– improvement of the preheating system,
– correcting incompatibilities between molding and fusion capacities, and
– controls for pretreatment and quality of feedstock.

Fide calculated electric energy saving potentials for three of the four companies. Based on these data and figures and the 1996 carbon emission factor for power generation in Mexico, the expected annual emission reduction potentials were estimated. Table 13 provides energy and carbon savings potential, based on conservative estimates.

Table 13: **Estimated Energy and Carbon Savings**

Company	Electric Energy Saving Potential (kWh/ton)	Emission Reduction Potential (tC/year)
1	197	286.8
2	260	137.4
4	285	19.5

4.4.6 CEC Questionnaire

Based on results from a questionnaire submitted for the present study, data was obtained from one integrated steel company. The plant statistics are shown in Table 14. Based on the average potential mitigation of carbon emissions at the 13 selected EAF furnaces discussed above, potential savings may be up to 17,000 t C per year. This estimate is based only on average mitigation potential and the production capacity of this plant. To determine the electricity and carbon savings, a detailed audit on the production process is necessary.

Table 14: **Production and Energy Data of Integrated Steel Company**

Company	Tech (Type)	Age (Years)	Prod. (t/year)	Type of energy % Coal	Gas	Electricity	Other
Integrated Co.	EAF	14	600,000	None	54	35	11

4.5 Conclusions

Technical audits and studies of energy efficiency opportunities in the steel sector have found specific investment opportunities for energy savings at the steel plants investigated. It is to be expected that for many other small and medium-size steel enterprises, additional detailed studies could identify similar investment opportunities to reduce energy consumption.

5 Land Use, Land-use Change and Forestry

5.1 Introduction

Mexico's forests are currently a net source of carbon dioxide and greenhouse gases to the atmosphere. This section considers two different scenarios for the conversion of Mexico's forests from a source to a sink of greenhouse gases. This potential sink could represent valuable opportunities for implementing flexible mechanism projects in the land use, land-use change and forestry (LULUCF) sector, were such projects to become eligible under the CDM or other flexible mechanisms. In fact, analyses presented in the current paper show that Mexican forests have the potential to be managed as a very large net carbon sink. Assuming that carbon credits will be worth US$10 each, and using a back-of-envelope calculation, the cumulative potential undiscounted value of carbon offset credits for the Mexican land use, land-use change and forestry (LULUCF) sector between the years 1990 and 2030 is in the range of US$ 23 million to US$ 51 million.

This section begins with a brief description of the extent of Mexico's forests, how those forests are used, and how they contribute greenhouse gas emissions to the atmosphere. The section continues with a description of greenhouse gas emission saving scenarios and how these different scenarios could be realized, either through conservation of already existing carbon sinks or through forest sink enhancement, emphasizing the role that SMEs could play in these reductions. Apart from the worthwhile goal of reducing emissions to the atmosphere, the reduction of carbon dioxide emissions presents an opportunity to earn certified emission reductions through the CDM flexible mechanism. A final section describes uncertainties facing CDM eligibility of land use, land-use change and forestry (LULUCF).

5.2 Mexico's Forests and their Greenhouse Gas Emissions

Mexico's forest vegetation covers a surface of 141,736,169 hectares (ha), according to the 1994 forest inventory of the *Secretaría de Agricultura y Recursos Hidráulicos* (SARH), which accounts for temperate and tropical forests, arid zones vegetation, hygrophilous and halophyte vegetation, and disturbed areas. Temperate and tropical forests account for 56,851,500 ha. An estimated 15.7 percent of the country's total forest area is classified in the inventory as disturbed forest, defined as forest areas that have lost forest resource "quality" due to degradation and fragmentation processes related to the reduction and loss of biomass and the loss of productive potential of the area, as well as to the alteration of soils and associated flora and fauna.

Mexico's land use change and forestry sector is currently a net source of greenhouse gas emissions. According to the *Instituto Nacional de Ecología* in its Greenhouse Gas Emissions Inventory, deforestation and forest degradation represent the second largest source of greenhouse gas (GHG) emissions in Mexico, with net emissions of 37 million metric tons of carbon/year in 1990. These emissions accounted for 31.4 percent of the total CO_2 emissions in the country in that year (INE 1997).

Forests are cleared for a number of often interrelated reasons. Land is cleared in order to expand agricultural production, including crop production, as well as cattle raising activities. Forests are also lost to forest fires (Conabio 1998; Food and Agricultural Organization 1999). In addition, forests are cleared for timber for Mexico's timber-related industries.

5.3 Small and Medium-size Enterprises and the Forest Sector

Defining the participation of SMEs in Mexico's forest sector is somewhat tricky, and can be examined based on the number of workers within a firm, or on the amount of land owned. Forestry industries (manufacturing enterprises) can be categorized using the classification established for the manufacturing sector based on the number of workers. As of March 1999, these industries are classified as follows: micro, 1 to 30 workers; small, 31 to 100; medium, 101 to 500; and big, greater than 500 workers (*Diario Oficial* 1999).

Forest enterprises (producers) can be classified according to the amount of land they own. In the case of private landowners, the smallest land parcels are under 20 ha and the largest are 20,000 ha (the largest amount allowed by law). Communal organizations, however, are not bound by these limitations and the size of their holdings depends mainly on the organization.

For the purpose of this paper, the following classification according to area of land owned is used: micro, 1–300 ha; small, 300–1,000 ha; medium, 1,000–5,000 ha; and large, >5,000 ha. As a result, all of the commercial plantation projects described in Annex C could be considered as small or medium-size, and cover both private and communal lands.

Mexico's forestry industry consists mainly of small-scale, low-efficiency wood processing plants, mainly sawmills. This industry can be classified as shown in Table 15, below.

Table 15: Number of Timber-Related Enterprises by Industry Branch

Industry	Number of enterprises
Sawmills (1)	2,058
Panel and triplay factories	48
Board factories	17
Box factories	515
Secondary workshops	525
Furniture factories	60
Impregnators	11
Cellulose factories	7
Other (2)	256
National Total	**3,497**

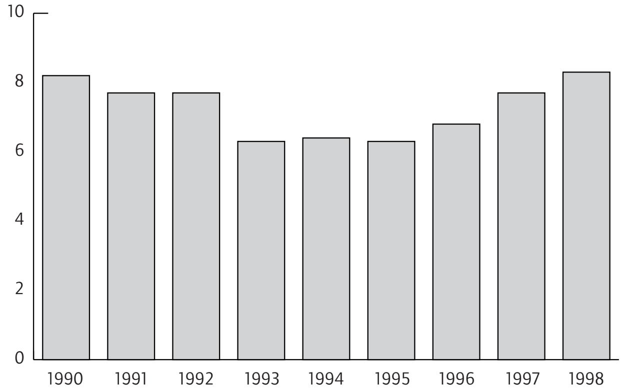
(1) Includes sawmills, sawmill-factories, sawmill-box factories and sawmill-secondary workshops.

(2) Establishments that do not report industrial branch.

Source: Anuario de la producción forestal *1998.*

As shown in Figure 10, annual timber production declined from 8.2 million cubic meters in round logs (m3r) in 1990 to 6.3 million m3r in 1993. This trend was reversed from 1996 onward, and in 1998 total timber production reached 8.3 million m3r with a value of 3,668,504,853 pesos (*Anuario de la producción forestal* 1998).

Figure 10: **Timber Production, 1990–1998**



Source: Anuario de la producción forestal *1998*

In 1998, the sawmill industry used 74 percent of the total raw material production, followed by the cellulose industry (15 percent) and the board industry (4 percent); the remaining (7 percent) was used to produce poles and fuels (firewood and charcoal).

The lack of road infrastructure in forest production regions, together with the inadequate access of many industries to markets and resources due to geographic factors, translates into high costs per unit of product, excessive transport-related costs, and lack of competitiveness compared with other countries. The situation contrasts notably with the United States and Canada in the forest sector, in part because of low transport costs arising from established infrastructure.

Mexico's competitiveness in the forestry sector is hindered by the need for the following: improved access by producers to market information, mechanisms to reduce the use of intermediaries, a regional market structure to minimize transport distances, and the development of commercial norms and measures. In addition to these barriers, producers face difficulties in accessing private funding due to the poor profitability of some forestry activities and the fact that governmental promotion banks have not yet found a way to increase the flow of resources to the forestry sector.

The CDM or other flexible mechanisms may offer an opportunity to reduce these and other obstacles. For example, the CDM could facilitate the transfer of more efficient management practices and technologies from Annex I counterparts to Mexico's small-scale, low-efficiency plants. The sale of certified emission reductions could provide a sufficient financial incentive to develop and implement more efficient transportation plans. The monitoring systems needed for CDM projects could be used to facilitate the development of quality certification systems for Mexico's forestry products.

5.4 Different Possibilities for Future GHG Emissions from Mexico's Forests

This section reviews work done by Masera (1995) that considers three different scenarios for the future net carbon intake of Mexico's forests. Critical to developing such scenarios is establishing actual deforestation rates. This, however, is not a straightforward task. In fact, there are wide differences between official and nonofficial estimates of deforestation rates in Mexico. As a result, "high" and "low" estimates for deforestation were used by Masera et al. (1992) in their study.

The "high" estimate uses the rates (percentage of total forest area) derived by Masera et al. (1992) of deforestation and disturbance by forest fires in closed forests, and incorporates SARH (1992) estimates of deforestation rates in open forests. The "low" estimate uses SARH (1992) estimates for open and closed forests. Using the suggested procedure, annual deforestation rates close to one percent for temperate forests and approximately two percent for tropical forests were obtained under the "high" estimate, giving an estimated total of 820,000 ha deforested per year.

Using the "low" estimate, the annual deforestation rates are 0.5 percent and approximately 0.8 percent for temperate and tropical forests, respectively, for a total of 370,000 ha deforested per year. For open forests, a deforestation rate of 0.08 percent was obtained (INE 1997). Deforestation rates used in the "high" estimate include all areas affected by forest fires, while the "low" estimate incorporates only those areas affected by forest fires that, it is assumed, will not regenerate.

Mexico's future carbon emissions and sequestration in the forest sector have been estimated up to the year 2030 taking into account 3 possible scenarios: a business as usual scenario and two mitigation scenarios (policy and technical potential), described in Table 16.

Table 16: Future Emissions/Sequestration Scenarios in the Forest Sector in Mexico

Scenario	Reference	Policy	Technical potential
Base Year	1990	1990	1990
Projections	2000, 2010, 2030	2000, 2010, 2030	2000, 2010, 2030
Population growth	Historic.	2.0%, 1.8%, 1.6%, 1.4%	2.0%, 1.8%, 1.6%, 1.4%
Macro-economic context	Historic trends continue.	Economic growth improves after year 2000.	Economic growth and income distribution improve after year 2000.
Deforestation rates	High (1.5% annual average in closed forests).	Reductions of the rate reach 50% in 2010 and 75% in 2030 with respect to the low estimate.	There is no further deforestation after 1990.
Mitigation options			
Conservation	Same effort as in the base year.	Governmental goals for 2000/2010 are achieved: better preservation of Natural Protected Areas, more than 2 million improved wood-burning cookstoves are distributed, wood demand is covered with improved cultivation systems in natural forests.	At least 10% of the forest area by type of forest is set apart as Natural Protected Area. All of the commercial natural forests are cultivated sustain-ably, 2 million improved wood-burning cookstoves are installed in the year 2000.
Reforestation	Same deforestation rates as in the base year.	Governmental plans for the period 2000/2010 are achieved: restoration plantation survival rates are improved. Up to 100% of the pulp and paper demand is produced by the plantations. About 20% of the reforested lands will be used to produce bioenergy in 2030. 20 kha/year of agroforestry shade systems will be established up to 2030.	Restoration plantations are established in half the lands currently degraded, plantations satisfy the domestic pulp and paper demand, 50% extra is exported. 25% of degraded forest lands are used for bioenergy. Agroforestry shade systems are established with an average of 40 kha/year between 1990 and 2030.

Source: Ordóñez 1999.

The business-as-usual scenario assumes that the deforestation rates mentioned above will continue into the future. This scenario would lead to emissions ranging from 23.9 to 62.4 million metric tons of carbon/year (MtC/year—based on the low and high deforestation rates, respectively) in the base year of 1990[18] to 17.5 and 28.1 MtC/year in 2030. Emissions are lower in 2030 than in the base year due to the fact that total forest area in the future is estimated to be lower and, as such, the percent decrease in smaller areas will also be smaller, resulting in lower overall emissions. Cumulative emissions are estimated to be between 0.8 and 1.7 billion metric tons of carbon between 1990 and 2030.

18 In contrast, the Inventory calculates a range of 10.8 to 61.9 million metric tons in 1990.

The two mitigation scenarios show that Mexican forests have the potential to shift from being net sources of greenhouse gas emissions to being significant carbon sinks in a 40-year period. The two scenarios are based on two general options: conservation (of natural protected areas, commercial forest management, improved wood-burning cookstoves), and reforestation (plantations for reforestation, plantations dedicated to pulp and paper production, plantations devoted to energy production, and agroforestry systems).

The estimated cumulative future carbon sequestration between 1990 and 2030 is between 2.3–3.0 billion metric tons of carbon under the "policy" scenario and 4.2–5.1 billion under the "technical potential" scenario (see Table 17). Assuming that carbon credits will be worth US$10 each, and using a back-of-envelope calculation, the cumulative potential undiscounted value of carbon offset credits for the Mexican land use, land-use change and forestry (LULUCF) sector between the years 1990 and 2030 is in the range of US$23 million to US$51 million.

Table 17: Cumulative Carbon Sequestration for Different Options in Mexican Forests

	Million ha		Total cumulative carbon (billions of metric tons)	
Option (Scenario)	**2030 (Policy)**	**2030 (Tech. Pot.)**	**1990–2030 (Policy)**	**1990–2030 (Tech. Pot.)**
Conservation				
Natural protected areas	3.8	6.0	0.37–0.57	0.42–0.65
Forest management (commercial)	13.2	18.7	1.36–1.81	2.13–2.80
Improved wood-burning cookstoves	2.0	2.0	0.05	0.08
Reforestation				
Reforestation plantations	0.8	4.2	0.19–0.20	0.31–0.33
Pulp and paper plantations	0.2	2.4	0.13–0.14	0.20–0.21
Energy plantations	0.8	4.2	0.17	0.94
Agroforestry systems	1.5	1.9	0.08	0.10
Total	**22.3**	**39.4**	**2.35–3.02**	**4.18–5.11**

Sources: Ordóñez 1999; Masera 1995.

The land area involved in implementing these mitigation options ranges from 22.3 million ha for the policy scenario to 39.4 ha for the technical potential scenario. Neither the policy nor the technical potential scenarios were implemented prior to 2000. Nevertheless, the calculated potential and the associated actions could be implemented irrespective of the initial year as long as the original assumptions are maintained. Calculated potentials in both scenarios are highly optimistic, although possible, as they require massive interventions in forest activities.

Even a much lower figure suggests very attractive opportunities for developing and implementing CDM or other flexible mechanism projects in the forestry sector. Small and medium-size organizations and landowners could participate significantly in the achievement of part of the potential by implementing carbon sequestration and sink conservation projects, as described later in this paper. The next two sections describe and explain each of the different options for the reduction of carbon dioxide emissions into the atmosphere from Mexican forests.

5.5 Project Opportunities in Forest Sink Conservation

The aim of the two following major sections is to provide an estimate of the typical carbon benefits associated with various sink conservation and sink enhancement options in Mexican forests, including those that could potentially involve small or medium-size enterprises.[19] There may also be considerable opportunities to implement sink conservation and sink enhancement projects on rural agricultural land. However, other than some discussion of agroforestry opportunities below, the assessment of Mexico's agricultural sink potential under the CDM or other flexible mechanisms falls outside the scope of this paper.

Much of Mexico's forested land is owned pubicly or communally. As such, in order to be effective, any project focused on the sustainable management of the forests should consider the specific needs of the communities and small land owners. There have been encouraging experiences with social forestry enterprises in Mexico that show the viability of the social focus in this field.

It should be noted that carbon conservation is not a priority for local inhabitants ("carbon conservation" should be understood as encompassing policies as diverse as carbon sequestration, biomass conservation and restoration, agroforestry and reforestation projects). Forestry projects must be evaluated on a broader basis, and should have as their central goal the promotion of a healthy economy and production of tangible local benefits. Carbon conservation must be considered as an additional benefit. Projects designed to account for these considerations will be more effective and more likely to provide long-lasting carbon benefits. This is consistent with the dual goals of the flexible mechanism which are to support sustainable development objectives and help mitigate climate change.

The carbon conservation options included here, if properly implemented, could meet the needs of the variety of social actors present in the rural sector, from small owners of agricultural and forest lands via agroforestry and social forestry projects, to the big forestry industries via implementation of large-scale pulp plantations and, in some cases, improvements in manufacturing efficiency. Medium-size enterprises, sharing characteristics of both, are likely to benefit from the whole range of opportunities. There may be additional opportunities to

19 The assumptions were taken from the study carried out by Masera in 1995. The estimates come from Masera and Ordóñez (1997) and Ordóñez, (1999).

expand the activities undertaken through the various forestry programs of local and federal governments to include the production of carbon benefits as an explicit program objective.

In the analysis in this section, the characteristic total net carbon benefits have been estimated assuming a reference scenario given by alternative land uses. Total carbon benefits refer to the average carbon stored in the various pools (above- and below-ground vegetation, decomposing matter, soils, wood products and the carbon saved by burning wood for energy instead of fossil fuels) during a period of time long enough to allow them to reach equilibrium.

Rough carbon estimates for short-term projects can be obtained by adjusting the total long-term carbon sequestration average with a factor used to calculate the value of having one ton of carbon out of the atmosphere for the limited time of the project.[20] The ton-year approach was used in order to provide some very rough annual carbon sequestration estimates for some of the options presented here. In developing this model it was assumed that a "perpetual ton" of carbon (or a ton of carbon not emitted) is equivalent to one sequestered for 60 years. It is to be noted that in this case, the ton-year is a very limited approach since it means assuming that the different carbon pools involved in a project will reach stability at 60 years. Actual annual carbon sequestration associated with each option will depend on a wide variety of particular project circumstances.

In the case of forest fire prevention programs, project benefits are calculated in terms of net emission avoidance. For bioenergy options, the net carbon benefits due to fossil fuel savings are estimated on an annual basis, assuming that the project lifetime is 40 years (the typical lifetime of a conventional power plant). Estimates include high and low values that reflect the uncertainties related to the carbon content in soils, the net change in carbon content in soils associated with each option, and other parameters.

5.5.1 Protected Natural Areas/Forest Conservation Projects

The carbon sequestration estimates presented below were originally made explicitly for Protected Natural Areas. However, provided that the same assumptions are applied, they are relevant to individual forest conservation projects.

If the land area protected by the federal government (111 Protected Natural Areas) and the area protected by the states and municipalities (176 Protected Natural Areas) are considered together, Mexico currently protects 13,746,465.3 ha, which represents 7 percent of the country's area. Counting only the 52 Protected Natural Areas for which information is available, the area covered by vegetation in 1997 reached 113,949.95 km^2 (see Table 18) (Conabio 1998).

20 The assumptions were taken from the study carried out by Masera in 1995. The estimates come from Masera and Ordóñez (1997) and Ordóñez, (1999).

Table 18: Surface Protected by the Federation by Vegetation Type for the 52 Protected Natural Areas

Vegetation	Protected surface (km2)
Conifer and oak forests	4,867.96
Thorny forests	1,297.81
Mesofilous mountain forests	1,049.74
Tropical deciduous forests	2,881.54
Tropical evergreen forests	14,884.99
Tropical subdeciduous forests	1,151.9
Xerofilous shrubland	44,896.02
Grassland	1,369.30
Aquatic and subaquatic vegetation	8,073.07
Sea	33,477.62
Total	**113,949.95**

Source: Conabio 1998.

In 1996, the annual fiscal budget devoted by the Mexican federal government to conservation of protected natural areas was about US$1 million, which is a comparatively low figure: the current budget means spending 10 US cents per protected hectare per year in the country. From 1995 onward, there has been an increase in fiscal resources for PNA operations. Since then, US$420,800 has been allocated annually. The amounts for 1996 and 1997 increased to US$1,409,600 and US$2,829,300, respectively, through an additional allocation by diverse programs. Other forest conservation activities, such as forest fire prevention and control had, during 1997, a budget for operating expenses (not including salaries) of US$4.6 million from Semarnap. The contribution of other sectors to these activities was estimated at US$4.4 million.

Effective protection of the Protected Natural Areas is difficult, since many of them are inhabited. In 1994, an estimated seven million people inhabited Protected Natural Areas. At present, given the noticeable increase in the number of Protected Natural Areas, this figure could reach 10 million people. For this reason, sustainable management of these areas could be secured only if tangible benefits for the local inhabitants were generated. The Mexican system for designating a region as a natural protected area does not involve a land purchase by the Government; instead, there are occasional compensations, including sums of money, that have worked with varying success.

It has been estimated (Masera 1995) that a minimum 10 percent of the total forest area (about 5,685,150 ha) could be set apart for long-term preservation (through Protected Natural Areas or individual projects) without conflicting with the inhabitants' forest use needs.

As discussed above, the objectives of the CDM and other flexible mechanisms can be compatible with both the environmental (carbon conservation, biodiversity protection, etc.) and the social needs of communities in Mexico. Well-designed projects should not only provide protection to forests, but also be productive enough to at least offset the lost opportunity costs to the inhabitants of undertaking the project (i.e., the income or other benefits inhabitants would receive from forest exploitation in the absence of the project). These kinds of projects could be applied especially within the buffer zones of Protected Natural Areas, where productive activities are allowed. The sale of certified emission reductions generated by CDM or other flexible mechanism projects could provide an additional source of income that could make sink conservation activities more economically attractive and competitive with other land uses.

It is Mexico's official position that carbon conservation projects inside established Protected Natural Areas should be able to produce certified emission reductions within the flexible mechanisms, following agreed criteria and eligibility rules. Such projects would generate carbon benefits, and the improvement or expansion of the existing Protected Natural Areas would represent an additional effort on the part of the country both to protect biodiversity and to avoid potential additional emissions. Sources and sinks associated with land-use changes are accounted for by Annex I countries in relation to their base year. If, in the future, the government introduces the possibility of protecting additional (beyond its "normal" protection effort) areas with resources obtained through carbon sequestration, this could become an important opportunity to sell emissions reduction credits, thus enabling proper maintenance of these areas and helping to improve the conditions of the communities involved.

A CDM project involving a PNA would benefit the participant communities and, at the same time, increase the resources devoted by government to assure the adequate management of the area. Communities would profit from the social and economic benefits of the project, while the federal government, which controls the PNA and guards it on behalf of the nation, could negotiate with the Annex I project partner to receive a share of the resulting certified emission reduction credits and could use the resources obtained from their sale to manage the area and to provide additional social services to the population of the PNA. The Annex I partner would likewise receive a share of certified emission reductions corresponding to the size of its investment in the project.

There is also the possibility of expanding already established Protected Natural Areas through the private or public sector. For example, an AIJ project in Querétaro, *Forest Rehabilitation and Conservation in the Sierra Gorda Biosphere Reserve, Mexico* (Woodrising Consulting 2000), is seeking to purchase some 1,200 ha through the Joya de Hielo Land Trust. This project would increase by 5 percent the protected lands in the Sierra Gorda Biosphere Reserve.

This initiative seeks to use AIJ, and potentially the CDM, to extend land protection efforts in Mexico's Sierra Gorda Biosphere Reserve, particularly in the buffer zones surrounding lands that have already been protected because of their importance for biodiversity or other ecological reasons. While the land will remain the responsibility and property of the Land Trust, the carbon sequestered or protected will become the property of the investor. This type of project could be replicated in other locations throughout Mexico and the world.

Mexican forests inside Protected Natural Areas or included in conservation projects have the potential to sequester between 33 tC/ha and 173 tC/ha. This figure assumes that immediate and subsequent emissions from deforestation are avoided, 10 percent of the biomass burned in forest fires is converted to charcoal, and there is a soil carbon loss from deforestation ranging from zero percent (low estimate) to 30 percent (high estimate). It is assumed that the alternative land use is the production of annual crops or degraded pasture with five tC/ha of carbon density in vegetation and decomposing matter (in temperate regions) or 10 tC/ha (in tropical regions). Based on this estimate and using a ton-year approach, annual carbon benefits could be in the neighborhood of 0.55 tC/ha/year and 2.83 tC/ha/year.

5.5.2 Natural Forest Management

This mitigation option involves two management systems: selective management of temperate forests (mainly pine and oak), and selective management of tropical forests (medium and tall).

About 95 percent of the commercial timber production in the country is conducted in natural temperate forests. Currently, only 6.1 million ha of the 12.8 million ha of commercial temperate forests are managed. Commercial yields in these forests range between 0.5 and 1.5 ton/ha/year (SARH 1989). It has been assessed that with more efficient forest management and harvesting practices, commercial yields could rise to 3.5 ton/ha/year, reaching up to 10 ton/ha/year in the warmest regions (Masera 1995). Revenues from the sale of certified emission reduction credits could improve the cost-effectiveness of improvements in production and harvesting efficiency.

While five percent of Mexico's total commercial timber production is carried out in tropical evergreen forests, these cover 5.9 million ha, representing 36 percent of the total commercial forest area. About 0.9 million ha are currently harvested. One of the main challenges affecting the implementation of sustainable management of these forests is the large diversity of tree species, of which only a small proportion has commercial value. The most common commercial species are mahogany, Honduras mahogany and chicle.

Areas with lower concentrations of commercial species are more susceptible to land-use conversion. However, incorporating carbon sequestration into the current assessment of benefits derived from managing tropical forests could be critical to identifying new conservation incentives that are cost-effective.

The potential net carbon benefits of natural forest management are estimated to be between 98 and 182 tC/ha based on the following assumptions:

- immediate and subsequent emissions of biomass carbon from deforestation are avoided and 10 percent of the biomass burned in forest fires is converted to charcoal;
- deforestation causes soil carbon emissions ranging from zero (low estimate) to 30 percent (high estimate);
- harvests are based on selective low-impact logging so that total forest biomass in managed forests is similar to that of the original natural forest; and
- carbon in wood products is taken into account and added to the net sequestration. It is assumed that these products have a constant decomposition of between 0.05tC/ha/year and 0.02tC/ha/year.

Following the ton-year approach, natural forest management projects could have annual carbon sequestration rates of between 1.63 tC/ha/year and 3.03 tC/ha/year.

5.5.3 Improved Wood-burning Cookstoves

About 93 percent of the total fuelwood demand currently comes from the domestic sector (i.e., 34.6 million m3) (Masera 1993). The average fuelwood consumption by a typical household using traditional wood-burning cookstoves reaches 4.3 ton/year. Due to low incomes in rural households, the cultural practices associated with the use of fuelwood for cooking, and the dispersion and reduced size of villages in Mexico (currently there are 154,000 villages with less than 2,500 inhabitants, with an average size of 146 people per village), the use of improved wood-burning cookstoves represents a good approach for reducing firewood demand in the short and medium term.

Improved wood-burning cookstoves, at a direct cost of US$10 to 16 (1993) per stove, can reduce fuelwood consumption by about 30 percent. Over a two-year period, the cost of saved energy would be 5–7 US$ (1994) per ton of wood saved. Wide dissemination of more efficient stoves in the rural sector could reduce wood consumption by 6.2 million tons (10.4 million m3) per year (Masera 1993). This option could produce emissions reductions of about 1 tC/stove/year (conservative estimate) (Ordónez 1999). This calculation accounts for the firewood saved at the point of use corrected by a factor for the total wood logged at the harvesting site.

5.5.4 Forest Fires

From 1983 to 1993, an average of 200,000 ha (ranging from 80,000 ha in 1990 to 518,000 in 1988) were affected by fires annually. In 1993, 14 percent of the 235,000 ha burned were adult trees, 9 percent were re-growing trees and 29 percent were bushes and semi-arid vegetation. The number of fires caused by humans grew during the 1980s, becoming the main factor causing deforestation of temperate forests in Mexico. These fires were often deliberately set to increase pasture production and to declare trees as "dead wood" in rural areas where logging is not allowed.

A large number of forest fires occurred in 1998 (see Table 19). From January to August, 14,302 forest fires occurred in Mexico, affecting an area of 583,664 ha (equivalent to 0.4 percent of the total forest area of the country). Pasture, bush and brushwood were burned in an area of 425,850 ha (73 percent of the total) while 157,007 ha (27 percent) of forested areas suffered diverse degrees of impact. Each fire affected an average area of 40.81 ha.[21] However, an important proportion of the disturbed area was reforested in the country during 1998.

From January to July of that same year, Semarnap alone (not taking into consideration the contribution of other governmental dependencies, state governments or international support) devoted 185 million pesos to fire control. An average estimate of fire control costs for this period is about 317 pesos/ha burned.[22]

Table 19: Profile of Forest Fires in 1998 (preliminary figures)

Most-affected Semarnap Delegations/ Totals	Number of fires	Affected surface (ha)				Efficiency indicators (average)			
		Grass-lands	Forests	Others*	Total	Surface/ fire (Ha)	Time in hours Detection	Arrival	Length
Chiapas	405	85,335	65,883	47,590	198,808	490.88	9:42	8:23	91:50
Durango	436	24,191	20,422	24,347	68,960	158.17	1:30	2:30	49:04
Oaxaca	419	144,694	35,340	61,674	241,708	576.87	10:20	6:33	42:45
Results 1998	14,445	352,242	198,487	298,903	849,632	58.82			
Percentage		41.5	23.4	35.2	100				
Average							1:17	1:22	16:54
Average 1992–1997	7,198	70,184	49,269	61,650	181,103	25.16	1:08	1:28	9:25
Comparison 1998/Average 1992–1997 (%)	101	402	303	385	369	134			

** Includes thorny forest and shrubs.*

Source: Anuario de la produción forestal 1998.

21 At the beginning of 1999, the official estimate of the area affected by forest fires in 1998 was updated for the period January–November to 849,632 ha.

22 Based on the budget from January to July and the number of hectares burned from January to August 1998.

Fire prevention projects and projects to reforest, and later to protect, burned areas could represent an opportunity to avoid greenhouse gas emissions and, later, to sequester carbon, thus generating certified emission reductions. However, some methodological issues should be taken into account, such as the average emissions avoided by reducing the burned area and the rate of natural regeneration. An improved capacity to prevent and control fires could potentially qualify as an additional project activity in the context of the CDM or another flexible mechanism. Estimating the benefits of this kind of project could be very challenging, though, since it would require the calculation of a hypothetical baseline for average annual deforestation due to fires under a business as usual scenario.

5.6 Project Opportunities in Forest Sink Enhancement

5.6.1 Reforestation Plantations

There are almost 30 million ha of degraded lands with varying levels of erosion in Mexico. An estimated 18 million ha of degraded lands and 3.5 million of severely degraded lands are located in areas previously covered by closed forests under different property regimes.

Experience has shown that, for a reforestation plantation to be successful, it must offer alternative benefits for the landowners that provide incentives for protecting and managing the forests. In order to capture the large potential of reforestation plantations and to secure their sustainability, it is important to design projects that provide goods and services for the landowners and local inhabitants (Bellón et al. 1994).

Potential net carbon sequestration up to equilibrium for this option ranges from 35 to 150 tC/ha, based on the following assumptions:

- the plantations are established on degraded lands with carbon densities of 5 tC/ha (temperate) and 10 tC/ha (tropical);
- plantations reach a carbon density of 70 percent (vegetation plus soils) of the carbon density of natural forests;
- there is a 50 percent carbon increase in the soils of degraded forest lands as a result of reforestation; and
- there is an assumed range of carbon content in soils.

Annual carbon sequestration of reforested plantations under the ton-year approach could be between 0.58 tC/ha/year and 2.5 tC/ha/year.

5.6.2 Industrial Plantations

Industrial plantations are devoted mainly to pulp and paper production. While pulp and paper plantations result in moderate net carbon sequestration when established in pasture or agricultural lands, they are not economically feasible in areas with commercial productivity below 10 tons wood/ha/year or with rotation periods of over 20 years.

For these reasons, most of the current initiatives are focused in the southeastern states (e.g., Tabasco), where large areas are agronomically suitable for high-productivity pulp plantations and short rotation periods. These areas can reach a productivity level up to 20 ton wood/ha/year (Masera 1995). However, for these plantations to be profitable, they must be located in contiguous areas of at least 20,000 ha and be geographically accessible.

Annex C lists many small and medium-size cellulose plantations currently in place. CDM or other flexible mechanism projects could, in some cases, ameliorate the cost-effectiveness of present and future plantations.

Potential long-term net carbon sequestration for industrial plantations is between 67 and 101 tC/ha, provided that:

- plantations are established on agricultural lands/pasture with carbon densities of 8 tC/ha (temperate) and 10 tC/ha (tropical);
- plantations reach 70 percent of the carbon density of natural forests;
- there is a 50 percent increase in soil carbon stocks as a result of the alternative land use; and
- pulp and paper have a constant rate of decomposition over a period of one year.

Following the ton-year approach, annual carbon sequestration for this option could vary from 1.12 tC/ha/year and 1.68 tC/ha/year. These estimates vary according to the assumed carbon content of soils.

5.6.3 Biofuel Plantations

The use of biomass for energy generation offers a promising alternative for the production of GHG benefits through the management of Mexican forests. Currently, there is no experience with these systems in the country. Nevertheless, if only 10 percent of the 18 million ha of degraded forest lands were converted to economically viable energy plantations, with expected biomass yields of 10 t wood/ha/year and 15 GJ/ton of energy content in wood, 240 PJ of energy generated by fossil fuels could be offset per year (Masera 1995).

This figure represents about 6 percent of the total energy produced during 1995 in the country, or more than double the total energy consumed for agricultural activities during the same year. In addition, this activity could help avoid carbon emissions of 6 MtC/year from fossil fuel combustion (assuming that the power plant using biomass replaces a plant working on oil having an efficiency of 30 percent).

The potential long-term net carbon benefit of this option is 215 tC/ha, taking into account the incremental carbon content in degraded forest lands (there would be a 50 percent increase in soil carbon stocks as a result of the alternative land use) plus the additional annual carbon mitigation resulting from reduced burning of fossil fuels and electricity consumption (Ordóñez 1999; Masera 1995).

It is assumed that biomass is burned using steam turbine injection generators, replacing thermal power plants of similar efficiency running on bunker fuels. The carbon emitted by bunker fuels is 0.023 ton/GJ (Swisher 1991).

5.6.4 Agroforestry Systems

For many centuries, indigenous cultures in Mexico used a diversity of agroforestry systems, especially in evergreen and deciduous tropical forests. In 1994, there were 0.9 million ha under shade agroforestry systems in Mexico (around 0.8 million ha planted with coffee and 0.1 million with cacao). A large but currently unmeasured area of fallow land is also managed as agroforestry systems. Total aboveground dry biomass productivity in coffee shade systems has been estimated at between 8.4 and 10 ton/ha/year and between 6 and 8 ton/ha/year for cacao systems (Masera 1995).

Agroforestry systems, particularly those in evergreen and deciduous tropical forests, can offer a promising economic alternative to the conversion of forests to pasture and agricultural lands.

Potential long-term net sequestration for agroforestry systems is between 43 and 74 tC/ha. This also assumes that agroforestry systems result in a 50 percent increase in soil carbon content (Masera 1995).

Annual carbon sequestration could be between 0.72 tC/ha/year and 1.23 tC/ha/year under a ton-year approach.

5.7 LULUCF Eligibility Uncertainties

The most significant potential problem associated with land use, land-use change and forestry (LULUCF) is that its eligibility for flexible mechanism projects has yet to be determined. A decision is expected upon termination of Part Two of the Sixth Conference of the Parties (COP VI (II)) negotiations to be held in 2001. There is a great deal of controversy surrounding the treatment of LULUCF projects under flexible mechanisms and, in fact, failure to reach agreement on these issues was one of the main blocking points of the latest round of COP negotiations.

Much of the controversy surrounding the treatment of LULUCF projects under the CDM can be linked to two central issues:

- concern that the potentially large magnitude and low costs of the GHG benefits from LULUCF projects in non-Annex I countries could influence Annex I Parties to focus their initial efforts in this area and delay making the energy-sector investments that will be needed to ensure long-term climate change mitigation and sustainable development; and
- potentially significant differences between LULUCF projects and projects in other sectors (particularly energy and industry) with regard to measurement certainty and permanence of the GHG benefits.

These issues are closely linked. Ideally, if emission reductions or sink enhancements in the LULUCF sector are used to offset emissions from other sectors, then the certainty and permanence of GHG benefits from LULUCF projects should be comparable to those of projects in the other sectors. This is not always the case.

In the case of a forest conservation project, the magnitude and timing of the carbon benefit depends on three factors: the biomass and soil carbon stocks on the project site; the rate at which the carbon would have been emitted in the absence of the project; and the length of time over which the developer can protect against the loss or reversal of project benefits.

Measuring the site's carbon stocks requires on-site sampling, statistical analysis, and modeling, all of which involve a higher degree of uncertainty than the estimation of benefits for the fuel-switching project. Determining the rate at which the site's carbon would have been emitted in the absence of the project can be a very challenging analytical process that involves the assessment of historical and projected land-use trends at the project, regional, and/or national levels.

Moreover, when claiming benefits from forest conservation, the developer needs to evaluate the potential for leakage: the net loss of project benefits when, rather than being eliminated, the land-use pressures threatening the project area are merely displaced from the project area to an unprotected area.

Finally, the GHG benefits of forest conservation can be lost or reversed if the forest is cleared at some time in the future, whether due to natural or anthropogenic causes.

Therefore, a forest conservation project may not produce GHG benefits with the same degree of permanence as a fuel-switching project. It may be possible to compensate for the differences in measurement certainty and permanence of LULUCF projects by discounting the benefits from LULUCF projects or by maintaining a contingency reserve of GHG benefits that can be used to offset the loss or reversal of benefits in the future.

Although intensive work has led to progress in estimating the relationship between land use and forestry in the climate agenda, considerable uncertainty remains. These uncertainties include estimating the carbon cycle of land use and forest, the composition of the carbon pool, and accounting procedures needed to assess either reductions in greenhouse gas emissions or increases in carbon uptakes related to land use and forests. Questions include how to measure the accumulated carbon uptake over the duration of a project, the spatial scope of the project, methods to measure emissions avoided over a project lifetime, and emissions avoided calculated for the specific spatial unit.

However, given earlier estimates that land-use change and deforestation account for approximately 22 percent of annual carbon dioxide emissions, it would be surprising at this point if land use and forestry were not included in some manner as flexible mechanism eligible projects.

5.8 Conclusion

This chapter was intended to give some ballpark estimates as to the potential for emissions reductions in Mexico's LULUCF sector. Based on these estimates, and provided that LULUCF sector investments are accepted as flexible mechanism eligible projects at the upcoming round of COP negotiations in 2001, Mexico's forests and forest-related industries have tremendous potential for carbon dioxide emission reductions and therefore for the creation of valuable carbon dioxide credits.

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Annex A: Reducing Emissions Associated with Power Generation: Flexible Mechanism Opportunities on the Demand and Supply Sides

Table A-1: Self-supply Permits Issued by CRE

Permit Number	Location	Capacity Mw	Energy Gwh/Year	Primary Fuel	Technology
02/Aut/94	State Of Mexico	2.66	19.81	Water	Hydro Turbine
03/Aut/94	State Of Mexico	1.35	10.17	Water	Hydro Turbine
04/Aut/94	State Of Mexico	2.73	19.48	Water	Hydro Turbine
05/Aut/94	Sonora	2.80	13.40	Diesel	Internal Combustion
09/Aut/94	Campeche	7.52	7.40	Sweet (Low Sulfur) Natural Gas	Gas Turbine
16/Aut/94	Sonora	26.60	140.00	Water	Hydro Turbine
17/Aut/94	Sonora	23.00	123.70	Water	Hydro Turbine
18/Aut/94	Sonora	30.00	167.40	Water	Hydro Turbine
19/Aut/94	Sonora	23.00	120.20	Water	Hydro Turbine
20/Aut/94	Veracruz	1.26	3.27	Water	Hydro Turbine
27/Aut/95	Querétaro	11.52	2.80	Diesel	Steam Turbine
28/Aut/95	Chihuahua	2.73	7.60	Diesel	Internal Combustion
33/Aut/95	Coahuila	198.00	1,261.00	Imported Coal	Fluidized Bed
34/Aut/95	Oaxaca	27.00	134.00	Wind	Fluidized Bed
35/Aut/96	San Luis Potosí	250.00	1,750.00	Coke	Fluidized Bed
36/Cog/96	Nuevo Leon	617.30	4,143.00	Natural Gas	Gas and Steam Turbine
36/Cog/96	Campeche	35.50	33.80	Sweet (Low Sulfur) Natural Gas	Gas Turbine
39/Aut/96	Campeche	2.12	2.60	Diesel	Internal Combustion
40/Aut/96	Campeche	3.24	4.25	Sweet (Low Sulfur) Natural Gas	Gas Turbine
41/Aut/96	Campeche	1.70	3.09	Diesel	Internal Combustion
42/Aut/96	Campeche	5.97	9.60	Sweet (Low Sulfur) Natural Gas	Internal Combustion
43/Aut/96	Campeche	6.23	11.65	Sweet (Low Sulfur) Natural Gas	Gas Turbine
44/Aut/96	Campeche	2.11	2.95	Diesel	Internal Combustion
45/Aut/96	Michoacan	2.20	4.58	Diesel	Internal Combustion
47/Aut/96	Tamaulipas	0.85	1.04	Diesel	Internal Combustion
49/Aut/96	Querétaro	22.70	133.92	Natural Gas	Gas Turbine

Permit Number	Location	Capacity Mw	Energy Gwh/Year	Primary Fuel	Technology
51/Aut/96	Quintana Roo	30.00	75.00	Wind	Wind Turbine
52/Aut/96	Querétaro	69.00	504.60	Natural Gas	Combined Cycle
53/Aut/96	Nuevo Leon	0.80	2.33	Diesel	Internal Combustion
54/Aut/96	Campeche	16.74	30.35	Sweet (Low Sulfur) Natural Gas	Steam Turbine and Internal Combustion
55/Aut/96	Tamaulipas	2.89	1.25	Diesel	Internal Combustion
56/Aut/97	Nuevo Leon	9.20	40.20	Biogas	Internal Combustion
58/Aut/97	Quintana Roo	32.14	234.00	Fuel Oil	Internal Combustion
59/Aut/97	Nuevo Leon	1.60	14.02	Biogas	Internal Combustion
62/Aut/97	Veracruz	59.20	175.20	Natural Gas	Gas Turbine
63/Aut/97	Veracruz	48.00	336.00	Natural Gas	Gas Turbine
64/Aut/97	Tamaulipas	6.00	15.02	Natural Gas	Steam Turbine
65/Aut/97	Tabasco	92.00	420.00	Natural Gas	Steam Turbine
66/Aut/97	Tabasco	24.80	152.57	Natural Gas	Gas Turbine
67/Aut/97	Veracruz	8.00	70.80	Natural Gas	Steam Turbine
68/Aut/97	Tabasco	64.00	245.00	Natural Gas	Gas and Steam Turbine
69/Aut/97	Puebla	60.00	166.00	Natural Gas	Steam Turbine
70/Aut/98	Oaxaca	30.00	50.00	Wind	Wind Turbine
71/Aut/98	Baja California	60.50	166.00	Wind	Wind Turbine
78/Aut/98	San Luis Potosí	9.00	18.00	Fuel Oil and Sugarcane Bagasse	Steam Turbine
79/Aut/98	Guanajuato	79.50	470.00	Natural Gas and Fuel Oil	Steam Turbine
80/Aut/98	Veracruz	76.80	128.00	Gas Natural	Gas Turbine
81/Aut/98	Tabasco	9.00	18.90	Fuel Oil and Sugarcane Bagasse	Steam Turbine
82/Aut/98	Veracruz	76.40	296.50	Natural Gas and Fuel Oil	Gas and Steam Turbine
83/Aut/98	Nuevo Leon	64.00	308.00	Natural Gas and Fuel Oil	Steam Turbine
84/Aut/98	Sonora	36.50	287.61	Fuel Oil	Steam Turbine
85/Aut/98	Veracruz	10.00	10.80	Fuel Oil and Sugarcane Bagasse	Steam Turbine
86/Aut/98	Morelos	8.60	20.50	Fuel Oil and Sugarcane Bagasse	Steam Turbine
87/Aut/98	Veracruz	3.70	5.45	Fuel Oil and Sugarcane Bagasse	Steam Turbine
88/Aut/98	Veracruz	24.20	38.15	Fuel Oil and Sugarcane Bagasse	Steam Turbine

Permit Number	Location	Capacity Mw	Energy Gwh/Year	Primary Fuel	Technology
89/Aut/98	Chihuahua	3.20	2.62	Diesel	Internal Combustion
90/Aut/98	Veracruz	6.00	8.20	Fuel Oil and Sugarcane Bagasse	Steam Turbine
91/Aut/98	Michoacan	1.60	1.96	Fuel Oil and Sugarcane Bagasse	Steam Turbine
93/Aut/98	Tamaulipas	65.00	270.60	Fuel Oil	Steam Turbine
94/Aut/98	Coahuila	184.30	1,102.00	Natural Gas, Coke Gas, Kiln Gas, and Fuel Oil	Steam Turbine, Gas Turbine and Combined Cycle
95/Aut/98	Nayarit	12.00	22.10	Fuel Oil and Sugarcane Bagasse	Steam Turbine
97/Aut/98	Oaxaca	115.00	609.00	Natural Gas and Fuel Oil	Steam Turbine
98/Aut/98	Jalisco	12.00	25.56	Fuel Oil and Sugarcane Bagasse	Steam Turbine
99/Aut/98	Jalisco	4.50	11.96	Fuel Oil and Sugarcane Bagasse	Steam Turbine
100/Aut/98	Sonora	1.67	1.40	Diesel	Internal Combustion
103	Campeche	9.80	12.26	Sweet Natural Gas and Diesel	Gas Turbine and Internal Combustion
104	Campeche	10.30	11.40	Sweet Natural Gas and Diesel	Gas Turbine and Internal Combustion
105/Aut/98	Campeche	3.15	6.13	Sweet (Low Sulfur) Natural Gas	Gas Turbine
106/Aut/98	Campeche	18.73	31.76	Sweet (Low Sulfur) Natural Gas	Internal Combustion
107	Campeche	8.10	21.35	Natural Gas	Gas Turbine
108/	Nayarit	5.50	8.50	Fuel Oil and Sugarcane Bagasse	Steam Turbine
109/	Tabasco	36.80	22.00	Sweet (Low Sulfur) Natural Gas	Gas Turbine
110/	Tabasco	99.15	186.80	Natural Gas	Gas Turbine
111/	Coahuila	16.20	102.00	Natural Gas	Steam and Gas Turbine
114/	Veracruz	15.00	45.60	Water and Natural Gas	Hydro Turbine
115/	Durango	4.44	12.91	Water and Diesel	Hydro Turbine
116/	Jalisco	10.47	27.14	Fuel Oil and Sugarcane Bagasse	Steam Turbine
117/	Sinaloa	10.50	20.90	Fuel Oil and Sugarcane Bagasse	Steam Turbine and Internal Combustion
118/	Tabasco	1.90	16.64	Diesel	Internal Combustion

Permit Number	Location	Capacity Mw	Energy Gwh/Year	Primary Fuel	Technology
119/	San Luis Potosí	6.40	13.20	Fuel Oil and Sugarcane Bagasse	Steam Turbine and Internal Combustion
120/	Campeche	1.45	4.10	Diesel	Internal Combustion
122/	Coahuila	0.55	1.00	Wind	Wind Turbine
123/	Durango	10.00	18.80	Fuel Oil	Steam Turbine
125/	Sinaloa	5.60	9.90	Fuel Oil	Steam Turbine and Internal Combustion
126/	Quintana Roo	42.73	318.15	Fuel Oil	Internal Combustion
129/	Veracruz	12.00	30.25	Fuel Oil	Steam Turbine
130/Aut/1999	Guerrero	30.00	101.30	Water	Hydro Turbine
134/	Coahuila	10.20	13.04	Diesel	Internal Combustion
137/	Veracruz	4.00	17.42	Water and Natural Gas	Hydro Turbine
138/	Estado Mexico	10.00	43.80	Natural Gas	Steam Turbine
141/	Michoacan	40.00	180.40	Natural Gas	Steam Turbine
142/	Oaxaca	13.50	21.60	Fuel Oil and Sugarcane Bagasse	Steam Turbine
143/	Oaxaca	13.50	21.60	Fuel Oil and Sugarcane Bagasse	Steam Turbine
145/	Chiapas	9.60	12.62	Fuel Oil and Sugarcane Bagasse	Steam Turbine
146/	Oaxaca	20.00	99.00	Water	Hydro Turbine
147/	Jalisco	8.00	37.00	Water	Hydro Turbine
149/	San Luis Potosí	260.00	1,850.00	Oil Coke	Fluidized Bed
150/	Veracruz	5.73	26.92	Water	Hydro Turbine
153/	Durango	20.00	79.00	Water	Hydro Turbine
155/	Jalisco	20.00	101.00	Water	Hydro Turbine
156/	State of Mexico	10.69	59.00	Natural Gas	Gas Turbine
158/Aut/2000	Chiapas	9.50	11.40	Sugar Cane Bagasse	Steam Turbine
159/	Hidalgo	11.13	30.00	Gas Natural and Diesel	Internal Combustion
160/	Campeche	7.78	22.63	Sweet Natural Gas and Diese	Gas and Diesel Turbine
161/	Jalisco	6.00	12.00	Sugar Cane Bagasse	Steam Turbine
162/	Durango	7.99	23.93	Diesel	Internal Combustion

Table A-2: Cogeneration Permits Issued by CRE

Permit Number	Location	Capacity Mw	Energy Gwh/Year	Primary Fuel	Technology
06/Cog/94	Coahuila	8.38	55.5	Natural Gas	Gas Turbine
07/	Nuevo Leon	18.46	96.61	Natural Gas	Gas and Steam Turbine
11/	Veracruz	422.4	130	Natural Gas	Gas Turbine
12/	Jalisco	12	17.5	Natural Gas	Gas Turbine
14/	San Luis Potosí	2.55	19.75	Natural Gas	Gas Turbine
16/	Querétaro	10.5	70.9	Natural Gas	Gas Turbine
22/Cog/1995	Veracruz	6.25	44	Natural Gas	Steam Turbine
23/	Hidalgo	30	229.7	Natural Gas	Gas Turbine
24/	Hidalgo	35	182	Natural Gas	Steam Turbine
25/	Jalisco	2.33	17.5	Natural Gas	Gas Turbine
26/	Quintana Roo	29.5	192	Combustoleo	Internal Combustion
36/Cog/1996	Tamaulipas	120	832.2	Natural Gas	Gas Turbine
46/	Estado Mexico	2.1	14.12	Natural Gas	Internal Combustion
48/	Sonora	4	21.25	Fuel Oil	Steam Turbine
50/	S. Baja Calif.	5	20.5	Solid Waste	Caldera De Parrillas
61/Cog/1997	S. Baja Calif.	19.9	164	Fuel Oil	Steam Turbine
73/Cog/1998	Chiapas	120.7	315.16	Natural Gas	Gas Turbine
74/	Veracruz	172	490.76	Natural Gas	Gas and Steam Turbine
75/	Veracruz	163.5	762	Natural Gas	Gas and Steam Turbine
76/	Veracruz	58.5	202	Natural Gas	Gas Turbine
96/	Tamaulipas	10.6	88.93	Natural Gas	Gas Turbine
113/	San Luis Potosí	3.53	20.3	Natural Gas	Gas and Steam Turbine
131/Cog/1999	Sonora	470	3000	Natural Gas	Combined Cycle
143/	Michoacán	10	31.54	Combustoleo	Steam Turbine
144/	Jalisco	13.3	56.94	Combustoleo	Steam Turbine
148/	Campeche	306	1971	Natural Gas	Steam Turbine
151/	Quintana Roo	114.5	848.84	Natural Gas	Combined Cycle
154/	Tlaxcala	6.64	37.27	Natural Gas	Gas and Steam Turbine
157/Cog/00	Tamaulipas	16.3	140.83	Natural Gas	Combined Cycle

Table A-3: Independent Power Production Permits issued by CRE

Permit Number	Location	Capacity Mw	Energy Gwh/Year	Primary Fuel	Technology
57/Pie/97	Yucatan	531.5	3400	Natural Gas and Diesel	Combined Cycle
124/Pie/1998	Sonora	252.7	1800	Natural Gas	Combined Cycle
128/	Tamaulipas	568.6	3700	Natural Gas and Diesel	Combined Cycle
133/Pie/1999	Coahuila	247.5	1650	Natural Gas and Diesel	Combined Cycle
135/	Guanajuato	545	4081	Natural Gas	Combined Cycle
139/	Veracruz	535.56	3707.45	Natural Gas and Diesel	Combined Cycle
152/	Nuevo Leon	570	3685	Natural Gas	Combined Cycle
164/Pie/2000	Campeche	275.00	2102.97	Natural Gas	Combined Cycle

Table A-4: Importation Permits Issued by CRE

Permit	Location	Capacity Mw	Energy Gwh/Year
31/Imp/1996	Sonora	4	18.4
60/Imp/1997	Coahuila	0.75	6.57
101/Imp/1998	Sonora	0.85	4.75
102/Imp/1998	Sonora	1.5	8
112/	Sonora	1.5	8
132/	Sonora	1.6	11.7
163/Exp/2000	Baja California	257.60	2119.12

Table A-5: System Expansion Plan, 1997–2007

Project	Location	Type	Bid Date	Required Capacity (MW) 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Samalayuca	Chihuahua	CC	1992	522										522
Merida III	Yucatan	CC	1996			499								499
Cerro Prieto	Baja California	Geo	1996			100								100
Rosarito 8 and 9	Baja California	CC	1996			550								550
Chihuahua	Chihuahua	CC	1996			418								418
Monterrey III	Nuevo Leon	CC	1996			490								490
San Carlos	BCS	CITD	1997			38								38
Guerrero Negro	BCS	CITD	1997		9									9
Hermosillo	Sonora	CC	1998				225							225
Rio Bravo III	Tamaulipas	CC	1998				450							450
Bajio	Guanajuato	CC	1998				450							450
Monterrey	Nuevo Leon	CC	1998				450							450
Altamira II	Tamaulipas	CC	1998				450							450
Naco-Nogales	Sonora	CC	1998				450							450
Rosarito 10 and 11	Baja Colifornia	CC	1998					225						225
Villahermosa	Tabasco	CC	1998						450					450
Saltillo	Coahuila	CC	1998					225						225
Rosarito 7	Baja California	TG	1997		165									165
Hermosillo	Sonora	TG	1997	142										142
Rio Bravo	Tamaulipas	TG	1997		154									154
Huinala	Nuevo Leon	TG	1997		141									141
El Sauz	Querétaro	TG	1997	123										123
Tula or El Sauz	Querétaro	TG/CC	1999		150									150
Valle de Mexico	Estado de Mexico	TG/CC	1999			280								280
Los Azufres III	Michoacan	Geo	1999				100							100
San Rafael	Nayarit	Hydro	1999				24							24
El Sauz	Querétaro	CC	1998				450							450
El Sauz	Querétaro	CC	1999					150						150
Francisco Villa	Chihuahua	CC	1999					150						150
Chicoasen	Chiapas	Hydro	1999					900						900
Tuxpan II, IV & V	Veracruz	CC	1999						900	450				1,350

Project	Location	Type	Bid Date	Required Capacity (MW) 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Altamira III-VIII	Tamaulipas	CC	1999						900	900	300	600		2,700
Laguna 1 & 2	Durango	CC	1999						225	225				450
Baja California I & II	BCS	CITD	1999						37.5			37.5		75
Rio Bravo II	Tamaulipas	CC	1999							450				450
Noreast I-III	Sonora	CC/TG	2000							225	225	225	150	825
Guerrero Negro II	Baja California I-III	CITD	2001								9			9
Baja California I-III	Baja California	CC	2000								225	225	225	675
Matamoros	Tamaulipas	CC	2001								450	450		900
Poza Rica	Veracruz	CC	2001								900	450		1,350
Valladolid	Yucatán	CC	2001								450			450
North I & II	Chihuahua	CC	2001								225		225	450
Dos Bocas	Veracruz	CC	2002									450		450
Coatzacoalcos	Veracruz	CC	2002										900	900
El Cajon	Nayarit	Hydro	2000									636		636
Tres Virgenes	BCS	Geo	1998				10							10
Tres Virgenes	BCS	Geo	2002									5		5
La Parota	Guerrero	Hydro	2001										765	765
Copainala	Chiapas	Hydro	2001										140	140
Subtotal				**786**	**619**	**2,374**	**3,059**	**1,650**	**2,513**	**2,250**	**2,784**	**3,079**	**2,405**	**21,518**

Note: Table does not include capacity privately developed for private industrial use.

Legend: CC, combined cycle; hydro, hydroelectric; geo, geothermal; CITD, internal combustion diesel; TG, gas turbine.

Annex B: Flexible Mechanism Opportunities in the Steel Sector

To develop a preliminary determination of the interest and possibilities for emissions reduction projects in the Mexican iron and steel sector, a short and concise questionnaire was given to 14 steel company representatives, including those from small, medium and large companies. Exhibit B1 shows the composition of the sample.

Exhibit B1. Composition of the sample of 14 steel companies who answered the questionnaire.

Classification	Size
1. Galvanizer	Medium
2. Integrated	Medium
3. Integrated	Large
4. Integrated	Large
5. Integrated	Small
6. Integrated	Medium
7. Integrated	Large
8. Minimill	Medium
9. Minimill	Medium
10. Minimill	Medium
11. Re-roller	Medium
12. Smelter	Medium
13. Smelter	Medium
14. Transformer	Medium

The survey results indicated that even though only one out of the fourteen companies is currently developing a climate change-related project (a medium-size transformer industry), 71 percent of them are aware to some extent of the energy and cost savings that could result from the implementation of such projects.

Although there is a wide-spread lack of information on GHG emission reduction projects, the survey results indicate that there is interest among steel companies to learn more about such projects and climate change-related issues. All the companies requested more information on the subject, and all but one of those aware of the opportunities stated that they would be interested in carrying out a project. Some general additional information on CDM was subsequently provided by this study team.

Fifty-seven percent of the companies are already running or designing an energy saving project (Exhibit B2). In contrast, only two integrated companies are currently running or designing fuel-switching projects: one is a large company changing from fuel oil to natural gas and the other is a small one switching from gas to coke.

Exhibit B2. **Is your company currently running or designing an energy saving program?**

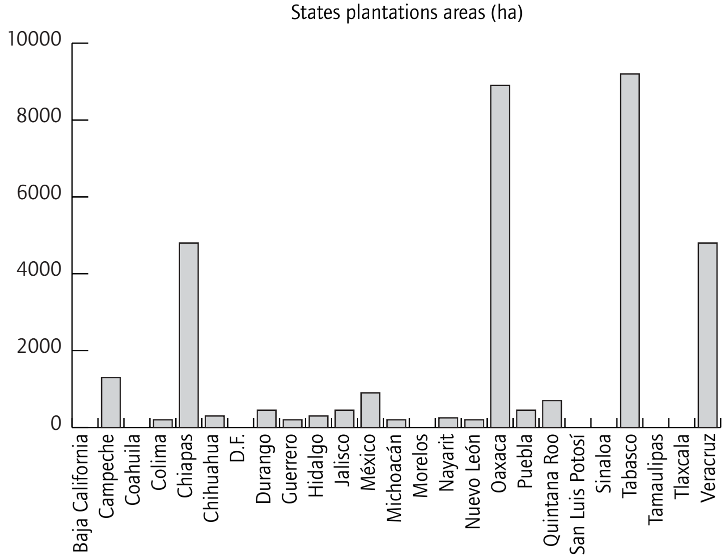
Companies running or designing energy saving programs		
Classification	**No.**	**Size**
Integrated	2	Large
Integrated	2	Medium
Minimill	2	Medium
Re-roller	1	Medium
Transformer	1	Medium

Annex C: Potential Flexible Mechanism Opportunities in Industrial Plantations

This annex provides the list of operating industrial plantations summarized in the 1998 annual report on forestry in Mexico (*Dirección General Forestal* 1998). They grow trees for different purposes, from Christmas trees to wood and pulp and paper production, as shown in the Table C-1 of this Annex. These plantations represent good opportunities for CDM projects, as has been mentioned in the text of Chapter 4, via expansion of plantation areas, establishment of new plantations, and amelioration of their production processes.

These commercial plantations are distributed essentially throughout the country, as shown in Figure C-1.

Figure C-1. Mexican Plantations by State, 1998



The concentration of commercial plantations is largest in the states of Campeche, Chiapas, Oaxaca, Tabasco and Veracruz, all of which are in the Southeast and have good growing conditions. The size and number of the plantations are described in Table C-1.

Table C-1. Mexican Plantations by Size, 1998

Dimension	Size	No.	Average size
>5000ha	Large	2	8,195
1000–5000ha	Medium	4	2,062
300–1000ha	Small	10	578
1–300ha	Micro	39	79
	Total	**55**	**609**

While approximately six plantations are categorized as medium or large in terms of area, these plantations can still be considered as small or micro enterprises because they are divided into subprojects. The plantations involve several species, including pine, oak and eucalyptus. Using the low estimate of sequestered carbon of

10tC/ha/year and the total area of 33,485 ha, the total carbon sequestration potential at these plantations is estimated to be 334,850 tC/year.

Table C-2. Main Ongoing Commercial Plantations Projects in Mexico—1998

State of the Republic	Name of the project or the property	Location or Municipality	Species used in the Plantation	Planted surface (ha)	Planted surface by state (ha)
Baja California	Innominate	Mexicali	*Eucalyptus camaldulensis* Wood for cellulose	50	50
Campeche	Smurfitt Cartón and Papel de México	Candelaria	Wood for cellulose *Gmelina arborea*	700	1,417
	Clemente Rámirez Vargas	Campeche	*Swietenia macrophylla* and *Cedrela odorata* Wood for sawmills	100	
	Unión de Sivicultores de la Región de Escarcega	Escarcega and Champoton	*Swietenia macrophylla* and *Cedrela odorata* Wood for sawmills	331	
	Productores Agropecuarios de Haro	Escarcega	*Swietenia macrophylla* and *Cedrela odorata* Wood for sawmills	137	
	Various projects Small landowners	Hopelchen and Campeche	*Swietenia macrophylla, Cedrela odorata* and *Cordia dodecandra* Wood for sawmills	149	
Coahuila	Various projects Ejidos and small landowners	Arteaga, Saltillo and Cepeda	*Pinus* spp. Christmas and ornament trees	43	43
Colima	Various projects Small landowners	Colima, Armería, Manzanillo and Cuauhtemoc	Various tropical species Wood for sawmills	98	98
Chiapas	Agroforesters of the state	Various locations	*Cedrela odorata*, *Tabebuia donnell-smithii*, *Swietenia macrophylla* and other Wood for sawmills	737	4,730
	SOCAMA	Various locations	*Cedrela odorata*, *Tectona Grandis*, *Tabebuia donnell-smithii*, *Swietenia macrophylla* and other. Wood for sawmills	2,674	
	Hule de Palenque	Palenque	*Hevea brasiliensis* Wood for sawmills	1,319	
Chihuahua	Stephanie Memmot	Casas Grandes	*Pinus eldarica* Christmas trees	5	205
	PIMSA-COPAMEX	Ojinaga	*Eucalyptus camaldulensis* Wood for cellulose	200	
D. F	Various projects Small landowners	Tlalpan, Milpa Alta and Alvaro Obregón	*Pinus ayacahuite* Christmas trees	38	38
Durango	Forestal Halcón	Durango and San Dimas	*Pinus* spp. Wood for sawmills and cellulose	450	450

State of the Republic	Name of the project or the property	Location or Municipality	Species used in the Plantation	Planted surface (ha)	Planted surface by state (ha)
Guerrero	Ejido El Balcón	Ajuchitlan del Progreso	*Pinus pseudostrobus*, *P. herrerae*, *P. teocote*, *P. ayacahuite*, *P. chiapensis* and *P. maximinoi* Wood for sawmills	10	110
	Commercial plantation	El Reparo	*Pinus* spp. Wood for sawmills	100	
Hidalgo	Tecocomulco Tres Cabezas	Cuautepec	*Pinus montezumae*, *P. rudis*, and *P. patula* Wood for sawmills	60	254
	Various projects Small landowners	Metzquititlan	*Pinus* spp. Wood for sawmills	194	
Jalisco	Industrias Emman de Ocotlan	Ocotlan, Tototlan and Poncitlan.	*Eucalyptus* spp. Production of splinter for agglomerates	473	473
México	Bosque de los Arboles de Navidad	Amecameca	*Pinus ayacahuite* and *P. pseudotsuga menziessi* Christmas trees	150	765
	Rancho El Capricho	Zumpahuacan	*Pinus* spp. Wood for sawmills and Christmas trees	113	
	Various projects Ejidos and small landowners	Various municipalities	*Pinus* spp. Wood for sawmills and Christmas trees	502	
Michoacán	CRISOBA	Patzcuaro	*Eucalyptus globulus* Wood for cellulose	50	170
	El Cirian and Cañas Viejas	Tuzantla	*Pinus* spp. Wood for sawmills and cellulose	120	
Morelos	Tlahichan	Tlalnepantla	*Pinus ayacahuite* Christmas trees	4	10
	P. El Vigía	Tlalnepantla	*Pinus ayacahuite* Christmas trees	6	
Nayarit	Soc. de Producción Rural Ecoteca de la Bahía	Bahía de Banderas	*Tectona grandis* Wood for sawmills	41	372
	Various projects Ejidos and small landowners	Bahia de Banderas, Compostela, San Blas, Tepic and Acaponeta	*Cedrela odorata*, *Swietenia macrophylla*, *Tectona grandis* and other Wood for sawmills	83	
	Plantaciones Forestales Comerciales Norte de Nayarit	Acaponeta	*Eucalyptus* spp. and *Gmelina arborea* Wood for cellulose	248	

State of the Republic	Name of the project or the property	Location or Municipality	Species used in the Plantation	Planted surface (ha)	Planted surface by state (ha)
Nuevo León	Ejido de San Joaquín de Soto	Arramberri,	*Pinus cembroides* and *P. pseudostrobus* Christmas trees and wood for sawmills	60	89
	Various projects Ejidos and small landowners	Galeana, Iturbide, Santa Catarina and Santiago	*Pinus* spp. Christmas trees	29	
Oaxaca	Plantaciones Forestales El Pénjamo	Pochutla	*Tabebuia rosae* and *Swietenia humilis* Wood for sawmills and plywood boards	20	
	Plantaciones Tehuantepec	23 properties in San Juan Cotzocón and Santiago Yaveo	*Eucalyptus grandis* and *E. urophylla* Wood for sawmills and cellulose	150	
	Ejido San Isidro Lagunas (FAPATUX)	Valle Nacional	*Pinus caribaea* and other 700 species of tropical pinus Wood for cellulose		
	La Sabana	San Juan Cotzocon	*Pinus caribaea* and other species of tropical pinus Wood for cellulose	8,000	8,870
Puebla	Various projects Ejidos and small landowners	Huachinango, Zihuateutla, Tlaola, Xicotepec de Juárez and Chiconcuatla	*Cupressus benthamii*, *Chamaecyparis pisifera*, *Cunninghamia lanceolata* and other Christmas trees	430	430
Quintana Roo	El Corozo	Felipe Carrillo Puerto	*Cedrela odorata* Wood for sawmills	25	691
	El Vergel	Othón P. Blanco	*Cedrela odorata* and *Swietenia macrophylla* Wood for sawmills	100	
	Commercial plantation with intense technology	Felipe Carrillo Puerto	*Cedrela odorata* and *Swietenia macrophylla* Wood for sawmills	53	
	Agroforestry	(11 Ejidos) Lázaro Cárdenas	*Cedrela odorata* and *Swietenia macrophylla* Wood for sawmills	513	
San Luis Potosí	Various projects Small landowners	Tamazunchale and Terrazas	*Cedrela odorata* Wood for sawmills and plywood boards	10	10
Sinaloa	Various projects Small landowners	Culiacan, Elota, Mazatlan and Calomato	*Cedrela odorata*, *Swietenia macrophylla* and *Eucalyptus* sp. Wood for sawmills and cellulose	74	74

State of the Republic	Name of the project or the property	Location or Municipality	Species used in the Plantation	Planted surface (ha)	Planted surface by state (ha)
Tabasco	Planfosur (13 Projects)	Huimanguillo	*Eucalyptus urophylla* and *E. grandis* Wood for cellulose	8,390	9,331
	Forest development (8 projects, 3 of them not planted yet)	Balancán, Tierra Nueva and Huimanguillo	*Eucalyptus urophylla* and *E. grandis* Wood for cellulose	941	
Tamaulipas	Various projects Ejidos and Small Landowners	Victoria, Jaumave, Gómez Farías, Güemez and Reynosa	*Pinus* spp., *Cedrela odorata* and *Prosopis velutina* Wood for sawmills, poles, fuel and charcoal	22	22
Tlaxcala	Various projects Ejidos and Small Landowners	Tlaxco and Teacalco	*Pinus ayacahuite* Christmas trees	3	3
Veracruz	Planfosur (16 Projects)	Las Choapas, Ixhuatlán del, Sureste Molocán and Agua Dulce	*Eucalyptus urophylla* and *E. grandis* Wood for cellulose	2,378	
	Particular (13 Projects)	Hueyapan de Ocampo, Catemaco, Santiago, Isla and San Andrés Tuxtla.	*Cedrela odorata*, *Swietenia macrophylla* and *Tabebuia donnell-smithii* Wood for sawmills	1,876	
	Reforesta Mexicana	Las Choapas	*Toona ciliata*, *Tectona grandis* and *Swietenia macrophylla* Wood for sawmills	200	
	Magueyitos	Perote	*Pinus cembroides*, *P. Montezumaeà* and *P. pseudostrobus* Christmas trees and wood for sawmills	43	
	El Chaparral	Juchique de Ferrer	*Gmelina arborea* and *Tectona grandis* Wood for sawmills	190	4,771
	Rancho Kirch	Poza Rica	*Cedrela odorata* and *Swietenia macrophylla* Wood for sawmills	48	
	Los Molinos	Perote	*Pinus patula* Wood for sawmills	31	
	El Colibrí	La Antigua	*Cedrela odorata* and *Swietenia macrophylla* Wood for sawmills	5	
TOTAL					**33,473**

Source: Dirección General Forestal.