Private vs. Public Ownership of Power Generation in Mexico: Should Environmental Policymakers Care?

by

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ABSTRACT

Congress has not yet approved regulatory reform in the Mexican energy sector. In fact, the debate is deadlocked, with many political actors disagreeing on even the most basic principles that ought to guide future investments in energy. The disagreement persists even as the structure of the energy sector has begun to change. Privatization of power generation, for example, has accelerated over the past five years, in spite of the fact that several of the obvious legal modifications that would provide greater certainty for private investors are not in place. International firms are the primary investors.

Some observers suggest that increased competition and privatization will benefit consumers by increasing energy supplies and reducing costs. These new developments, however, might have mixed environmental consequences. That is what I set out to discover. While it may be true that new investments in electricity generation can produce technology improvements that are more efficient and environmentally cleaner, it is also possible that, with competition keyed primarily to price, the free market could perpetuate fossil-fueled generation, making investments in renewable energy unattractive and reducing investments in emission abatement.

The fact is, privatization of power generation in Mexico, which has occurred within a market that is only partially open, seems to have produced cleaner and more efficient plants. This appears to have occurred primarily because newer technologies (and the fuels they employ) happen to be cleaner than the technologies that have traditionally been used. Some private power producers, who own and operate new plants in Mexico, have chosen to adopt environmental practices that exceed those that public producers have been required to meet.

There is actually great variability in the environmental management practices of both publicly-owned and privately-owned plants in Mexico. Among public utilities, most improvements in environmental management practice seem to have come in response to pressure from regulatory bodies at the national level. Private producers, on the other hand, seem to respond more to corporate strategy dictated by their parent companies and to mandates from funding institutions.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

ANES	Asociación Nacional de Energía Solar (National Association of Solar Energy)
BLT	Build, Lease and Transfer
BTU	British Thermal Units
CFE	Comisión Federal de Electricidad (Federal Commission of Electricity)
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CONAE	Comisión Nacional para el Ahorro de Energía (National Commission for Energy Conservation)
CRE	Comisión Reguladora de Energía (Energy Regulatory Commission)
DF	Distrito Federal (Federal District)
EDFI	Electricité de France International
EIA	Environmental Impact Assessment
GHG	Greenhouse Gases
GW	Gigawatt
GWh	Gigawatt-hour
Hg	Mercury
IDB	Inter-American Development Bank
IFC	International Financial Corporation
INE	Instituto Nacional de Ecología (National Institute of Ecology)
IPP	Independent Power Producer
ISO	International Organization for Standardization
KWh	Kilowatt-hour

LFC	Luz y Fuerza del Centro
l/s	Liters per second
MW	Megawatt
NAFTA	North American Free Trade Agreement
NGO	Non Governmental Organization
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxides
O_3	Ozone
PAN	Partido Acción Nacional (National Action Party)
PEMEX	Petróleos Mexicanos (Mexican Petroleum Company)
PF	Public Funding
PIDIREGAS	Proyectos de Infraestructura Productiva de Largo Plazo (Long-Term Productive Infrastructure Projects)
PPA	Power Purchase Agreement
ppm	Parts per million
PRD	Partido de la Revolución Democrática (Democratic Revolution Party)
PRI	Partido Revolucionario Institucional (Institutional Revolutionary Party)
PROFEPA	Procuraduría Federal de Protección al Ambiente (Federal Environmental Protection Attorney Office)
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales (Secretariat of Environment and Natural Resources)
SEN	Sistema Eléctrico Nacional (National Electric System)
SENER	Secretaría de Energía (Secretariat of Energy)
SO_2	Sulfur Dioxide
SoM	Estado de México (State of Mexico)

1. INTRODUCTION

In the fall of 2000, I went to Houston to attend a conference about the Mexican energy sector. From its title, which was something like The Future of the Energy Sector in Mexico, and from its program as well, I had inferred that the conference speakers were there to present and discuss issues related to technological development and policy tools that would improve the sector's performance. In reality, the topic of discussion was narrower, and more than the sector itself, what was of interest was the sector's opening to private investment.

Among the attendees at the Houston conference, there were representatives from all major international energy providers, transnational bank officials, technology developers, and several other people who were interested in knowing just two things: when was the Mexican energy market going to fully open, and what did they need to do to invest there. Practically no academics or researchers attended, and those who were there representing offices in the Mexican government (I was at the time working at the federal Ministry of Environment) were almost expected to behave like salesmen. Our role was to convince "clients" about the attractiveness of the "new" market, and to provide certitude that existing barriers to investment were going to be removed as soon as the new administration came into office.

At the time, there were reasons to be optimistic. Recent political changes in Mexico had generated great expectations. Just a few months earlier, in July of 2000, the first president from an opposition party was elected. This took place after more than 70 years of dominance of the Institutional Revolutionary Party (PRI), under whose rule the energy sector, including oil exploration and production and, to some extent, electricity generation, was deemed strategic, and thus was the exclusive property of the nation, with very little intervention from the private sector.

And even though some changes in the energy sector had started to occur, they were moving slowly. In fact, it was not until the administration of President Zedillo, the last of the PRI presidents, when serious discussion about energy reform began, at least to bring private investment to the electricity sector. Nevertheless, this discussion was leading nowhere. There was major disagreement about reform from all opposition parties and even within PRI itself. In part, this was due to PRI's nationalistic principles, and to a fear of alienating unions, which had always been a crucial part of their political base.

The democratic transition taking place in 2000 helped to boost the optimism of the private sector. The political system was showing signs of maturing, allowing citizens to elect, democratically and without any major incident, an opposition candidate for the first time in decades. But more than that, there was also the fact that the winning candidate happened to be from a right-wing party, the Party of National Action (PAN), whose most prominent members were industrialists and businessmen, among them, the new president himself.

It was in this context that investors began to become increasingly optimistic about privatization of the Mexican energy sector, and about electricity generation in particular. Without significant investment, it was apparent to them that the generation capacity of the country would soon become obsolete. In fact, it was already showing signs of being insufficient to satisfy growing demand. Besides, the new administration promised that the economy was going to grow at an annual rate of 7%, and there was no reason to believe it would not. If the economy grew as fast as the incoming administration promised, it would probably mean that electricity supply would need to grow at an even higher rate (i.e., as the country developed and the per capita consumption of electricity grew, and as population, simultaneously, increased).

At the time, most people were confident about the ability of the new government to achieve its goals. It seemed then to have the support of most stakeholders. However, all that optimism soon turned to disenchantment. The government was, as President Fox himself admitted, "paralyzed" by the Congress. Only a few of the many major changes that were expected with his arrival were going to be achieved. The general population would soon be disappointed as well, although they would not put all the blame for the broken promises on the Congress, as President Fox argued they should, but partly on his administration as well. All of this became evident in Fox's mid-term elections, in which his party was the big loser.

Paradoxically, it seemed as if democratization, which was the reason to be optimistic about change, was later on to a large extent what impeded it. As one of the officials that I interviewed put it, "with the democratic change, the *politization* of policymaking had taken place." With democratization, the multiparty system appeared to have gotten, in many respects, in the way of policy implementation, although the cause may not have been that Congress forced the paralysis of the government as President Fox declared, because of irreconcilable ideological principles, or because of competing interests. The inability of the executive branch to build consensus and to negotiate change with other stakeholders may have been the primary problem. For energy reform, at least, this seems to have been the case.

In the past, in the times of more authoritarian rule, PRI presidents had decreed nationalizations and privatizations, depending on the mood of the moment, without much opposition. Banks, for instance, were nationalized in the early 1980s, and then privatized again a few years later by the following administration (at a tremendous cost to society). Nowadays, with a more solid democratic system in place, it was not that easy. In the case of proposed energy reform, the change from a centralized power structure to what some scholars call a "divided democracy" (Dresser, 2001) had negative effects on the chances of this initiative succeeding. I say negative effects, and I mean, of course, from the perspective of the policymaker whose efforts to put a policy in place have not been fruitful, and not, certainly, from the point of view of political actors whose voice is now heard. Ideally, I would expect, not negative either from the perspective of the whole society, but am not sure that this is the case, since the political debate over energy reform, as it is happening in the case of several other fundamental policies as well, does not appear to be driven by the public interest, but by the interests of various factions. So far, whatever the reason, of the three major structural reforms the current federal administration tired to achieve -fiscal, labor, and energy- not one has moved forward.

Small steps have been taken here and there, but nothing like what was promised has been achieved.

For energy reform, the expectation of opening the sector to competition has not been realized, at least not at the scope and pace desired by the federal government. Still, at least in what is referred to the electricity sector, private participation in power generation has, slowly but firmly, increased. Certainly not without a lot of opposition, and often through legal maneuvers and all sorts of disguises, but still the private sector has been granted "concessions" to design, build and operate power generation facilities, even when the strict interpretation of the Constitution is, as I will discuss later, clearly opposed to any private involvement in power generation.

1.1 Attempts to Reform the Energy Sector

Following an international trend, and continuing a domestic practice that had significantly downsized the public sector over the decade of the 1990s, President Zedillo introduced, in February of 1999, an electricity sector reform proposal to the Senate. Its intention was to increase competition in the sector, and to stimulate private investment in power generation and distribution. Up to that point, pretty much the whole energy sector had largely been left out of the privatization wave of the 1990s, with the sector's public ownership, especially in the case of oil exploration and refining, being ferociously defended by many political actors as a fundamental element of national sovereignty.

In President Zedillo's proposal, which did not pass in Congress due to lack of consensus, the reasons for urging the reform of the electricity sector, which, had it been successful, would probably have been extended to the oil sector as well, were, arguably, of a more technical nature. They related, according to the administration, to the need to respond to the increasing demand for generation capacity, while the public sector was very limited in its ability to provide the necessary investment.

Looking at the experiences of other Latin American countries, where the situation is comparable to Mexico, we can see that the experience of deregulation of the power sector has generally followed a pattern that differs from the story in developed countries. Whereas in the developed world, the main rationale behind the deregulation of the electricity industry has been to improve efficiency, in Latin America, in general, the main goal has been to attract investment to meet growing demand and, to a certain extent, to generate financial resources for local governments embattled, in many instances, in financial crises.

In almost all "successful" cases in Latin America, the need to carry out deregulation and privatization derived from the inefficiencies of state-owned electric utilities, which reflected in the poor service being provided to final consumers. According to some authors, one of the main causes of the bad performance of state-owned utilities in the region was the political abuse by both politicians and interest groups of the power sector, which, as a consequence, produced a heavily subsidized sector (often with perverse and badly targeted subsidies), poor planning of the sector's growth, and the sector acting as the employment agency of interest groups, with corruption arising at all levels (Millán and von der Fehr, 2003).

The administration of President Zedillo perceived that a similar situation was occurring in Mexico, but left office, by late 2000, without having made much progress in its attempts to achieve any substantial change in the operation of public electric utilities. Then came the administration of President Fox, optimistic at first about their better chances of success on this issue. Still, more than four years into his six-year term, the energy reform proposal promoted by President Fox's administration, even though it is a "lighter" version of President Zedillo's, since it is crafted not to touch the existing assets of the public power utilities, seems to be a failure. Nevertheless, the government keeps arguing that the sector will not have the capacity to grow at the pace that the market demands, unless private investment is allowed. If this does not happen, the government threatens, serious blackouts will soon afflict the country, and the economy will lose competitiveness. These arguments, nevertheless, have not been strong enough to win over relevant stakeholders and decision makers. In fact, several of the arguments opposing privatization, some of which I will discuss in this dissertation, disregard completely the reasons offered by the federal government, assuming more of a political and even ideological perspective, rather than a technical one. Therefore, at the end of the day, not even common ground for discussion has been found.

The fact that the debate over the reform of the power sector has turned into a political battle is fairly evident to all stakeholders I had conversations with in Mexico (listed in Appendix A). So far, there have been at least ten initiatives formally introduced in Congress, seven of which had not been discussed by the end of 2004. Out of these, three were introduced by PRI congressmen, two were introduced by members of the leftist Party of the Democratic Revolution (PRD), one was introduced by the Labor Party (PT), and one was sent to Congress, on August 2002, by President Fox. These initiatives can be divided into two groups, those that propose the continuation of a public monopoly, although allowing some indirect financing from the private sector, and those that would open the sector, or at least power generation, to competition, allowing also direct private investment. All these initiatives agree that the public sector should remain as the regulator, and on the fact that public power utilities should be more autonomous. They also agree on the need to reduce rates and to improve the quality and reliability of electricity service. As for allowing private participation, only the PT initiative is totally against any private investment, although their representation in Congress is insignificant, so their position alone would probably not determine the outcome.

In recent months, the debate over energy reform has increased, with a new Congress in place, presidential elections nearing, and several changes taking place at the highest level at the Secretariat of Energy, which has had three Secretaries in four years. To this day, in summary, most of the strong resistance to any significant change in the operation of the energy sector has come from unions, but also from some political parties which, whether because of principle, or simply because they may profit from "defending the country's sovereignty," have blocked any attempt by the government to debate the issue in Congress. The media has also been divided on the topic, although it seems to be clear to the general population, and especially to industry, that new investments are required in electricity generation infrastructure, and that the government is not capable of making these without neglecting other areas that have already been given priority.

1.2 Reform or Not, the Power Sector Needs to Grow

Currently, the Mexican electricity sector has total installed capacity of 45.6 GW, which means that the per capita installed capacity in the country is of roughly 0.46 kW. If the Mexican economy is to grow, and reaches the level of development to which the country aspires (which, I can assume, is comparable to that of a developed country), it will need, at least, a level of installed generation capacity of 1 kW per person. Considering the expected growth in population, according to one of the better sustained projections available which relies on a multi-regional model that accounts for mortality, fecundity, and migration, among other factors, Mexico could have more than 120.6 million inhabitants by 2020 (CONAPO, 2002). This would imply that generation capacity would have to increase, over the next 15 years, to 120.6 GW, which would represent roughly more than two and a half times existing capacity.

According to some estimates, as early as in 2010, as much as 76% more capacity than what is currently installed may be necessary to satisfy the increasing national demand for electricity (CONAE, Web-page), which is a figure in line with my estimates above. The Ministry of Energy itself has estimated that 32 GW of generation capacity should be added to the national electricity system between 2001 and 2010 (SENER, Web-page), and that amount does not even consider the portion of generation plants already in operation that will become obsolete during this period and will have to be replaced.

Recently, there have not been any significant capacity retirements in the Mexican power sector, due mostly to budgetary constraints. Nevertheless, this does not mean that they are not necessary. Over the last decade, for instance, only 816 MW of capacity were retired (World Bank, 2004). As a result, all new capacity being developed, even when it is largely newer natural gas combined cycle technology, is additional to what was already operating, which involves mostly relatively dirty and inefficient fuel-oil thermal generation. Since a significant turnover has not occurred, and it is not likely to occur any time soon, new generation capacity is put in place just to satisfy growing demand. In fact, the electric system does not even comply any more with capacity reserves that are common practice worldwide.

All this points to the fact that there is, in all, a need for major investment in the Mexican electricity sector, which could bring, simultaneously, the opportunity to improve environmental performance, by creating a more diversified power generation portfolio. Currently, about 69% of installed capacity comes from thermal processes using fossil fuels, roughly 25% from hydroelectric facilities, nearly 4% from nuclear power, and about 2% from geothermal plants. Wind power, even though it has great technical and economic potential in Mexico, has an installed capacity of a negligible 2.2 MW.

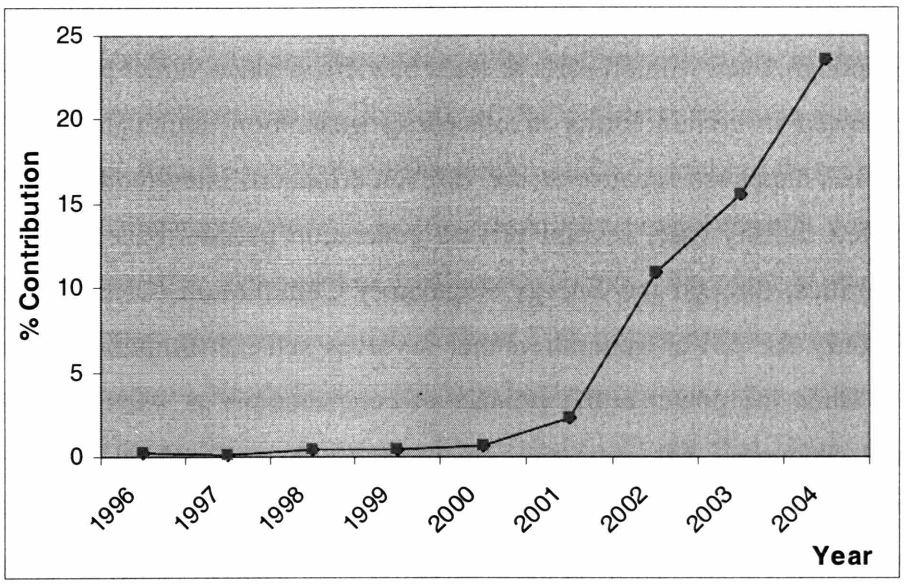
Necessary investments in power generation over the next 10 years or so are in the range of US$ 22 billion (SENER, 2004b), and this, is additional to the US$ 13 billion required for transmission, US$13 billion for distribution, and about US$ 7 billion for maintenance of the electric infrastructure. The public sector alone has no resources for doing this sort of investment, and is even less willing to, since the public utilities are operating with great financial losses and providing poor service.

1.3 Privatization Quietly Makes Its Way Into the power Sector

Not having many other options, the public sector has resorted to private investment as a means of meeting increasing power demand. Even while official reform of the electric sector has not been achieved, and although there is no open competition in the market, the fact is that there is already direct private investment in generation. Not only that, but it has been growing significantly over the last 5 years, going from less than 1% of total generation in 2000, to almost 24% in 2004 (see Figure 1.1).

Currently, the greatest portion of "external" power generation occurring in Mexico, is produced by independent power producers (IPP), who contribute about 16% of total national generation. Included also in the figure for external generation, there is a smaller portion of electricity production, about 4% nationally which in strict sense is carried out by the public sector, although outside of the electric utilities. This electricity is generated mostly in facilities owned and operated by the public oil company PEMEX, which produces a significant amount of power for self-consumption (see more detail about the structure of the electricity market in Chapter 4).

FIGURE 1.1
PRIVATE CONTRIBUTION TO ELECTRICITY GENERATION IN MEXICO
(% OVER TOTAL GWh PRODUCED)



Note: 2004 contribution estimated with figures for the January to September period.
Sources: INEGI, 2003; SENER, 2005.

As strange as it may sound, direct private investment in the energy sector is highly constrained by the federal Constitution. Public sector utilities are not allowed, for instance, under any circumstance, to sell stock to private investors, and practically the only option they have for obtaining funds beyond their operational resources, is either through the direct financial support from the public sector, or through debt.

The Constitution clearly stipulates that the state is the only entity allowed to produce and distribute electricity, and that no concession to the private sector, for any of those purposes, can be granted. Presently, the general objective of Mexico's energy policy, which is periodically redefined with the coming of each new federal administration, as constitutionally mandated, is to "strengthen the national energy sector, so as to promote a vigorous, sustainable, and equitable economic and social development, guaranteeing the state's authority in the area, and consequently, creating a more prosperous and sovereign Mexico" (Secretaría de Energía, web-page). This is a very ambiguous mandate, leaving a lot of room for interpretation. I suspect that this is intentional, to make the energy policy reachable, regardless, for instance, of whether or not there is private involvement in the sector.

Amazingly enough, even with all sorts of legal barriers in place, direct private investment has been allowed in certain forms of electricity generation, although the question of whether this has happened because of lax, or even erroneous interpretation of the law, is still unresolved. In any case, several private generation permits have been granted by federal authorities, through the Energy Regulatory Commission (CRE), although such permits are only for power generation that involves self-consumption; exportation or importation; when the power is the product of cogeneration; or when it is done by an independent producer, but for the exclusive use of public power utilities.

The electric sector started allowing permits for private generation in 1992, although it was not until 1997 that IPP permits were first granted, by CRE, to satisfy increasing demand in spite of the limited resources available to the two public power utilities, Comisión Federal de Electricidad (CFE), and Luz y Fuerza del Centro (LFC). Up until now, all IPPs which have received operation permits from CRE and have signed power purchase contracts with CFE, have been owned by international corporations.

From 1994 until the end of 2004, investment by external generation permit holders amounted to an estimated US$ 13.6 billion (CRE, 2005). Over the same period, these external producers developed generation capacity in the range of 21 GW, which represents almost 25% of the national installed capacity (or 21% when not considering PEMEX among external producers).

A fact that has propelled privatization even farther is that public utilities are operating at a loss, and are highly indebted. CFE alone has a debt of about US$ 6 billion, out of which about one third must be paid between 2005 and 2006. The amount of debt that CFE has is roughly equivalent to 45% of its annual budget. The company is also struggling financially to cover normal operation, with a net loss of about US$ 145 million in 2004.

Still, it is not clear whether consumers may see any advantage to private investment in generation, and consequently that they favor its continuation. Big consumers, like industry and even large retailers, may be in favor of it. They have complained repeatedly about the high price of power and the poor quality and low reliability of the service they receive. By and large, they are making use of the option to produce their own power whenever they can. Paradoxically, even the public sector is looking to replace CFE and LFC with private producers, since it is cheaper to buy power directly from the latter, through self-consumption agreements. Smaller consumers, like most of the commercial and residential sectors, constantly complain about high power prices, even demonstrating in an organized fashion. Nevertheless, the link between privatization of generation and the possibility of lower fees and improved service is still not that clear. After all, the monopoly over distribution persists, and CFE still determines consumer prices pretty much regardless of cost, creating little incentive for energy efficiency.

1.4 What does All This have to do with the Environment?

Changes to the structure of the electricity sector are likely to have environmental implications. The whole energy sector has been, historically, among the most significant contributors to environmental degradation in Mexico pretty much since it started developing, without much regard to the environment, in response to a relatively rapid process of urbanization and industrialization. Even though environmental awareness has increased, and although the government and the energy industry itself have taken action to improve their environmental performance, energy production, transformation and consumption remain among the main causes of several environmental problems.

Relatively recently, and more evidently since the early 1970s, society's environmental awareness has gradually increased in Mexico, forcing some improvements. However, what has been probably more influential in fueling better environmental practice, at least in the case of industrial activities in Mexico, has been the improvement of technology, coupled with the increase in international trade and foreign investment. In 1994, with the signing of the North American Free Trade Agreement (NAFTA), Mexico was forced to put in place and enforce more stringent environmental regulations (Logsdon and Husted, 2000).

There is no doubt that the energy sector is now "greener" than it was in the past, even though it is still far from being sustainable. By most accounts, even if it was the cleanest it could be, some of its impacts would anyway be unavoidable, given the present "state of the art" of the technology, and considering the structure of the market, and particularly the relative prices of energy.

Still, there is room for optimism, since some of the environmental impacts of the energy sector, and possibly even the vast majority of the negative ones, still fall in the category of areas for potential improvement. In some cases, achieving these improvements depends on removing barriers, often political, that hinder the implementation of what would otherwise be technically and even economically feasible policies.

Among those negative impacts, besides the emission of greenhouse gases (GHG), the energy sector is a major contributor to local air pollution in several urban and industrial areas, and plays a major role as a source of other environmental problems, like water depletion and contamination, solid waste generation, and soil contamination, which affect both rural and urban areas. Electricity generation, in particular, is among the greatest contributors to atmospheric pollution. In Mexico, this sector is by far the most important source of sulfur dioxide (SO2) emissions, generating 68% of the total, and is also responsible for significant emissions of carbon dioxide (CO2), particulate matter of less than 10 microns in diameter (PM10), and nitrogen oxides (NOx), (see Table 1.1).

TABLE 1.1
CONTRIBUTION OF ELECTRICITY GENERATION TO AIR POLLUTION EMISSIONS IN MEXICO
(% OF TOTAL NATIONWIDE)

POLLUTANT	% CONTRIBUTION
SO_2	68
NOx	20
PM_{10}	24
CO_2	30

Source: Conzelmann et al., 2003; Miller and van Atten, 2004.

As the power sector expands, and more so as it is gradually being opened to private investment, it is possible that more environmentally sound technologies and practices could be adopted, although probably more so if environmental policy pushes in that direction. Through my research, I aim to, first, find evidence about what difference privatization does make to the environmental sustainability of the electric sector, and to then find ways for policymakers to use that information on behalf of more environmentally-friendly policies.

Strangely enough, environmental agencies have not assumed a uniform position regarding energy reform, and have not been very vocal either about what kind of reform they would prefer. This may be because of the lack of definitive evidence about its likely impacts on the environment. The Green Party has indicated that they are in favor of energy reform since they expect major improvement in the environmental performance of firms in the sector. Still, it is not at all clear that their expectations are realistic, since experiences in other countries where privatization and deregulation have occurred have left mixed environmental results.

In general, it has been observed that markets alone cannot promote the development of renewable technologies in the electricity sector because there are a series of barriers that prevent these technologies from competing evenly with more traditional generation technologies (Woolf and Biewals, 1998). And, energy efficiency and environmental practices beyond what is strictly required by law, may become a burden for companies competing in a free market, in which their final costs determine their behavior. In the same way, consumers have no way to require the firms they would prefer to buy from, to produce "greener" power.

Regulatory reform and privatization of the energy sector would increase competition, and, as I will argue in this dissertation, even though this may bring some environmental benefits with the deployment of new technology, it might also have adverse environmental effects in the long term, especially with the current cost structure of inputs, which makes fossil-fuel generation of electricity far more competitive than renewable energy, and especially as long as environmental controls are viewed as an additional cost in energy transformation. So, at the end of the day, even if the restructuring of the energy sector creates increasing competition, reducing heavy government involvement, and improving economic efficiency, there is good reason to be afraid that it may neglect the environment, and even endanger it as a result (Harris, 2002).

As a consequence, I argue that, as deregulation and privatization progress, a series of policies and incentives are necessary to promote the expansion of more sustainable energy technologies like renewable generation and energy efficiency. They are the only viable electric resources that do not emit GHG (Woolf and Biewals, 1998), and that may also reduce significantly the emission of other pollutants.

In general, the answer to the question of how much the fact that certain industries have opened to direct private investment has led to more sustainable practices, seems to be case-specific. In the particular case of the Mexican energy sector, it is widely believed that the fact that it is mostly a publicly-owned monopoly, has made it inefficient and led to bad environmental performance. If, by opening the sector to private participation it becomes more efficient, and if to achieve efficiency the sector adopts improved technology, it is possible that its environmental performance will improve. Whether it does so significantly, will probably depend on several additional factors, which environmental policymakers would benefit from knowing, to design public policies accordingly.

Summarizing, one of the fundamental hypotheses of my research is that private firms contributing to power generation have better environmental practices than public utilities, even if they use comparable technologies. I also suspect that the environmental performance of private power producers, which rely on foreign investment, varies significantly from one another, depending on the corporate strategies of their parent companies. Finally, on a more general note, I foresee that, if environmental policy does not force a move towards a more sustainable power generation, deregulation and privatization of the electricity sector in Mexico could lead, under current market conditions, to an electricity sector that relies almost completely on conventional fossil-fueled technologies. The main reasons for this are that they are still the most competitive in the market, and second, that there are several legal and institutional constraints on the development of alternative technologies.

The main question that I aim to answer in this dissertation is whether it would make a significant difference for the environment, currently and in the foreseeable future, whether the ownership of electricity generation in Mexico is public or private. A further question, having established this, is whether environmental policymakers can and should do something to force the electricity sector to become more sustainable, and, if so, which policies are most likely to help them achieve this end.

To answer the above questions, I have carried out research that is both descriptive and prescriptive, ultimately leading to policy proposals. From my understanding, these issues have not been sufficiently explored, and certainly not in the Mexican context. My intention is not to take a position regarding what the structure of the electricity market ought to be, but rather to present an analysis of the process by which environmental policy-makers might inform and influence the electricity reform process, so that it produces a more sustainable energy sector.

1.5 Environmental Policy and Electricity Generation

Trying to simplify the relationship between energy and the environment, for the case of air pollution, and in particular for the concentration of a fictitious pollutant named α, for instance, it could look something like the following equation (equation derived from Kursunoglu et al., 2001).

Factor : 1 2 3 4

$$\alpha_{conc} = \text{Population} \bullet \left[\frac{\text{energy}}{\text{person}}\right] \bullet \left[\frac{\alpha_{emit}}{\text{energy}}\right] \bullet \left[\frac{\alpha_{conc}}{\alpha_{emit}}\right]$$

In this equation, the first factor to consider is population, which, depending on the geographic scope one is interested in, could be, for instance, a country's, or the world's population. The second factor is the per capita rate of energy consumption. The third factor is the pollution intensity of the energy produced and consumed, which up to this point, if we eliminated the fourth factor of the equation, adds up to total a emissions. Finally, the fourth factor in the equation is the rate of α concentrations in the atmosphere caused by emissions. The multiplication of the four factors gives us the concentrations of α, which means, simply put, that changes occurring in any of these factors, in any direction, will lead to changes in a concentrations. Put in another way, policies that attempt to abate the concentrations of this pollutant and improve the environment can be achieved by altering any or all of the contributing factors.

The third factor in the above equation, which may be called the "pollution intensity of electricity generation," is the independent variable that this dissertation will discuss. I propose to analyze the dynamics (like increasing private ownership) that may affect this variable in the particular case of the evolving Mexican electricity generation structure. Also, I am interested in the policy interventions that could achieve desirable changes in this variable, resulting in environmental improvement. It is precisely this improvement that is my dependent variable, which in the case of the equation above is expressed as pollutant concentrations, but which could also be translated as well as "sustainability".

I begin by acknowledging that a major challenge for policymaking, throughout the process of deregulation and privatization of the electricity sector, is to find the right balance, ideally designing a new regime that takes advantage of the economic benefits of competition, without sacrificing the public purposes currently served by state-owned industry (Wiser et al, 2000), among which environmental protection should be fundamental. Environmental policymakers should promote this balance, at least in regard to the minimization of pollutant emissions and environmental degradation.

As I will discuss in more detail later on in this dissertation, the decision-making process within the environmental sector in Mexico has several internal limitations and is subject to multiple external pressures. In order to improve the outcomes of the environmental policymaking process, environmental agencies must improve their understanding of these issues. I expect, for the prescriptive component of my analysis, to derive some useful insights about how to achieve this.

1.6 Organization of this Dissertation

The structure of this dissertation obeys the following logic. With Chapter 1, which serves as the introduction, I have attempted to define the problem I will deal with, my motivation for selecting this problem, and my research questions and hypotheses, which derive from the empirical and theoretical evidence I have studied. I the move on to the definition of my research design, which I present in Chapter 2. Next, in Chapter 3, I discuss the theoretical basis for my dissertation, which derives from a review of the literature most closely related to my research topic. From there, I move to the development of an electricity sector profile for Mexico, which I present in Chapter 4. After this, I offer several case studies which I explore in two chapters. First, in Chapter 5, I present evidence about the environmental performance of several power plants in Mexico, and then in Chapter 6, I develop a crosscutting analysis, to elucidate whether private or public ownership appears to make a difference in the environmental performance in the cases I have looked at, and whether there may be other factors to consider for environmental policymaking. After this, I look briefly at some general ideas that sketch a policy path towards a more sustainable power sector, which I present in Chapter 7. In this chapter, I also attempt to foresee what particular "future" environmental policymakers should aim to achieve. To conclude, I summarize my main findings and the lessons I have derived from my research, particularly stressing those that may be relevant for policymaking.

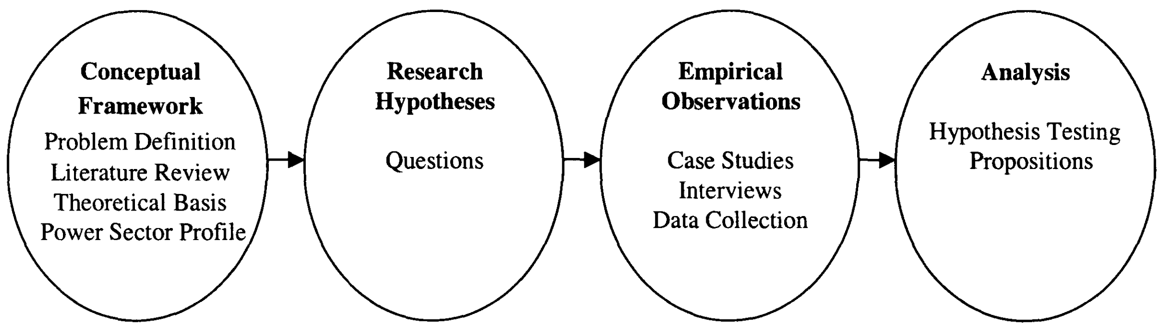
2. RESEARCH DESIGN

On the scope of my research, to begin with, it may be pertinent to clarify that, although the energy sector in Mexico comprises several producers of energy and related industries, all mainly evolving around the oil and electricity industries, and even though regulatory reform is currently being discussed for the whole energy sector, and privatization is moving on throughout the whole sector as well, the analysis that I will carry out will center on stationary sources of pollution within the power generation portion of the electricity sector exclusively, and mostly on their contribution to greenhouse gas and air pollutant emissions.

As for the research methods that I will use, given the eminently social and political nature of my research topic, and its focus on very particular events, I will include mostly qualitative methods, and particularly a case study approach, to answer my research questions. At a lesser extent, I will also use quantitative approaches, but only when they are feasible and appropriate within the analysis of my case studies.

The steps that I have included in my research design (see Figure 2.1) consist of four major components, which I will attempt to develop sequentially, as research steps. The first, is a component which aims at the development of the conceptual framework on which my research builds upon. This framework includes the introduction to my problem of interest, the review of the most relevant literature relating to it, and the preparation of a profile of the Mexican electricity sector, to ground my research in a particular situation, as it is my intention to do. After this step, the next one is the development of my research hypotheses, which derive at a large extent from the concepts and ideas analyzed in the conceptual framework that precedes this step. The third component is the incorporation of empirical observations, which I have performed through a case study, through a series of interviews that I had with some of the experts on the field and some relevant stakeholders, and through data collection. Finally, the last major component of my research design is the analysis of my empirical observations, with which I expect to test my hypotheses, and to also attempt to develop propositions that may be useful for policymaking.

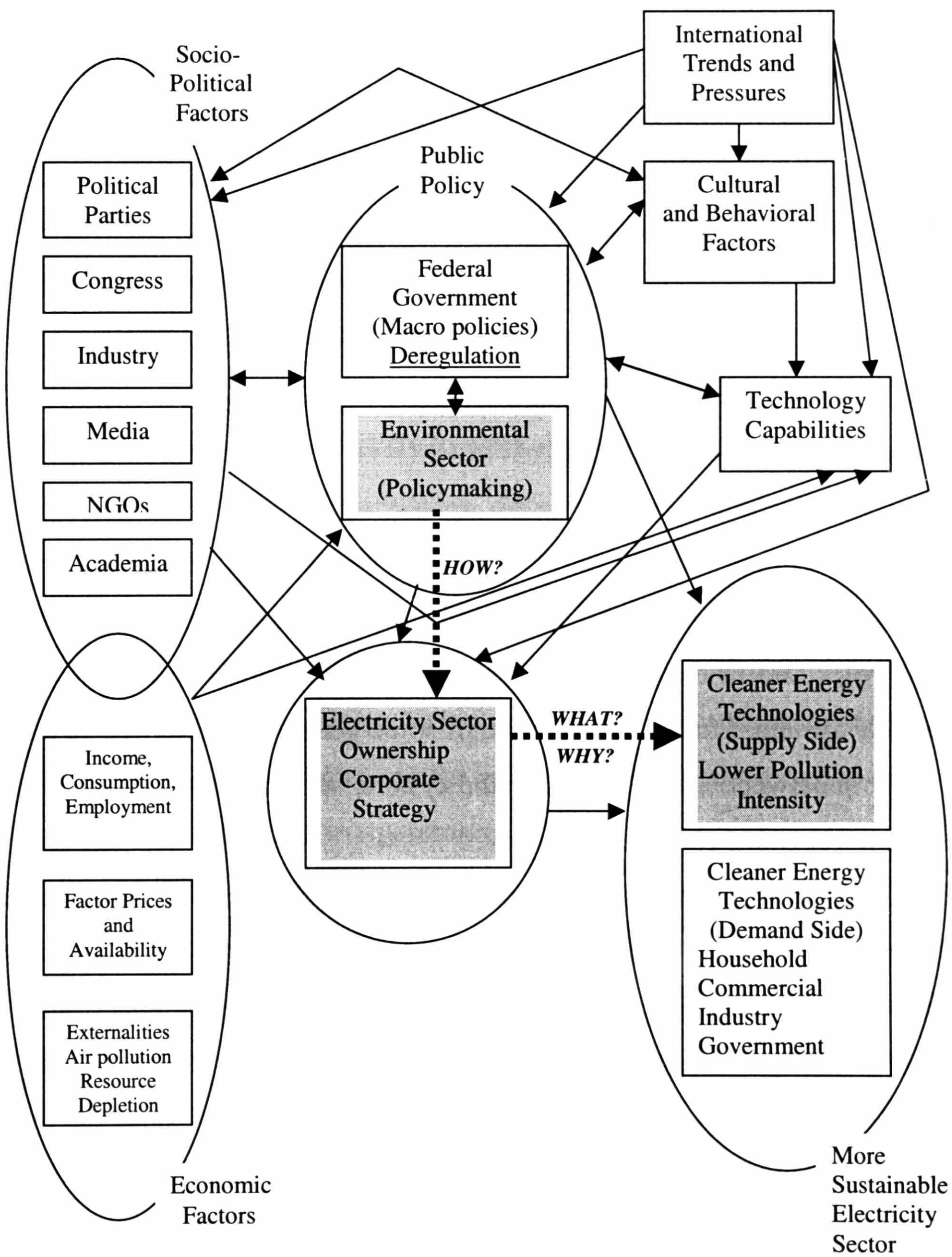
FIGURE 2.1
RESEARCH COMPONENTS



The questions that I will attempt to answer with my research are of diverse nature. First and foremost, I am fundamentally trying to prove whether there is a link between an independent variable, the privatization of electricity generation in Mexico, and a dependent variable, which is the degree of sustainability of the sector, which could be measured in several ways, for instance by comparing environmental practices, or by assessing pollutant emission intensities across firms. This is eminently a "what" and "why" type of question. Besides, I am also concerned about a series of "how" questions, since I will attempt to move my research further from the descriptive analysis, to a more prescriptive mood, in which I will try to define if and how environmental policymakers can intervene in the power sector to make it more sustainable, in light both of the answer I get to my first question, and of the interactions between my two variables of concern and several other factors around them.

My variables of interest are part of a complex system, represented in Figure 2.1. Several factors are included in this figure, as they might all affect to some extent the possibility of achieving a more sustainable electricity sector in Mexico, whether there is a reform of the sector or not. In this diagram, which illustrates my analysis framework, I have grouped these factors, whenever there is an evident categorization of them, for instance as sociopolitical, or economic factors. In other cases, some factors are left as individual phenomena, like cultural and behavioral factors, and technological capabilities. Most of them are, in any case, interlinked, and often strongly.

FIGURE 2.2
ANALYSIS FRAMEWORK



All the factors included in this framework, and all the links among them, are relevant and interesting for my research, although the main focus of my analysis lies on three components of this system, which are highlighted as shadowed boxes in the diagram. The central one among them, at the lower-center part of Figure 2.1, is the *electricity sector* sphere, and particularly the sector's structure. This element is linked, to the right, through a dotted line that represents my "what" and "why" questions, to a sphere which I called a *more sustainable electricity sector*, within which I am most interested about cleaner technologies, including environmental practices, and also about pollution intensities. There is also a dotted arrow coming from the top towards the electricity sector sphere. This arrow represents my "how" questions, linking *environmental policymaking* to the electricity sector.

The answers to my "what" and "why" questions will come first, sequentially, and they will be in the form of postulates. The answers to my "how" questions, coming afterwards, will be in the form of policy proposals.

There are, in all, so many factors interacting with the variables I am dealing with, that it would be difficult to isolate them, and to establish causation. These variables are, as I attempted to illustrate in the diagram above (Figure 2.2), immersed in a very complex socio-technical system. Furthermore, although some generalizations may be possible, the interrelationship between all the factors in the system varies from case to case.

These facts, and the nature of my questions, make my research propitious for a case study approach, which, as stated, is central in my research design. But before getting into it, I have also included a couple of steps that will serve to put my questions in context, both theoretically and pragmatically. Then come my case studies, and their analysis, followed by a further step in my research, in which I develop some projections for the future of the power sector, to then derive some general ideas for policy design and implementation. I describe what I attempt to achieve with each of these research steps next.

2.1 First Steps: The Setting

There are two steps in the first part of my research. The first one is the review of the theory that is more relevant for my analysis, and the second one is the development of a profile of the Mexican electricity sector. I will briefly describe what I attempt to achieve with these two steps next.

Regarding the first step, the main objective of the review of the literature that constitutes the theoretical basis of my research, is to support or discard already conceived hypothesis about my topic that I may have had, and to build new ones as well. A second objective of my literature review is to look at where my research fits within the existing literature. As the title of the literature review chapter states (Chapter 3), the review of existing theory serves as the basis on which to build upon, to try to expand or refine knowledge already established or currently being developed in the fields that my research touches upon. It serves also to guide my research work, and particularly to establish the research methods that would be appropriate and most likely to work out well.

As part of this theoretical basis, I have included the literature of several fields, but have attempted not to be very extensive, especially since there is a broad body of works that could be considered relevant and related to my topic. I looked primarily at the antecedents and main theories relating to my problem of study, which basically evolves around the coexistence of the market and the public sector, focusing on the most relevant findings that may be of relevance to my research.

Basically, what I did for my theoretical chapter, was to research the relevant literature on public regulation, regulatory reform, sustainability, and policymaking and implementation. In order to present some of the main findings in the literature for the purposes of my analysis, I divided the chapter into six sections. On the first section, I discuss market failures and the rationale for public regulation, and, in general, for public sector intervention in markets. After this, I look specifically at the issue of policy failure, which may often have as bad, or even worse consequences than the lack of policy intervention. Next, I discuss some of the most relevant literature on policymaking and implementation, since an important component of my research is, at the end of the day, determining how these processes can be used more effectively to produce a more environmentally sound electricity sector in Mexico. Then, I explore some of the most relevant literature on globalization and regulatory reform, as these are processes from which deregulation and privatization have often resulted. Then, in the following section, I look at the issue of sustainability, particularly as it applies to energy systems and their link to the environment. Finally, to conclude the chapter, I attempt to establish the relevance of my research, according to how it fits within the existing literature, and to how it may help understand and solve a practical problem.

The next step of my research is the development of a profile of the Mexican electricity sector. I included in it an analysis of the market structure of the sector, looking both at its supply and demand sides. I also looked briefly at its history, technological profile, and legal and institutional framework, paying particular attention to the characteristics of the sector that may be relevant for environmental policymakers, or that may be affected if and when a regulatory reform of the electricity sector is in place.

My intention when developing this analysis, was to achieve a better understanding of the electricity sector in Mexico, and to further establish the basis for the analysis to be carried out later on. To develop the Mexican electricity sector profile, I start by looking at some of its history, its market structure (including both the supply and demand sides of the market), its technological characterization, its related institutional and legal frameworks, and its role in the emission of atmospheric pollutants, and particularly of greenhouse gases. I also looked separately, in the last section of the chapter where I present the profile of the electricity sector (Chapter 4), at private power producers, to begin establishing their relevance in the market.

2.2 Case Study Approach: Comparative Analysis

For my case study, I have selected a series of what I believe are interesting cases of power plants around Mexico, to try to compare the environmental impacts of public vs. private ownership structures in the sector, and to then attempt to evaluate as well if differences in the environmental practices among the plants that I have looked at, may also have something to do with the technologies implemented in those plants, or with the corporate strategies of the firms that own them, among other factors. My analysis of the case studies has been comparative, in two directions. First, I have attempted to compare different ownership structures and corporate strategies, looking at cases with similar technology and scale. Second, I have also attempted to analyze cases of different technology, to try to establish the impacts of technology improvement, and, further in my dissertation, to look for the policy lessons that may be the most relevant for achieving these improvements.

I have included six cases. Three of them are of privately owned plants, which have very similar technology and scale, although they belong to different corporations. My intention when analyzing these cases, is to assess their approach to the environment, which may vary according to their corporate strategies, funding mechanisms and agencies, or country of origin of their main investors, among other factors. The three other cases that I looked at, are of publicly-owned plants, which have very different technology and scale among themselves. Across these cases, I expect that it would be possible to compare technologies, and to establish how much the technological factor may determine the environmental performance of power production. The crosscutting analysis among the six cases, centers on comparing the group of private vs. the group of public plants, even though among the public plants that I included, there is only one with similar technology and roughly the same size of the private ones that I looked at. Still, as I will explain with more detail in Chapter 6, the crosscutting analysis turns out results that are relevant for policymaking, especially as they are complemented with the ideas and assessments about my problem of interest that I got directly from my interviewees in Mexico.

The number of cases that I have included is small, but I expect it to be sufficient to derive abundant and conclusive evidence. The cases I selected, attempt to represent the spectrum of technologies in operation in Mexico, from the traditional to the most innovative, from the dirtiest to the cleanest, and to cover also the most significant producers in the sector, particularly on the private side. In each of the cases analyzed, I have included a brief description of the plants I looked at, their technology, and their operative structure, to then get into more detail about their environmental practices and impacts. For the crosscutting analysis, I included, besides the information presented on the cases themselves, aggregate data for the whole or parts of the sector, as it was deemed relevant, as well as a lot of information that came from the interviews I had with different stakeholders.

To assess, quantitatively, the difference in environmental performance among plants, I have mostly relied on air pollutant emissions, and on emission intensity per production unit, as a proxy of the sustainability of different plants, although I have also included in the analysis several other, more qualitative indicators of environmental performance and social responsibility.

Relevant in my case study analysis, especially to move on to the following steps in my research, is finding out whether any changes occurring in power generation, have taken place as a consequence of environmental policy, as well as what the environmental consequences of these changes have been. Another relevant issue in this part of the analysis is whether policy has attempted at all to induce change towards more sustainable practices and technologies, and whether it has succeeded or not, and why.

2.3 Last Step: The Link to Policymaking

From the case study analysis, I move to develop some projections for the electricity sector, extending over a time span of 25 years. This analysis is useful for foreseeing the energy needs of Mexico in the future, to try to start thinking about the likely impacts of alternative environmental policies, and to start defining the principles to consider for drawing a policy path for environmental policymaking.

I divide this analysis into four components. The first one is the definition of a projection for the power sector, for which I consider socioeconomic and demographic variables. The second one is the characterization of a "future" in which environmental policy goals are achieved. These goals, for the particular case of my research, can be summarized as a "more sustainable power sector", which I would define as one that implements better environmental management practices and produces less adverse environmental impacts than the current one. Then, the third component of this part of the analysis, has to do with ideas to consider when looking for ways for getting from the current state of affairs, to that future that policymakers have imagined. Finally, I included a few specific policies that I suggest as steps for moving on in the policy path that I am discussing.

As part of my analysis, I have analyzed also the role of stakeholders to achieve policy success. This is helpful not only to understand what lies beneath the process of restructuring of the electricity sector in Mexico, and what we could expect according to the balance of power among different decision-makers and stakeholders, but also, and more importantly within the scope of my research, to start assessing the political feasibility of policy strategies that may result from my analysis.

2.4 Validity of Research

Through my research, I intend to advance knowledge related to the design and implementation of environmental policy that may induce more sustainable practices and technologies, in the particular case of the Mexican energy sector. The topic has been explored before, although, to the best of my knowledge, not for the particular case that I am looking at, and not with the approach that I will follow throughout this dissertation. I expect that the findings I reach with my analysis could be generalized to other technology systems and to other developing countries. I also hope that the study that I will carry out contributes as well to improve policy outcomes, in practice, within environmental agencies in Mexico.

The variables that I have included in my analysis, have resulted from the empirical and the theoretical explorations that it is based upon. The analysis methods that I have chosen would provide good indications for policy analysis and further for policymaking, although they sure have several limitations. In any case, I made sure to spell out the assumptions upon which all the results that I present are based, first, so that the analysis can be replicated, but also to convey a sense about the sensitivities of the analyses carried out in this study, and the reservations with which to take the outcomes that have resulted.

3. THE MARKET AND THE PUBLIC SECTOR: THEORETICAL BASIS OF RESEARCH

My research builds upon several bodies of literature. Among them, the first is the literature on market failure, especially since often, failures of the market are a major reason to justify public intervention in them, most commonly through regulation. I then look particularly at the literature on environmental externalities, which are a set of market failures which are very relevant for my research. I also review some literature that has explored the policy responses to correct or mitigate these externalities, and particularly the literature on policy implementation and policy failure. Moving to more specific grounds, I attempt to develop a brief critical review of the literature that has explored the recent trends of globalization, which is relevant to my research, specifically, since it has often implied limiting the role of the state in the economy, commonly through deregulation or privatization. After this, I look at the topic of sustainability, trying to define concepts around it that may be applicable to my research field. Finally, I try to assess the relevance of my research, both as a contribution to the existing literature, and as a useful insight to understand a problem of the real world as well.

3.1 The Rationale for Public Intervention in Markets: Correcting Market Failures

One of the most commonly argued reasons to justify public intervention in markets, is to correct market failures. Economic agents perform several exchanges or transactions among themselves, for reasons of mutual advantage, but these exchanges are often not efficient, due to the failures in the markets where they take place. As a result of these failures, these exchanges often end up affecting other actors who may not even have voluntarily participated in them (Wade, 1973).

The failures of the market call for the intervention of the public sector, which imposes restrictions on, or establishes rules to the exchanges that take place in the market, limiting in some sense the free will and sovereignty of political and social actors (Baumol, 1965). The public sector has several alternative public policy tools at hand to correct market failures, depending on the type and source of the market failure that arises.

In general, there have been three main sources of market failure identified: the first one is due to asymmetric information, the second to monopoly power, and the third to externalities (Armstrong et al, 1994). The effectiveness of public regulations of some sort or another would vary depending on the source of the market failure that the government deals with. When there are market failures deriving from imperfect information, for instance as in the case of consumers buying technically sophisticated goods, like vehicles, or services, like medical attention, governments usually intervene via standards, to make sure that these goods and services comply with minimum performance conditions, or, if they fail to do so, to make sure that some form of compensation is in place. In the case of markets failing due to the exercise of some degree of monopoly power, which would commonly lead to firms with high market power to set prices at levels above marginal cost, the public sector has two alternative ways of intervention. They could either regulate via price setting, or they could "create" the conditions to increase competitiveness in the market, for instance giving incentives to new firms to enter. In the case of externalities, which are external costs or benefits that a firm transfers to society without any compensation or payback, the public sector has several alternative options to go about correcting market failures. They could either impose some sort of direct regulation, or they could design and put in place some modality of market-based instrument, with the intention of *internalizing* the externality, which means forcing the party that generates external costs to absorb them internally, or, if they fail to do so, to compensate affected parties.

Several economic theorists have addressed the problem of market failures and particularly the problem of the transfer of externalities. Their approach has commonly been analytical, looking at these issues descriptively, even though they have often also prescribed solutions to them.

The first seminal work on the topic was published as early as in the 1920's, by Arthur Pigou (1920), who supported government intervention to correct market failures and to achieve a socially optimal level of pollution. His solution was that the government imposed a tax on polluters (which could also take the form of a subsidy for abatement), based on marginal damage or abatement costs. With this tax in place, polluters would, theoretically, move automatically to a socially optimal level of production and pollution. This solution is known as the Pigouvian tax, and although it has been attempted in practice, it is mostly ineffective, due to insufficient knowledge about damage (Baumol and Oates, 1979). Still, the Pigouvian tax was considered, for decades, as the only solution to solve the bad allocation of costs caused by externalities.

Later on, already in the 1960, when, coincidentally, environmental problems began attracting the attention of the media and the general population, Ronald Coase (1960) introduced a new factor in the analysis and search for solutions related to the issue of externalities. The new factor he brought to the theoretical discussion was property rights, which is very relevant in the case of environmental externalities. For Coase, it is not necessarily the case, as it was implicitly assumed in the Pigouvian tax, that the *pollutees* are the ones who have the right to a clean environment, and that polluters should compensate them for messing with it. He argued that, initially, both polluter and *pollutee* have the same right over their common environment, so, in principle, anyone of them could purchase some of the rights of the other. He suggested that a bargaining between polluter and *pollutee* might be sufficient for reaching a social optimum level of pollution, since both polluters and victims of environmental degradation are assumed to negotiate about the optimal level of environmental degradation and economic activity producing it, theoretically on the basis of their marginal damage costs and abatement costs. This approach, if practicable, would make government intervention unnecessary in the reaching of a solution for the externality problem.

The question is whether Coase's solution is realistic in practice. The answer, in most cases, is no. To begin with, there is the issue of who defines property rights, for instance over environmental assets that do not have a market, or over *the commons*, which by definition belong to all (or to no one in particular) in a society. Another issue is whether the parties who would participate in the bargaining behave rationally, which would be a condition, in practice not always observed, for reaching a social optimal. Another issue is who could represent both involved parties: polluters and *pollutees*, in a bargaining, when these groups, and particularly the latter, can be too large to be even identified, let alone represented. Also, there is the fact that there would be transaction costs deriving from information, bargaining, monitoring and enforcement of an agreement, which would create additional costs which are not clearly the responsibility of either part taking place in the bargaining, which may also require capacities that most often neither one of them has. And finally, a further barrier for creating the conditions for reaching a bargaining between polluter and *pollutees* without public intervention, lies in that that the creation of markets for some environmental goods, often requires a process longer than that of their depletion, and also on the fact that most economic activities have traditionally developed parting from the assumption that the right to use the environment belongs to the polluter, and that the *pollutees* are the ones who must pay if they want to buy some of these rights. Not that these conditions could not change, only that in most cases they would, but only if governments intervene to make this change happen. And even for market-based policies, which by definition imply less regulation, the role of government agencies is still crucial for their operation.

There are also some particular instances in which, besides correcting market failures, there are other justifications for public intervention in markets. One such justification, particularly relevant in a country with the social disparities and contrasts of Mexico, for instance, derives from the need of achieving social justice, which markets, if left alone to operate, could often fail to achieve (Lindblom, 2001). And there is also an efficiency argument for justifying public intervention to abate pollution, which is also frequently found in the theoretical literature (Baumol and Oates, 1979; Tietenberg, 1988), although there is no consensus on it being enough justification to intervene in the free market. According to Coase (1960), for instance, there is no efficiency reason for a government to be involved, except to enforce property rights. In any case, and whatever the reason, when environmental resources are involved in, or affected by economic transactions, markets are often found to fail when left on their own, and even those economists who are the firmest advocates of the free market, like Dornbusch (2000), see abundant reasons to justify public intervention in it.

In what refers to market failures that have environmental consequences, they appear mainly for two reasons. First, because many marketed goods may have prices reflecting private costs of production, but not their social cost. In this case, there are many ways of intervention to ensure that social prices are charged, among them through regulations via standards, pollution taxes, or other form of market-based instruments of environmental policy. Second, because many environmental goods and services have no markets at all, so intervention is required to establish prices for them. Assigning property rights to the "free resource" is one way in which this can be accomplished, although this intervention, by itself, may not guarantee full social cost pricing (Eröcal, 1991), because even if rights are assigned, other market failures may persist.

Pollutant emissions may be a good example of a negative externality, since they impose harmful effects and costs on people other than the polluter and also because, in general, the free market does not induce the polluter to reduce the damage caused by the emissions she generates, since the costs associated to these emissions are easily transferred to others, commonly external agents, to whom I have earlier on referred to as *pollutees*. The market, if left to itself, is consequently often not the most effective mechanism for keeping pollution at reasonable levels (Eskeland and Jimenez, 1992).

Even though some scholars argue that pollution is, pretty much, an unavoidable externality (Ayres and Kneese, 1969), since, by the mere laws of physics, almost any process that transforms inputs into outputs has a waste stream associated, there are at least two things which can be done about this externality, if eliminating it completely is in most cases out of the question. It could be minimized, through technological improvements and behavioral changes that reduce the waste stream of production or consumption processes, be it by reducing the demand for the outcomes of these processes, by substituting them for "cleaner " ones, or by improving the efficiency with which inputs are transformed into outputs and end-products consumed. And a second solution is not to minimize the environmental externality or to try to avoid it, but to compensate for its effects, through what is commonly referred to, mainly by economists, as the *internalization* of externalities. In which refers to environmental degradation, I would argue to do as much as technically and economically possible to minimize externalities, since compensation would probably still cause environmental degradation.

In all, as I have discussed so far, public intervention is needed and amply justified, due to the failures of the market, and to the imbalances between polluters and their victims. But, just like the free market, public intervention may also have deficiencies, some of which I will address next, that it is worthwhile being aware of.

3.2 On Policy Failure: When the Cure is Worse than the Disease

As it is true that markets fail, obligating the intervention of the public sector, it is also true that the policies and regulations that commonly result from this public intervention, may also have some shortcomings, which scholars in the field of public policy commonly refer to as regulation (or policy, more generally) failure. This failure can arise because of several reasons. To begin with, there is the fact that regulatory agencies are often bureaucratic organizations, with administrative structures and processes that are often costly and inefficient, so their actions lead to equally inefficient and ineffective interventions (Dornbusch, 2000). Besides, compliance with regulations is also often expensive by itself for regulated agents and, as some of the critics of public intervention in markets argue, in many cases with very little being obtained in return (Breyer1982). Some also argue that the regulatory process is in most cases not democratic or, to say the least, not fair, as it is carried out by not-elected officials in executive areas of the public administration, commonly with little input from affected or interested stakeholders (de Leon and de Leon, 2002). As a consequence, the implementation of the resulting regulations is not successful, due to lack of support from the regulated parties.

Even if it is justified that the government interferes in markets when market failures arise, it is also true that the government has to be very careful to ensure that its mediation leads to improved allocation outcomes over those of the free market, which means that the net social benefits of government intervention are positive. Otherwise, government failure can have very adverse consequences, whether it is the result of inappropriate actions, willful or unforeseen, or due to lack of intercession or deficiency to correct existing market failures (OECD, 1991). To put it in other words, policy failure occurs when there is no implementation at all, or when implementation is unsuccessful, failing to produce the desired outcomes. In the latter case, the gap between what was intended and what actually occurs might go anywhere from very narrow to very wide. And it should be understood that even if the outcome of a policy is positive, if it differs from what was intended, even for the better, then that policy could be deemed as failed. Even though the latter is probably not the most common case, and not one that the "affected" parties would have a problem with, it is still worth mentioning anyway, at least to clarify the concept.

In the case of intervention failure, internal and external market deficiencies may be the result. In the case of lack of intervention, existing market failures may grow deeper when the end result of political and administrative processes is that prices are leading away from the social optimum, for reasons entrenched in the institutional system (Eröcal, 1991). Frequently, government failures may even manifests in a different sector from that to which the relevant policy is targeted, for example, when a policy that is implemented to increase cattle population, unintentionally causes deforestation.

Regarding the factors that may explain policy failure, the issue of how and why policies change when translated from intent into practice, has been analyzed extensively in the field of public policy. And there are several case studies which provide empirical evidence that suggests reasons why this may happen, and which serve as the basis to attempt theory building, even though the construction of theoretical frameworks on the issue is still limited.

Still there is, nevertheless, enough in the literature to suggests what barriers may hinder policy success under particular circumstances, so a prediction of what may get on the way of successful implementation of a particular environmental policy in a country like Mexico, for instance, may be possible, through a critical analysis of the relevant theoretical background, even though there may be particularities in the policy context of the country which the theory gives few elements to predict.

At its current state, the literature on public policy focuses, mostly, on the processes by which policies are designed and implemented. Some of it is general, but there are also subsets of it that look in depth at the different stages of the policy making process. One such subset, which is probably the most relevant for this dissertation, looks specifically at the issue of the implementation of policy, analyzing and trying to theorize about the factors that may determine policy success or failure in practice.

The main focus of the literature on policy failure seems to center on the implementation stage of a policy, and less often on its design stage. The presumption is, I assume, that policies fail mostly due to limitations in the process of policy implementation, whose outcomes may be determined by the interrelation among several factors, both internal and external. Little has been explored about the failure of policies as a result of the mere shortsightedness of policy makers. I suppose that this happens because this last case is of little interest for theoretical exploration, and also because not much can be done against it in practice.

The whole study of implementation tends to lean towards empirical analyses, and its focus is most often on specific government programs, after getting "locked in a dead end in theory development" (de Leon and de Leon, 2002). Still, the one thing that seems clear, in lack of sufficient theory to sustains the analysis of implementation (and its failure, for that matter), is that it is a highly contingent phenomenon. This being the case, the understanding of policy success (or lack of it) relies greatly on case studies, from which it is possible to derive generally applicable observations.

3.3 Policy Implementation: A Crucial Stage in the Policy Making Process

There are several approaches to the study of policy making. One approach focuses on the stages of the policy making process, sometimes positively, sometimes normatively. Another looks at the institutions and organizations involved in policy making, sometimes focusing on the characteristics of the institutions involved and, in other cases, on the interactions among them. A third approach looks at the actors involved in policy making, including those outside the formal policy making institutions, to focus on their interactions. The final approach, more empirical than the others, looks at policy making through specific lenses, to try to learn from case studies, assuming that policy areas differ, and assuming that a lot of what determines policy making depends on the singularities of each case.

With many diverging theories on public policy, at least there seems to be consensus on the fact that policy making is a process (Gerston, 1997), and it is also commonly accepted that one of its stages is policy implementation. Points of entry to the public policy process, among its several stages, though, are not always straightforward, nor are its ending points. Contrary to common sense, some authors, for instance, would argue that the outcomes of the policy process, in the form of policies implemented (or not), would often shape policy design probably more than policy design shapes its own outcomes (Majone and Wildavsky, 1978). Something similar we would observe if we look, for instance, at the evaluation stage, which lies further down in the policy process. Evaluation, although it can be thought of as a consequence of policy design and implementation, has also implications on these earlier (thinking of a sequential process) stages, being often particularly difficult to separate from the implementation stage. To give an illustration, if a policy maker wishes to improve the chances of a positive policy evaluation, and with that, maybe of a good perception among her constituency, she may focus special attention to the implementation feasibility of policies, possibly even sacrificing more ambitious policies whose success is not guaranteed. In this case, the design of policy would be very much determined by subsequent stages of the policy process, even before any iteration between them occurs.

In general, there is often a very close interrelation between the different stages of the policy making process, so the line between them, commonly made in scholarly literature, is difficult to draw in practice. On top of that, several of the actors that take part in the policy process are commonly involved in more than one stage of it (Lindblom, 1980), making the separation of stages difficult in practice as well as in theory.

There is, in any case, a body of literature that focuses on implementation, even though, as we could expect, given, among other, the points I made earlier, it often crosses the line into other stages of the policy process. Among the most valuable works in the implementation literature, I would highlight Pressman and Wildavsky's *Implementation* (1973), Bardach's *The Implementation Game* (1977), Mazmanian and Sabatier's *Implementation and Public Policy* (1989), and de Leon and de Leon's *What Ever Happened to Policy Implementation? An Alternative Approach* (2002), which is a relatively recent work that presents a novel approach to the implementation issue.

Even though the field was defined already in the 1950's, its related literature was very scarce for a couple of decades. The first wave of studies on implementation only came about the 1970s, with a series of works now known as the "first generation" of implementation studies (de Leon and de Leon, 2002), which are mostly case study analyses. These studies illustrated several of the complexities involved in moving from policy to implementation (several of which could be generalized and serve for theory building), and view the problem of achieving successful implementation as a results of several factors, among which the contention between actors with opposing stakes is important, but not in all cases as central as it was previously assumed, being it only one among several other elements that may be determinant for policy success. At that time, and especially during the mid to late 1970s, interest in the issue increased tremendously, as several implementation problems became evident, that policy researches got so heavily concentrated on questions of policy implementation, that other phases of the policy process were practically excluded from any research efforts (de Leon, 1988). Not coincidentally, several of the most significant contributions to the implementation literature are from around this time. Among the works of this first generation of implementation studies, two that stand out are the Oakland case, analyzed by Presman and Wildavsky (1973), and Bardach's look at the 1960s mental health reform in California, from which he constructed a conceptual framework. In both studies, their authors look at the implementation problem as a dynamic issue, and as a complex process. Next, I give a brief analysis of these studies, focusing on their findings regarding possible barriers to policy implementation.

In what is perhaps the seminal study on policy failure, Pressman and Wildavsky (1973) analyze how and why the actual consequences of a policy put in place departed from what was intended. Their analysis begins by presenting a case study of a national public policy designed to create jobs for minorities, which was put to test in Oakland in the second half of the 1960s, at a time when the country was at war, and when several cities had high unemployment rates and suffered from racial tensions. The program analyzed was some sort of social experiment, by which the federal government transferred public funds to local infrastructure projects, developed by the business sector, expecting that these would generate jobs, and that these jobs would go mostly to racial minorities.

That the implementation of this program was not successful became obvious when it was evaluated, four years after its initiation, and results showed that a few jobs had been created, at an extremely high investment for the government. Although some viewed some signs of success, given the alliances between minorities, businesses and the government that resulted from the program, most viewed it as a complete failure. As to the reasons why the program failed, Pressman and Wildavsky argue in their detailed account that, fundamentally, failures were due to a "mismatch between means and ends", which speaks of failures in implementation, but on policy design as well. Their analysis points, specifically, at administrative antagonisms, institutional fragmentation, contradictory legislation, multiple and confusing goals, and lack of concrete action definition for involved stakeholders, between the many reasons that came on the way of successful implementation.

In the background of the whole story, there seems to lie the fact that the responsible agency failed to predict and prepare for the complexity of the program they were in charge of, or, using the authors' own words, of understanding and dealing with "the complexity of joint action". A question that I would derive from this analysis is that of whether policies fail because of poor implementation, or if it is their design that fails, given that at the design stage of a policy, its implementation limitations could have been predicted, and ideally maybe even offset.

In another case study centered in California, but in the late 1960s and early 1970s, Bardach (1977) builds on the work of Pressman and Wildavsky, when he deals with the disconnect between policy and implementation, concerned about the several policy failures documented throughout the 1960s. The particular case analyzed in his book, is the implementation of a mental health system reform in California, which happened via the implementation of an Act intended to restore the civil liberties of persons deemed as mentally ill, and to transfer their care from state mental institutions to community-based care establishments. The success of the reform is arguable, but Bardach still derived several insights from its implementation process, mostly by analyzing the political process that took place around it. In fact, even though he observes that "the character and degree of many implementation problems are inherently unpredictable", he still derives a conceptual framework of the implementation process.

Implementation, though itself a stage of the larger policy process, is, Bardach argues, also on itself a process, which assembles several elements and in which several parties, that are in great part interrelated, intervene. The interrelation of these parties is, according to Bardach, of political nature. Actors interplay in the implementation process in a series of "games", which is a term to be understood as bargaining, persuasion or some sort of negotiation by which actors exercise their "control" or power, over other elements involved in the policy to be implemented.

Bardach characterizes four "games" that interfere with successful implementation: (1)"the diversion of resources", mostly in the form of an inadequate allocation of money; (2)"the deflection of policy goals stipulated in the original mandate", which may be due to several reasons, among them the lack of consensus in the policy design stage, or the interference of unforeseen political interests; (3)"resistance to (...) efforts to control behavior administratively", which may come from several social actors that often attempt to resist what they may see as excessive public interference in their lives or businesses; and (4) "the dissipation of personal and political energies in game-playing", which results from actors spending too much time and energy trying to avoid responsibility, defending themselves from other actors, or creating advantageous conditions for their own "game playing", which results in that they are left with little impetus to comply with public mandates adequately.

A "second generation" of policy implementation studies, which, mostly in works published in the 1980s, attempted to move from case studies to more formal theory building, includes works of several authors who, based on empirical observations, tried to build models to move policy proposals into action. Among these authors, some emphasize the role of administrators, or bureaucrats, in the success of policies, while others, with a contending view, assume a "command-and-control" orientation (de Leon and de Leon, 2002), putting in the existence of effective leadership much of the responsibility over successful implementation.

With the latter view, the work of Mazamian and Sabatier (1983) stands out as a classic in the implementation field. These authors offer a prescriptive model for implementing policy, which derives from empirical observations, and which includes a wide range of factors that may be considered for implementation to succeed. Their intention, as they state, is to build a framework that is useful to both social scientists and practitioners. Central to their framework are three issues: (1) the degree of manageability of the problem being dealt with, or, as they call it, its "tractability", which varies greatly in practice, with some problems being simpler than others; (2) the ability of the policy response to this problem to structure implementation, which could be done, for instance, through the design of implementation mechanisms, the definition of involved actors, or the provision of resources, among several other provisions; and (3) the effect of external political variables, for instance socioeconomic conditions, public support, and the commitment and capacity of implementing officials. I can see in this theory several suggestions that may be useful for analyzing public policy in practice, but would not discard the role of the implementers of policies, and their available capacity, willingness, resources and commitment, as significant factors in policy implementation. I do not think it is a matter of necessarily leaning towards a top-down or a bottom-up approach, since I suspect that the causes for policy failure come from both ways, being one or the other more relevant depending on the particular policy analyzed.

This leads me to talk a little about later works on the field, published from the 1990s onwards, which could be categorized as part of a third generation of implementation studies, and that, although they are more difficult to categorize, at least at this point, since no particular trend is observable, could be said to be, in general, contingent. The focus on the implementation literature of these years is, initially, on understanding why the actors involved in policy implementation behave the way they do, moving in more recent years, after little theory development, to contingency theories, whose premise is that there is no best way to implement policy, but that the "appropriate" strategy depends on its context (de Leon and de Leon, 2002).

Among these recent works, I would highlight the work of de Leon and de Leon (2002), which introduces a participatory approach to solve the implementation problem. Their main argument is that bottom-up policy implementation would reflect community interests, whereas, they argue, top-down directives often lack it. Besides, they say, it would be more "realistic and practical" to have a participatory approach to policy implementation. Still, even if we agree on that, the main issue is how to make the policy process effective and expedite if it becomes *democratized*, which may be even more of an issue in most of the developing world, where resources are limited, and the "participatory culture" is a new thing, if and when it exists at all.

Some would even argue that a bottom-up approach is not necessarily more democratic than a top-down one, since government officials are the representatives of the "people", and are elected through democratic processes, or, if not, at least they are part of a line of "democratic control", in which, at the top, there would always be elected officials (Redford, 1969). One of the main problems with this latter view, is that of whether bureaucrats are accountable, which is but one aspect of the bureaucracy problem, often regarded as one of the most important issues in the implementation process (Wilson, 1984). The question remains if public officials, and especially appointed ones, are accountable, although even if they were, probably a more important issue is whether they, elected or appointed, serve the public interest, or if, on the other hand, their own interests are put before those of the society. This question, I would expect, is more relevant in places with more incipient participatory tradition in policy making than in established democracies.

Looking at some anecdotal cases on policy failure recorded relatively recently (Browne, 2001; Eskeland and Feyzioglu, 1995; Dasgupta, 1996; OECD, 2000), it seems clear that implementation failure is commonly the consequence of several factors: disconnections and misunderstandings between policy designers and implementing agencies, lack of resources, inability to link cause and effect, lack of clear objectives, lack of compliance capabilities, involvement of too many and too distinct parties, lack of support from target parties; unrealistic expectations, and often even external factors which impede the success of policies.

The lessons from the literature on policy implementation and policy failure might be useful for analyzing the Mexican environmental policy, and particularly that which aims to target the electricity sector, and for assessing as well how to improve its chances of success in practice. I expect that other lessons can be derived from reviewing the literature on privatization and structural reforms that have attempted to reduce the role of the state in the economy, since it is very relevant for my case. Next, I will attempt a brief critical analysis of some of the literature on this topic.

3.4 Shrinking the State: Structural Reforms in a Globalized World

Currently, economic integration is visible in several parts of the world. Countries in Western Europe, North America, the Asia-Pacific region, and South America, are forming economic coalitions, both within but also beyond their regions. And even though the degree of integration achieved so far differs from place to place, at the global scale, in any case, international trade and foreign investment are taking place each time more often, and also more freely.

The world is becoming more interdependent every day, as markets for goods, services, capital, and some times even labor, are integrating among countries. In the last decade of the 20th century, economic integration was happening practically everywhere, while major changes in the telecommunications and transportation sectors were also happening, making access to people and markets easier and faster. In one word, with all these changes, globalization was taking place.

In simple terms, globalization can be defined as a global-wide integration of markets, with free transfer of production factors and goods, which implies, at a certain extent, the giving up of national sovereignty, with nation states and their governing capacities weakening (Offe, 2000). In other words, as markets integrate globally, the role of the national state in the economy generally shrinks. Often, for instance, even in those countries where the state has had relatively little intervention in the economy, the trend has been to deregulate certain economic activities, and in those countries where the state has traditionally been stronger, and has even had a role as an entrepreneur, owning and running public enterprises, privatization of public assets and even services has been a common phenomenon, in addition to deregulation, constituting two structural reforms often running in parallel to globalization.

The issue is that, even when market efficiency calls for a smaller state, the role of the state as policy maker remains more than justified, being often crucial, mainly to correct the bad allocation of resources that may result from the free market. Earlier on, I discussed this and other justifications for public regulation, some of which apply to public ownership of some assets as well. As many justifications as there may be, there are still theorists and practitioners who challenge them in favor of a greater deregulation of the economy. And although there are really no substantial challenges to the social and political rationales for regulation, there are some scholars who believe that rather than regulating markets, the government should simply define property rights; or set liability rules to allocate the costs of pollution, which is an idea that goes as far back as when Pigou (1920) suggested a tax solution to externalities; or, as Coase (1960) argued, let people be free to bargain on optimal levels of pollution, and on compensations for its related damages; or simply let the market be free, to become more efficient through its own dynamics.

With all the caveats that some of the solutions being proposed to substitute classical regulation have, of which the most important is probably their impracticality in many circumstances, together with the reluctance of public officials to lose predictability of policy outcomes, some of these solutions have proved useful in practice, in certain specific situations, although in most cases to supplement, rather than substitute traditional regulation (Breyer, 1982). And even though the need for traditional regulation is indisputable, for all the reasons argued here and several others that go from political, to economic and even cultural factors, the trend is to have as little of it as absolutely necessary, to look for more economically efficient ways of achieving policy goals. In other words, the current trend in *globalized* economies, is clearly towards deregulation, particularly of some specific sectors that were for many years deemed as natural monopolies, and which in many cases were also publicly owned. It is a situation in which there have been, among other industries, the telecommunications industry, the steel industry, and the electricity supply sector. The wave of deregulation that has moved along several developed and developing economies has touched on these and several other industries, proving that the market is generally better at reducing prices and increasing efficiency than the state has been (Newbery, 1999), and even more so when considering the additional risks of policy failure, which I explored earlier on in Section 4.2.

When the state is not only a regulator, but also the owner of productive assets, other concerns may arise. Of these, I will just mention a couple of common problems, which relate to the allocation of resources and to the achievement of efficiency in nationalized industries. In those industries that are state-owned, investment decisions usually follow a cost-benefit analysis that demonstrates adequate social returns, but which fails, in most cases, to consider information on the financial viability of investments, meaning basically the financial recovery of the investments made. And on top of that, these state-owned enterprises are also commonly run less efficiently than private for-profit enterprises (Breyer, 1982).

And it is not the case that all the activities traditionally performed by the state would work better if they were privatized. In many cases, it makes sense that the rationale behind investment decisions is their cost-benefit ratio to society. Only that in several other cases, the public ownership of productive assets does not seem to make much sense, not economically, and nor socially and politically either, as the costs of the inefficiency in the management of these assets are largely paid by society.

Regarding privatization, which, defined broadly, is the shifting of a function, either in whole or in part, from the public to the private sector (Butler, 1991), most commonly, it is the financial implications of the issue the ones that are discussed in the literature, even though privatization can often provoke several political and institutional changes, which are broader in scope, but usually little understood and cared for (Feigenbaum et al, 1998). And the same applies for globalization, and, though at a lesser extent, to the topic of deregulation as well. Despite the negative implications that these phenomena may bring to some members of the society, privatization and deregulation of markets have advanced, together with globalization, because their aggregate net benefits to the whole of the society have been generally deemed as positive by society itself (The Economist, 2001). The issue which is relevant for policy making, in any case, seems to be not about the balance resulting from these phenomena for society at large, which, as I just mentioned, seems to be perceived as positive, but instead, about how the benefits and costs resulting from these phenomena are distributed among members of society, be there the rich vs. the poor, or the South vs. the North (Brennan, 2003). This leads us back to one of the reasons that justifies public intervention in markets, which is that of achieving social justice (see Section 4.1), which together with other social criteria, including the environmental criterion, seems to be getting far less weight than economic efficiency criteria in the move towards privatized and deregulated markets.

In part as a consequence of this disregard to social concerns, in both developed and developing countries, globalization and privatization have been opposed fiercely by several groups. Often, these groups feel that they have been left behind, or that they are at a disadvantage as economic integration develops (Brennan, 2003). And not that these groups necessarily oppose increasing interdependence among countries, only that they would like to see its economic benefits spread both among individuals and among countries living under different conditions, and for achieving that, that the public sector intervenes through effective policies (Rodrik, 1997).

3.5 Achieving Sustainability: What does That Mean?

Effective policy making, at last in regards to the environment, could be simply expressed as that which achieves sustainability, or that which leads society towards sustainable development. I say "simply" but am not sure that it is so. The term *sustainability*, in all its possible conjugations, is invoked very often, and by so many stakeholders, but still it is not clear that there is among them a common understanding of it (Mazmanian and Kraft, 1999). To try to avoid getting into that confusion, it is relevant at this point to clarify a few concepts.

The most widely accepted definition of sustainable development was articulated by the World Commission on Environment and Development (WCED), as follows: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). By development, we shall understand a qualitative more than a quantitative indicator, which expresses improvements in the quality of life, that economic growth, per se, does not necessarily help accomplish.

The term sustainable development has two dimensions. On the one hand, it has a justice dimension, since it implies that the present generation (by which we should understand everybody in the present generation) satisfies its own needs. And on the other, it has an inter-generational dimension, which implies that the present generation does not compromise the ability of future generations to satisfy their own needs.

In practical terms, policies to move in this direction should satisfy at least one, but ideally all, among three main criteria: (1) that, with them, the allocation of resources is improved, while resource degradation is reduced; (2) that they correct market failures, improving the functioning of markets; and (3) that they help internalize environmental and social externalities (Panayotou, 1993).

Behind the widespread interest about the topic of sustainable development, lies the increasing concern about the environmental consequences that economic growth has had in the past, especially in developing countries, and also about the interactions between the economy and the environment (Pezzoli, 1997a). As the WCED stated, originally it was mostly the impacts of economic activity on the environment that were of concern, but most recently society is also worried about the impacts of environmental degradation upon their economic prospects (WCED, 1987). And with economic interdependence increasing among nations, as I discussed earlier, environmental interdependence increases as well.

The increasing concerns about environmental degradation and economic development led to the 1992 United Nations Conference on Environment and Development (UNCED), which drafted initiatives and specific principles for designing policies to achieve sustainable development, covering a wide range of economic and social activities. These principles and proposals were presented in two documents produced by the UNCED, the Rio Declaration, and Agenda 21 (UNCED, 1993).

In regards to energy production and use, one of the principles of sustainability implies that an urban area or a region uses energy in balance to what that area can supply continuously through natural processes (Pezzoli, 1997a). In practice, this principle could almost be taken as a synonymous of moving towards renewable energy and energy efficiency.

In practical terms, when it comes to electricity generation, for instance, most environmentalists view natural gas combined cycle plants as a relatively clean technology that may result as a positive step in the transition from dirtier fossil fuel plants to the most desirable renewable energy sources (Heydlauff, 1999), and in that way to move towards sustainability, achieving improvements, though maybe not all the way at once. The problem is that, at about one-third of the carbon dioxide (CO_2) emissions of coal generation, for instance, natural gas combined cycle plants remain as significant polluters (Woolf and Biewals, 1998), especially when compared to renewable technologies. These natural gas plants, though better than the status quo, could be regarded in comparative terms as more sustainable than what exist, although in absolute terms they could still not be regarded as sustainable.

In all, achieving a balance between environmental concerns and economic considerations remains as an issue in several fields. In the previous example, the technology exists to move to close to zero-emission electricity generation, but the market is not ready yet, so a compromise should be reached. Most would agree that both economic growth and environmental protection are desirable and attainable, but it is nevertheless difficult to balance them, especially when they run counter to each other (Mazmanian and Kraft, 1999).

Besides, sustainability, even if there was agreement on the concept, and it became the preeminent factor in investment decisions, is still difficult to apply, and even more to measure in reality. The literature on indicators of sustainable development is vast (see Pezzoli, 1997b for a comprehensive list of references on the topic), and although the field of industrial ecology, for instance, has come up with analytical tools to assess the impact of an economic activity on the environment, on a systematic way, so that as a result of the analysis, process design, public policy, and decision making in general can be improved (Lowe, 1995), one major difficulty remains in drawing the borders of the system of analysis, especially since, as I discussed earlier on, and have stressed again a few paragraphs above, countries and regions are becoming each time more interdependent, not only in which respects to their economies, but to their environments as well.

Achieving sustainability implies several challenges, and among them one that is imperative is the development and exchange of technologies, and the achievement of a collaborative action between academia, the government, industry, and society (UNCED, 1993). Policy makers have a decisive role to achieve both.

3.6 Relevance of Research

The relevance of this research can be assessed using two different criteria. On the one hand, by making sure that it "poses a question that is important in the real world", and on the other, seeing that it “makes a specific contribution to an identifiable scholarly literature, by increasing our collective ability to construct verified scientific explanations of some aspect of the world” (King et al, 1994). I expect that this dissertation achieves both criteria.

The focus of my research on the links between environmental policy design and implementation; the social, economic and political conditions affecting policy making; and the energy technology changes that would be expected from effective policy design and implementation, derives in part from my perception of them being little understood, especially in developing countries, and certainly in Mexico. The analysis of some of the most relevant literature, the empirical evidence that I have reviewed, the interviews that I have conducted, and my experience within the environmental administration of the Mexican federal government, make me firmly believe that it is relevant to perform this analysis. There is clearly a need for research in this area, not only to better understand the link between market deregulation and the environment, which has not been systematically explored in depth (Harris, 2002), but to lead as well to improved policy design, and consequently to achieve better policy outcomes.

My research, as I mentioned in Chapter 1, intends to be both descriptive and prescriptive. With it, I expect to build upon several fields of the literature, first through the application of the existing theories in which I can find answer to my problems of concern, and also generating evidence with which to support (or not) those theories.

4. PROFILE OF THE MEXICAN ELECTRICITY SECTOR

4.1 Background

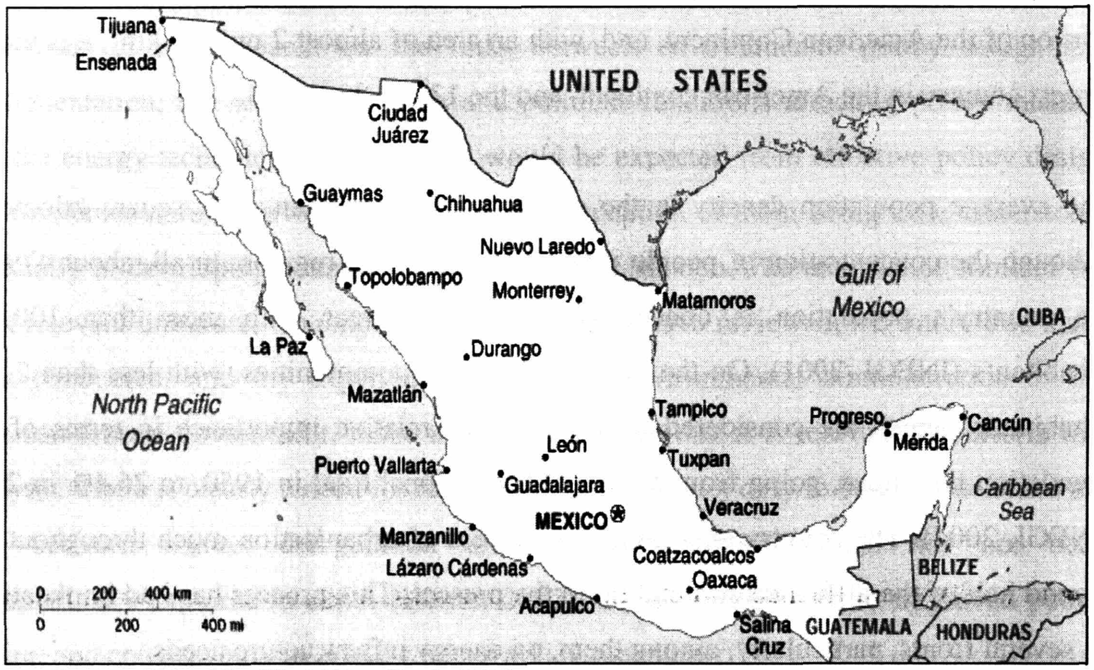
Mexico is a country with a population of nearly 100 million inhabitants (INEGI, 2001), which makes it the 11th most populated country in the world. It is located in the North portion of the American Continent, and, with an area of almost 2 million km^2, it is the 5th largest country in the American continent, and the 13th in the world.

The average population density in the country is 50 inhabitants per square kilometer, although the concentration of people varies greatly among regions. In all, about 47% of the country's population is concentrated in urban areas with more than 100,000 inhabitants (INEGI, 2001). On the other hand, small communities, with less than 2,500 inhabitants, which are considered rural, have lost relative importance in terms of the population they have, going from 57.4% of the national total in 1950, to 25.4% in 2000 (INEGI, 2004). The country experienced a process of urbanization much throughout the second half of the 20th Century, and up to the present. This process has had implications on several fronts, particularly, among them, on energy infrastructure needs.

The largest urban areas in the country (see map of Mexico in Figure 5.1) are Mexico City, with 17.8 million inhabitants, Guadalajara with 3.7 million, and Monterrey with 3.3 million (INEGI, 2001). In all, there are 8 urban areas in Mexico with more than 1 million inhabitants (INEGI, 2001). Together, they concentrate about 32% of the total national population.

Mexico is a very rich country in natural resources, being considered one of seven countries with mega bio-diversity in the planet (OECD, 1998b). This diversity developed, in part, thanks to the climatic and landscape conditions of the country, and to its geographic situation, that make it the bridge between the North and South portions of the American continent. Natural resources make an important contribution to Mexico's economy, particularly with significant energy and agricultural activities. In fact, the country's economy relies at a certain extent on exports of natural resources, being a major exporter of oil.

FIGURE 4.1
MAP OF MEXICO



Source: CIA – The World Fact Book, 2002.

The Mexican economy took off in the 1940s, leading to three decades with an average annual GDP growth rate of over 6%. Beginning in 1970, the Mexican economy was continually disrupted by mounting inflation, fiscal imbalances and foreign-trade deficits, which had as a consequence a marked decrease in the value of the currency, that culminated in the 1982 debt crisis. Major structural reforms took place afterwards, with major privatization and the opening of the economy to foreign investment and free trade, and the overall economic situation improved between 1988 and 1994, in the context of lower inflation and narrowing deficits, while the currency stabilized. At the end of 1994, a new financial crisis brought an abrupt decrease in the value of the Mexican peso, inflation, and a collapse in the amount of imports. Nevertheless, the economy recovered relatively rapidly, in great part thanks to fiscal discipline and the support of the U.S. government.

A new breakpoint for the economy came with the political changes that culminated at the end of 2000, when a president from a political party other than the Party of the Institutional Revolution (PRI), came to power for the first time in 71 years. After the arrival of President Fox, and until recently, the country's economy has been stagnated, in part due, as I mentioned earlier, to the impasse provoked by the distribution of power among several political parties, which often do not seem to achieve the fundamental agreements that may boost the economy (Baer, 2004). Still, more recently, as democratization has deepened and political parties have attempted to improve their image, especially with general elections nearing, some agreements have been reached, and the economy seems to be growing again. The national GDP grew at a modest annual rate of 1.3% in 2003 (OECD, 2004), but jumped to 4.4% in 2004 (SHCP, 2005).

According to the latest available data, Mexico has a GDP estimated at some US$ 625.6 billion in 2003 (OECD, 2004), which means a GDP per capita of about US$ 6,256. It is a relatively industrialized economy, though still a developing country, with shocking contrasts between affluence and extreme poverty. Mexico is, nevertheless, a member of the Organization for Economic Co-operation and Development (OECD) since 1994. It is also a signatory of the North American Free Trade Agreement (NAFTA), with the U.S. and Canada; a member of the Asia Pacific Co-operation Forum (APEC); and member of the World Trade Organization (WTO). The main economic activities in the country are industry (manufactures), oil extraction, and agriculture.

Accounting for purchase power parity and for population distribution among member countries, Mexico's per capita GDP is roughly equal to 38% of the OECD average (OECD, 2004). Still, the main issue is not that average income in Mexico is low, but that it is so badly distributed. Nowadays, in fact, one of the main economic and social problems that the country faces is that of extreme poverty. Around 52% of the Mexican population live in poverty, which means with a per capita income among the members of their household below the level necessary to satisfy their needs in regards to food, health, education, clothing, housing and transportation. And worse than that, there is an alarmingly large subset of the poor, roughly equal to 20% of the total population, who live in extreme poverty, being incapable of satisfying even their basic food needs (SEDESOL, 2004).

As it happens in many developing countries, a substantial part of the Mexican population has limited or no access at all to commercial energy, due both to the remoteness of the places where they live, or to their low income. Currently, more than 5 million people, which means roughly 5% of the Mexican population, have no access to the electricity network (de Buen, 2004), and consequently, have no access to potable water, communications, and sometimes even education.

The country's economic and social development is a priority for policymakers, and a sound energy sector is fundamental for achieving it. The Mexican energy sector comprises mainly the activities of the oil (including other fossil fuels) and electricity industries. Both these industries are, as I mentioned earlier, mostly state-owned, although private participation, even from international firms, has been allowed in some specific activities within these sectors, often through legal maneuvers that have led to a somehow lax interpretation of some constitutional precepts, as I will discuss in more detail later on. This has often, and even very recently, been contested by those interested in maintaining the state monopoly over energy, namely, particularly, worker unions and left-wing parties.

Total primary energy produced in Mexico in 2003 is estimated at 10,064.5 PJ , or 9.54 quadrillion Btu (quads) (SENER, 2004a). Total energy consumed in the country in that same year was 6.13 quads, with the difference being due, mainly, to crude oil exports. Per capita consumption is at a level of 61.3 million Btu per year, which is less than one fifth the present energy consumption in the U.S., estimated at roughly 338 million Btu per person per year (EIA, 2004). Energy consumption in Mexico, by 2010, is estimated to increase to approximately 9.0 quads, following an average rate of increase of 2.8% per year (USDOE, web-page), compared, for instance, with a growth rate of 0.8% per year in the US, observed since 1983 (UNDP-UN-WEC, 2000). If the same rate of growth continues through 2020, national energy consumption in Mexico, by then, would reach nearly 12 quads.

For primary energy production in Mexico, hydrocarbons account for around 90% of all sources (see Table 4.1). Among hydrocarbons, crude oil accounts for almost 72% of the total primary energy production in 2003, followed by gas-oil, which contributes with around 13%. Coal accounts for an additional 1.9% of all primary energy produced in the country, and has lost relative importance in recent years, due to the decrease in the production of coal for thermal industrial processes, and particularly for the steel industry.

TABLE 4.1
SOURCES OF PRIMARY ENERGY PRODUCTION IN MEXICO

SOURCE	%
Hydrocarbons	90.9
Biomass	3.4
Hydro-energy	2.0
Coal	1.9
Nuclear	1.1
Geothermal	0.6
Wind	n.s
Solar	n.s

n.s.: Not significant
Source: SENER, 2004a.

In all, Mexico is important for international energy markets mainly for two reasons: it is a big producer and exporter of oil, and it is believed to have relatively big reserves of natural gas (SENER, 2004a), although it currently is a net importer of natural gas. The exploitation of these resources, by the way, has played an important role in the economic development of the country, and in all likelihood will still be crucial for its future.

4.2 History of the Power Sector

Electricity generation in Mexico has a history of nearly 125 years. It began by 1879, when a textile industry in the city of Leon, in the Central-North portion of the country, called La Americana, installed a generation plant for self-consumption. That plant was followed, in the succeeding years, by an incipient grid, which initially developed with the main purpose of bringing electric light to major urban areas in the country, but developed further as other uses for electricity, particularly productive uses, were more widely spread.

Nearly 200 electric firms, then called "light and motor power companies", were formed between 1887 and 1911, when the War of Revolution interrupted, for more than a decade, much of the country's economic development. By then, power generation capacity in the country had reached 112 MW (El Universal, Oct. 27, 2003). Up until this time, investment in electricity generation had mostly been national.

The process of electrification continued, fueled by early industrialization, after the Revolution, with two of the many utilities in operation involved in the process of concentrating most of the country's generation capacity. They were the Mexican Light and Power Company Limited, which was mostly Canadian-owned, and Impulsora de Fuerzas Eléctricas, whose main investors were American. These companies, through time, became the two only power utilities in Mexico, nowadays operating under the names of Luz y Fuerza del Centro (LFC), and Comisión Federal de Electricidad (CFE).

Initially, they were privately-owned, but in 1960, these two companies, and the whole electricity sector, were nationalized via a presidential decree signed by President López Mateos. With this decree, the state monopoly over electricity generation, transmission and distribution was created. The focus of the nationalized utilities, especially during the 1970s and up until the late 1990s, was on consolidating their business, through a series of modifications to the laws, and on expanding, in order to meet increased demand and to reach out to even the most remote areas of the country (Breceda, 2002).

All throughout the second half of the 20th century, not only the energy sector, but the whole Mexican economy, was heavily influenced by the policies and performance of state-owned industry. This was especially the case during the late 1970s and until the mid 1980s, when oil production, coincidentally, was booming, creating in the country an atmosphere of unlimited optimism (Wionczek and Mallakh, 1985). Throughout this time, the public sector developed several links among state-owned industries, some of which have persisted, even after some privatization and market reform has taken place. For the power sector, it is perhaps not surprising to see how much it has relied on fossil fuels, even though some other options, and particularly hydropower, have been exploited.

The State ownership and control of the supply-side of the electricity sector, together with several technical, political, economic and even historical factors, has determined the market structure and technology deployments of the generation portion of the sector in the years to follow, and even up to the present day, as I will discuss later in this chapter, after I discuss the legal and institutional arrangements within which the sector has evolved.

4.3 Legal and Institutional Framework

The Mexican Federal Constitution establishes that the State is responsible to "look after the national development, by planning, conducting, coordinating and orienting the economic activities within the national territory".

In the particular case of electricity, Article 27 of the Constitution establishes that "the Nation must be the only one in charge of generating, transmitting, transforming, distributing and providing electric energy, when these activities are performed as a public service", which means in the open market. It also states that "no concessions to private parties are to be allowed, and that the Nation will be in charge of managing the resources necessary for providing the electricity service".

In 1992, a change to the Law of the Public Service of Electricity allowed the operation of independent power producers (IPP) and other "external" producers, which would either lease their facilities to the public utilities, sell all of their power exclusively to the public utilities, or use it exclusively for self-consumption. The "constitutionality" of this reform is still being debated in Congress, and was also discussed by the Superior Auditing Office of the Federation, who ruled that it in fact contradicted the Federal Constitution. In practice, IPP and other private power producers continue in operation, and it does not seem likely that the state would be capable of nationalizing all the assets these private parties own, and especially of buying back all private assets already existing in the sector.

Regarding environmental protection, according to the Constitution, the Federal Government, the states and the municipalities within the national territory, "must work together for the preservation and restoration of the environment, in their particular sphere, and according to what the applicable legislation dictates". These spheres are given powers on different levels of action in regard to policy making, regulatory prerogatives, compliance and sanctions, administrative assignments, and other generic duties.

Public policies mandate that environmental offices work in combination with other agencies within the government, for the making and execution of policies, in a multi-sector task. These offices have also the responsibility of taking into consideration other members of the society, who traditionally play an important role in the implementation of environmental policies.

The Mexican environmental law, called General Law for Ecological Balance and Environmental Protection, took effect in March 1988, to regulate matters concerning the protection and restoration of the ecological balance, as well as the protection of the environment in the country. Its provisions lay the basic rules to define general ecological ordering (zoning) matters; restoration and improvement of the environment; protection of natural areas, plants and animals; sound exploitation of natural resources; and pollution prevention and control.

The environmental legislation in Mexico stipulates that any measure considered *ideal* to prevent and control pollution, and to assure the more efficient use of natural resources, must be executed.

Several regulations derive from the General Law for Ecological Balance and Environmental Protection, being among them one for hazardous waste and another one for the prevention and control of atmospheric pollution. The first one delineates the registry and information procedures that every generator of hazardous waste must comply with, as well as the lineaments for the management and disposal, and for the importation and exportation of hazardous waste. The latter establishes principles for managing stationary and mobile sources of atmospheric emissions. These two regulations are very relevant for the energy sector.

Besides the federal one, state governments have enacted their own environmental legislation, which under no circumstance should contradict the federal law, but can only be stricter than it.

According to the environmental law, the Nation has the right, always, to impose to private and public properties any measure considered appropriate in order to serve the public interest, as well as to regulate, for the social benefit, the exploitation of natural elements susceptible of appropriation, with the purpose of "making an equitable distribution of the public wealth, take care of its conservation, and accomplish the balanced development of the country and the amelioration of the living conditions of the urban and rural population".

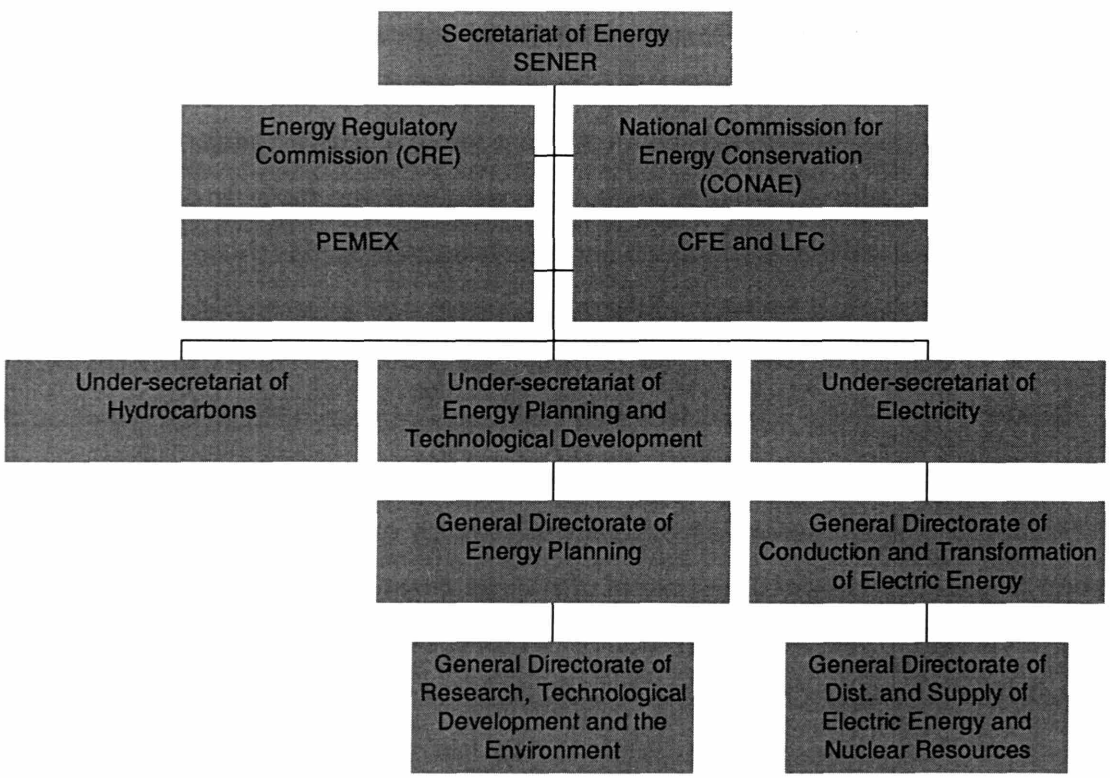
To make any change to federal regulations, the same as for any constitutional reform, that change should be approved by the federal Congress, which is composed of 500 deputies, and currently controlled by opposition parties. Any reform should also be ratified by the Senate, which has 128 seats.

In regards to the institutional framework relevant to the electricity sector, the Secretariat of Energy, which, after a period of intense privatizations and the near-disappearance of the mining sector, evolved from what at the beginning of the 1990s was the Secretariat of Energy, Mines and State-owned Industry, has formal control over LFC and CFE. The Secretariat of Energy, in fact, controls most of what remains of State-owned industry in the country. Namely, the giant Mexican Petroleum Company (PEMEX), which is the national oil and gas company, and the two electric utilities.

Besides these companies, the Secretariat of Energy also controls the Energy Regulatory Commission (CRE), the National Commission for Energy Conservation (CONAE), the National Nuclear Safety Commission (CNSNS), the Mexican Petroleum Institute (IMP), the National Nuclear Research Institute (ININ), and the Electricity Research Institute (IIE). All these organizations inform and influence energy policy design (see Figure 4.2 for an aggregate organizational chart of the Secretariat of Energy).

Currently, there are three under-secretariats in the Secretariat of Energy. The first is the Under-secretariat of Hydrocarbons, the second one is the Under-secretariat of Energy Planning and Technological Development, and the third one is the Under-secretariat of Electricity. Under this last one, there is a General Directorate for Generation, Conduction and Transformation of Electric Energy, and a General Directorate for Distribution and Supply of Electric Energy and Nuclear Resources. These two offices are directly responsible for the national electricity policy, although the sector is also affected by the work of other offices within the Secretariat of Energy, among which the General Directorate of Energy Planning dictates the general policy guidelines of the energy sector, and the General Directorate for Research, Technological Development, and the Environment is pretty relevant for matters related to the environmental performance of the sector.

FIGURE 4.2
ORGANIZATIONAL CHART OF THE SECRETARIAT OF ENERGY



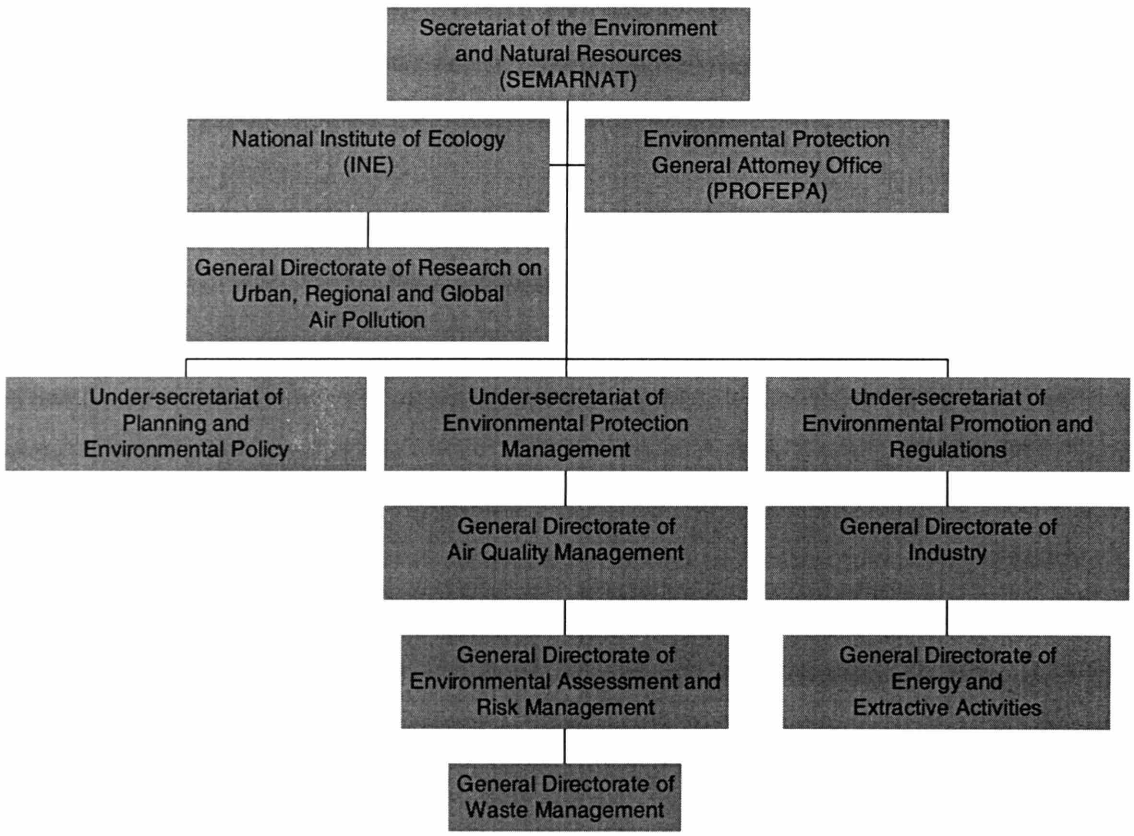
Source: SENER, Web-page, 2004.

In which refers to the offices in charge of environmental policymaking and implementation, they remain in most part distributed among federal and local public institutions. At the federal level, environmental concerns, even though they became part of the public interest since the early 1970s, did not translate into high-level offices until the mid-1980s, when an Under-secretariat of Ecology was created within the Secretariat of Urban Development and Ecology (SEDUE). This office suffered a few changes throughout the following years, the most important at the beginning of the 1990s, when it was divided it into two offices, one in charge of policy, called the National Institute of Ecology (INE), and the other in charge of enforcement, called the Environmental Protection Attorney Office (PROFEPA), both within the new Secretariat of Social Development (SEDESOL), which replaced SEDUE.

Later on, in December 1994, the Federal Congress approved the creation of the Secretariat of Environment, Natural Resources and Fisheries (SEMARNAP), concentrating most of the offices in charge of environmental affairs within the federal government, including INE and PROFEPA. The structure of SEMARNAP brought together the policies, programs, and administrative resources for forests and fisheries, soil conservation and restoration, environmental management of federal laws, and environmental policy (SEMARNAP, 1997). This secretariat suffered some changes at the beginning of the current federal administration, and on December 2000, it lost its "Fisheries" part, and became the Secretariat of Environment and Natural Resources (SEMARNAT), with INE becoming the research arm of the secretariat, and no longer being in charge of policymaking (See Figure 4.3).

Within SEMARNAT, there are now several offices with responsibility over the energy sector, and particularly over electricity generation and consumption. INE does research on several topics that are of relevance for the energy sector, and particularly over air emissions. PROFEPA is still in charge of enforcement, and a few other offices within SEMARNAT have some say when it comes to energy policies that affect their sphere of responsibility. There is, for instance, a General Directorate of Energy and Extractive Activities, which is in charge of overseeing the links between the energy and the environmental sectors. And there are other offices that have different types of influence on the energy sector, for instance in what refers to climate change issues. I will go into more specifics regarding these offices in Chapter 7 of this dissertation, especially at the point when I analyze the stakeholders that are relevant for the design and implementation of environmental policy.

FIGURE 4.3
OFFICES DEALING WITH THE ELECTRICITY SECTOR AT THE FEDERAL SECRETARIAT OF ENVIRONMENT AND NATURAL RESOURCES



Source: SEMARNAT, Web-page, 2004.

According to the dictates of the public administration, environmental offices must ideally work in combination with other agencies within the government in the making and execution of policies, in a multi-sector task. They have also the responsibility of taking into consideration other members of the society, who may play an important role in the implementation of policy.

According to the Constitution, the state has the right, considering always "social equity and productivity criteria", of supporting the social and private sectors of the economy, subjecting their activity to the public interest and the efficient use of the resources, while taking care of their conservation and of the environment in general.

One of the main principles that guide policy making in Mexico is that of sustainable development. This principle, as understood in public planning in Mexico, implies that poverty must be abated (present human needs must be satisfied), while the environment is preserved (for satisfying the needs of future generations). The integration of environmental, economic (including of course the energy sector) and social policies, is envisioned as one of the best mechanisms to reach sustainability.

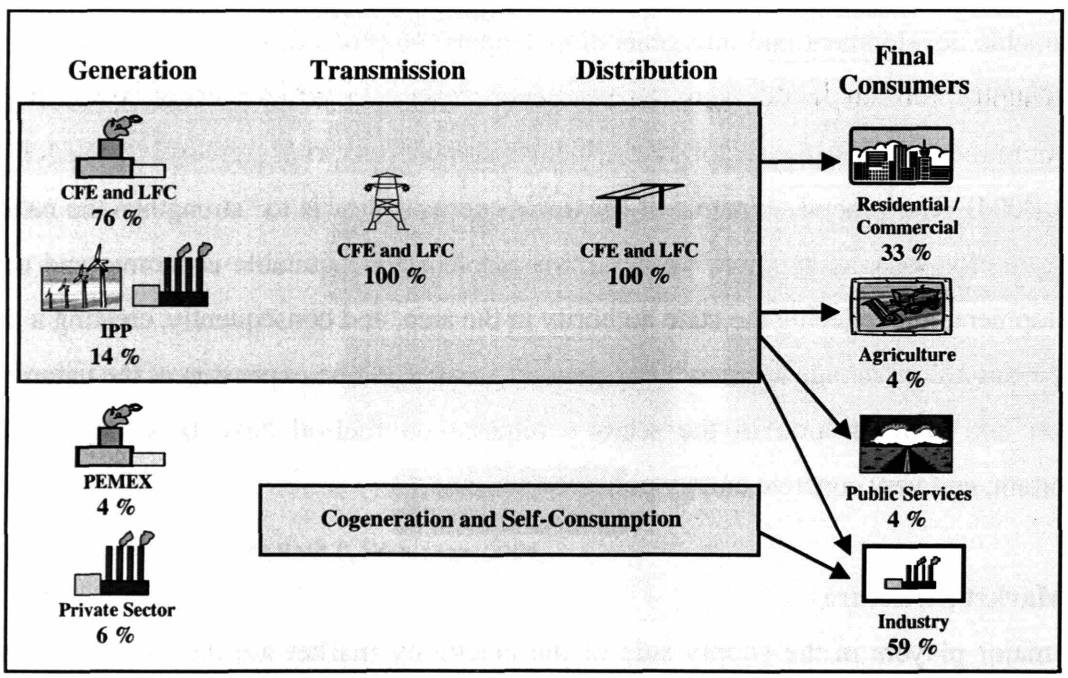
The national energy policy currently pursues the following broad goals: "to increase the quality of life of the Mexican people; to promote a rational use of resources in the context of sustainable development and intergenerational equity; to promote investment in productive and feasible projects in Mexico; and to generate an 'elastic' supply of hydrocarbons; increase productivity in the sector; and achieve a competitive pricing policy" (SENER, web-page, 2004). The general objective of Mexico's energy policy is to "strengthen the national energy sector so as to promote vigorous, sustainable, and equitable economic and social development, guaranteeing the state authority in the area, and consequently, creating a more prosperous and sovereign Mexico". For achieving this goal, the expansion of the natural gas market and the reduction in the sector's reliance on fuel-oil have been expressed as important, and very concrete energy policy objectives.

4.4 Market Structure

The major players in the supply side of the electricity market are the two state-owned utilities, which own all transmission and distribution, and are also in charge of most generation (see Figure 4.4). Other players in this side of the market are PEMEX, who has a substantial generation of electricity for self-consumption, and the private sector, be it industry who have co-generation capacity or who have their own generation facilities; power plants that produce exclusively for exporting their power; private investors who build and own power generation facilities, but who lease them to the public utilities; or independent power producers (IPP), who own electricity generation facilities, although they can only sell their production to the national grid, which is controlled almost entirely by CFE.

On the demand side of the electricity market, practically all economic agents are included (see Figure 4.4). The main categories of final consumers are, first, the industrial sector, contributing with 59% of total final consumption; then the residential and commercial sectors, who consume 33% of the electricity produced in the country; and finally the agricultural and the public sectors, who consume, each, roughly 4% of the electricity used in Mexico.

FIGURE 4.4
MARKET STRUCTURE OF THE ELECTRICITY SECTOR



Source: With data from SENER, 2004b.

A more detailed look at the market structure of the electricity sector comes in the following sections. First, I take a look at the supply side of the sector, and in then at its demand side.

4.4.1 Supply Side

As I mentioned earlier, there are two major components of energy supply in Mexico. On the one hand, the oil sector, which includes mainly oil and natural gas exploration, processing and distribution, and is mostly in the hands of a state-owned monopoly, PEMEX, which happens to be also the largest single company in the country, with more than 81,000 employees (INEGI, 2003). On the other hand, there is the power sector, which comprises generation, transmission and distribution of electricity, and is mostly controlled by two state-owned industries, Comisión Federal de Electricidad (CFE), and Luz y Fuerza del Centro (LFC), which are no small either, providing, the first, around 80,000 jobs, and the latter, more than 38,000 (SENER, 2004b).

In what refers to electricity supply, nowadays, LFC and CFE, which are the only two utilities in operation in Mexico, have a spatial distribution of the market. LFC is concentrated exclusively in and around the Mexico City Metropolitan Area, and CFE in the rest of the country. Besides them, there are around 15 independent power producers in the country, although the electricity they generate is almost exclusively for the consumption of related industries, or sold exclusively, through long-term contracts, to the public utilities (DOE-EIA, Web-page, 2004). Service currently reaches 95% of the population (CFE, Web-page, 2004).

Total generation capacity in the Mexican national electric network, is in the order of 45.6 GW (see Table 4.2). Electricity generation relies in most part, around 74 %, on fossil-fueled thermal generation, mainly using fuel-oil. Out of the 95 thermoelectric generation plants owned by CFE in the country (not accounting coal fired plants), only 2, with total capacity of around 1,050 MW, operate fully with natural gas, and that because of atmospheric emissions concerns, being them located in Mexico City (as I will discuss in more detail in the Valle de México case that I present in Chapter 5). Another 4 plants use both fuel-oil and natural gas, and the remaining, exclusively fuel-oil. As for the newer plants operated by IPP, they work almost fully with natural gas, with the combined cycle technology.

Hydropower is the second largest source of electricity generation in the country. Nowadays, there are 64 hydro plants, contributing with roughly 9,600 MW capacity, which is equivalent to almost 21% of the electricity capacity of the country. These plants produce about 10% of total national electricity generation (see Figure 4.5), considering co-generation and some industrial generation for self-consumption.

TABLE 4.2
ELECTRICITY GENERATION CAPACITY IN MEXICO BY TYPE OF PLANT IN THE NATIONAL ELECTRIC SYSTEM

TYPE	CAPACITY (MW)	%
Thermoelectric (hydrocarbons)	31,073.8	68.1
Coal Fired	2,600.0	5.7
Nuclear	1,364.9	3.0
Hydroelectric	9,600.1	21.1
Geothermal	959.0	2.1
Wind	2.2	n.s.
TOTAL	**45,600.0**	**100.0**

n.s.: not significant
Source: SENER, Web-page, 2005.

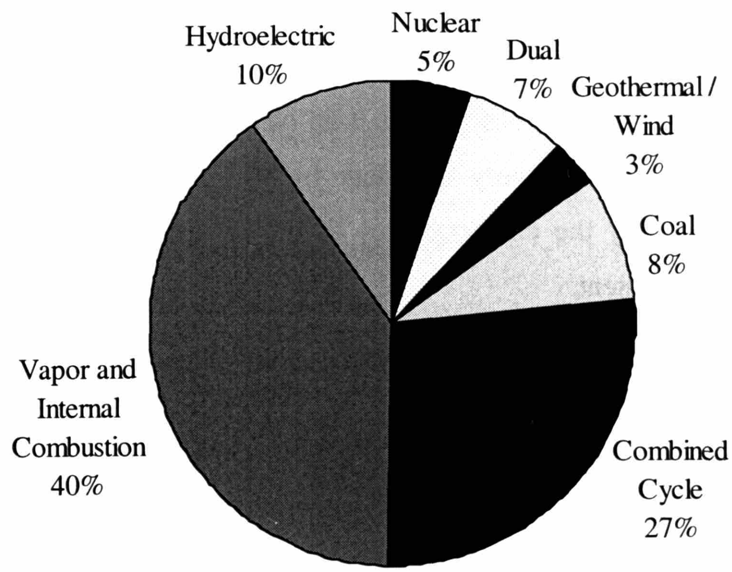
The third contributor to electricity generation is coal-fired power plants, with a total capacity of 2,600 MW, and a contribution of 5.7% to total generation. Currently, there are only 2 coal-fired power plants in the country, and both are located in the north, in the state of Coahuila, close to Texas. In fact, the largest producer of coal in the country is Mission Energy, which is a U.S. company.

Besides these plants, there is also one so called dual plant in operation in the country, with total capacity of 2,100 MW. This plant uses both fuel-oil and coal for its operation, and is one of the two largest power plants in the country. It is located in the southwest of the country, and contributes with around 7% of total generation.

Nuclear energy, with only 2 units in one single plant in operation in the country, contributes with roughly 3% of the national generation capacity. These nuclear units started operation in 1990 and 1995, respectively, and have both the same capacity, of roughly 680

MW. The nuclear power plant is located in the coast of the state of Veracruz, in the Gulf of Mexico, and uses a once-through salt water cooling system. There has always been major opposition to the construction, in first place, and then to the operation of this plant, especially by environmental groups such as Greenpeace. Whether it is because of the political pressure surrounding this plant or not, the fact is that no other nuclear plant has been planned in the country. Currently, the contribution of nuclear energy to national electricity generation is 5%, which is significantly higher than its contribution to generation capacity, mainly because, due to technological and financial considerations, this type of generation technology is almost always dispatched.

FIGURE 4.5
NATIONAL ELECTRICITY GENERATION BY TYPE OF PLANT (PERCENTAGE CONTRIBUTION)



Source: SENER, 2004b.

Geothermal energy, contributes with roughly 2.1% of generation capacity, mainly coming from one single plant located in the northwest of the country, close to the border with California. Together with wind power, geothermal generation contributes with 3% of the national electricity generation. In the case of wind energy, its total capacity is of about 2.2 MW, although most of it comes from a single wind farm in the south of Mexico, in La

Venta, Oaxaca, which has total capacity of roughly 1.6 MW (see Chapter 5 for more detail about this facility).

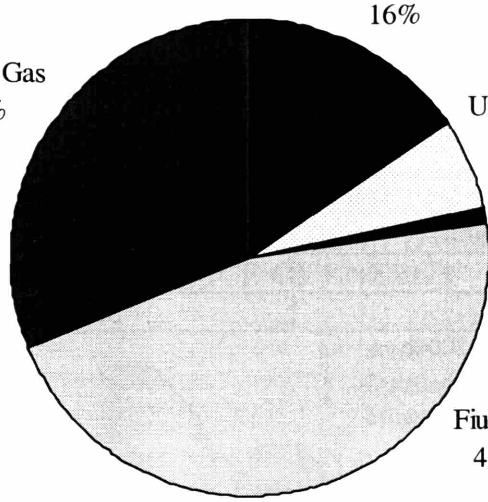
Biomass, even though it has a great potential in Mexico, mainly due to the volcanic characteristics of the sub-soil, and to the size of its agricultural sector, is little used for electricity generation. In any case, the fact is that biomass, even though it may not be significant for the electricity generation sector, has historically been important in Mexico as a source of energy in the domestic environment, as well as in productive self-consumption activities. Firewood and sugarcane bagasse are the major sources of biomass in Mexico. The use of biomass has been maintained pretty much constant throughout the last five years, although its relative contribution to the total production of primary energy has been decreasing.

Regarding fuel consumption for electricity generation, currently, nearly half of it, when accounted by calorific content, comes from fuel-oil (see Figure 4.6), which is a relatively dirty byproduct of oil refining, very abundant in Mexico given the current refining technologies and especially the characteristics of the oil extracted, which is relatively heavy, with high sulfur content.

Natural gas is the second most popular fuel for electricity generation in the Mexican national electric system, accounting for a little more than 30% of the total fuel consumption in the sector. The use of this fuel for electricity generation in Mexico was relatively small until very recently, but it has increased substantially since the national energy policy has favored the use of natural gas combined cycle technologies, particularly for the new private generation plants that have been granted IPP permits. As a matter of fact, the contribution of natural gas to electricity generation doubled between 1998 and 2002 (SENER, 2004a). This, even though Mexico is not currently self-sufficient in natural gas, and has to import this fuel for satisfying the demand of new generation plants.

Coal is, in terms of calorific content, the third most important fuel used in electricity generation in Mexico, satisfying roughly 16% of the total fuel consumption. It is followed by uranium, with 6%, and finally by diesel, which has a small contribution, of about 1%, being it used mostly in backup internal combustion generation equipments.

FIGURE 4.6
FUEL CONSUMPTION IN THE NATIONAL ELECTRICITY SYSTEM (PERCENTAGE CONTRIBUTION IN PETAJOULES)



Source: SENER, 2004a.

Of all the thermoelectric plants in operation in the national electric system, including those that are operated by CFE , LFC and IPP, which in total contribute with about 90% of the total generation capacity in the country (see Table 4.4), more than one third currently use a combined cycle technology (see Table 4.3).

Partly, the shift in electricity generation towards natural gas combined cycle technology that has occurred recently is due to environmental considerations, being this technology substantially cleaner than the more traditional thermal generation processes. Another factor was the supposed availability of natural gas, and its favorable price, even though it has recently fluctuated to levels higher than predicted (SENER, 2004b). I will discuss in more detail this topic, and its implications particularly for environmental policymaking, in Chapters 5 and 6.

In all, even though some switch to more efficient technologies, like combined cycles, has occurred, still, nowadays the most commonly used generation technology among thermoelectric plants (even considering coal-fired and geothermal plants, not included in Table 4.3) is the steam technology, which is among the most traditional ones.

TABLE 4.3
THERMOELECTRIC GENERATION CAPACITY IN MEXICO BY TYPE OF PLANT IN THE NATIONAL ELECTRICITY SYSTEM

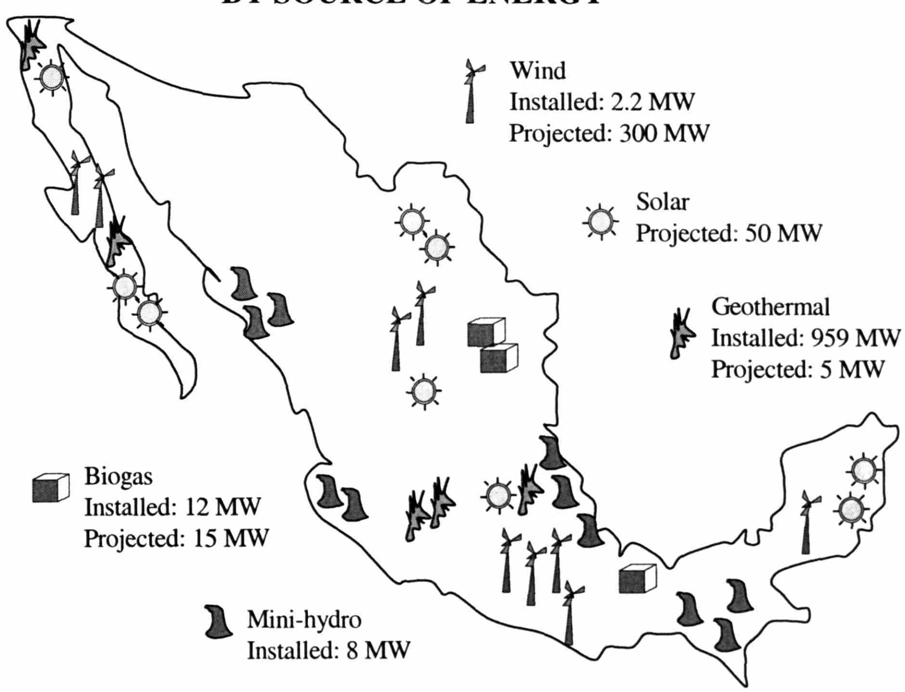
TYPE	CAPACITY (MW)	%
Steam	14,283	47.6
Combined Cycle	10,604	35.3
Turbo-gas	2,890	9.6
Internal Combustion	143	0.5
Dual	2,100	7.0
TOTAL	**30,020**	**100.0**

Source: SENER, 2004b.

Regarding renewable energy, as I mentioned earlier, the national energy policy has established as a principle that most of the increase in electricity generation capacity in the country should be achieved through natural gas combined cycle technology. Even though some would argue that this is a good step to move towards even cleaner technologies, and particularly towards renewable energy, little has been achieved in terms of taking that additional step. In fact, even the potential for renewable energy in the country is largely unknown, as there has been practically no comprehensive analysis of it. Nevertheless, there are good suspicions about what particular regions of the country are "rich" in what resource (see Figure 4.7). In some of these regions, a few renewable generation facilities are already in place, although in most cases at scales that could normally be considered as demonstrative. For most renewable technologies, there are a few projects in progress, which would in some cases, and particularly in the case of wind power, increase production significantly.

By some estimations, the potential for wind generation capacity, in the state of Oaxaca alone, is in the order of 33,000 MW, which is more than 60% of the current national generation capacity. Wind energy is probably the renewable source that has the best chances of contributing significantly to electricity generation in Mexico, at least in the near future, given both technical and economic aspects associated with this technology. For other renewable sources, like solar energy, the theoretical potential is much larger than for wind generation, but the technology is still not sufficiently evolved, and it is very expensive as well. In any case, perhaps its potential is not in large-scale interconnected power generation, but more for the consumption of isolated consumers and remote communities. And the same would probably be the case for mini-hydro developments, which, according to CONAE, have a potential to reach 3,200 MW of installed capacity.

FIGURE 4.7
MAP OF RENEWABLE ELECTRICITY IN MEXICO: CURRENT SITUATION AND AREAS WITH POTENTIAL BY SOURCE OF ENERGY



Source: With data from SENER, 2004a; and SENER, 2004b.

As I mentioned earlier, most public power generation plants in Mexico are operated either by CFE or by LFC. The first contributes with roughly 74% of the total generation capacity, while the latter contributes only about 1.7 % of the electricity capacity existing in Mexico, which, including both the electricity destined to the national electric system (SEN) and that outside of it, is in the order of 50.7 GW (see Table 4.4).

TABLE 4.4
INSTALLED ELECTRICITY GENERATION CAPACITY BY PRODUCER

	MW	%
CFE	37,512	74.0
LFC	834	1.7
PEMEX	1,973	3.9
IPP	7,265	14.3
Self-Consumption	2,185	4.3
Cogeneration	909	1.8
TOTAL	**50,679**	**100.0**

Source: SENER. Web-page, 2004. Data as of May, 2004.

IPP contribute with more than 14% of the total national generation capacity, and PEMEX itself, though only for self-consumption, accounts for an additional 3.9%. The remaining 6.2% is produced by other private and mixed producer, mainly for self-consumption, but also in the form of industrial co-generation, for instance in the steel and the paper industries.

According to their actual participation in generation, the contribution of CFE is dominant, with it generating almost 84% of the national production of electricity (see Table 4.5). The second largest producers are the private and mixed producers, among which IPP have a fundamental role, mostly as suppliers of the electricity being demanded in the country which the existing utilities have no capacity to satisfy, and no resources either to make the necessary investments that would allow them do it. The contribution of LFC to generation is negligible, having it a much greater role as a distributor of electricity in the country's central region, buying from CFE a significant portion of the electricity it sells.

TABLE 4.5
GROSS ELECTRICITY GENERATION IN MEXICO BY PRODUCER

PRODUCER	GWh	%
CFE	169,178	83.6
LFC	1,629	0.8
Private and Mixed Producers	31,645	15.6
TOTAL	**202,452**	**100.0**

Source: SENER, Web-page, 2004

Most of the power grid is nationally interconnected. The national electricity system is divided into nine operational regions, out of which six are fully interconnected. Currently, the northeast is not connected to the national systems, although there are plans to connect it in 2005. And there are also two regions that cover the whole of the Baja California Peninsula, which will remain isolated for the time being, due to technical and economic constraints (SENER, 2004b).

In the north border, the national electricity system is also connected to the U.S. grid, at nine separate points, two of which are in California, and the remaining in Texas. There are plans for developing a North American interconnected grid, although at this point, it is not certain that they will be reached in the near future (EIA, Web-page). There are, anyway, plans to build new power plants in Mexico, and actually some of them are under construction and a few already in operation, along the border, in the Mexican side, especially in areas close to California. These plants will both satisfy the increasing domestic demand, and export electricity to the U.S. market.

Currently, 953.2 GWh of electricity are exported, and 71.9 GWh imported (CFE, 2004). There are, in other words, net exports of electricity of 881.3 GWh, which is roughly equivalent to 0.44% of the electricity produced in the country. Even when they are still relatively small, the exports of electricity more than quadrupled between 2000 and 2003, going from 202.7 to 953.2 GWh, while imports decreased even more dramatically in the same period, from 1,080.9 to 71.9 GWh (CFE, 2004).

An important part of the electricity infrastructure is the electricity transmission and distribution network, which has a total of 689,034 km, divided into transmission lines, sub-transmission lines, and distribution networks (see Table 4.6). Transmission lines are used to transport electricity among regions, whereas sub-transmission lines are of regional coverage, reaching distribution networks and some final users of high-voltage electricity. Distribution lines reach most final users, and are subdivided into medium-tension and low-tension lines. These networks cover, each, a relatively small geographic extension.

All transmission and distribution networks are owned by the two public utilities, although CFE is, clearly, the dominant firm in regards to transmission and distribution as well (see Table 4.6), since it is the only firm with national coverage.

TABLE 4.6
ELECTRICITY TRANSMISSION AND DISTRIBUTION NETWORKS
(Km)

TYPE OF LINE	CFE	LFC	TOTAL
Transmission	41,241.0	389.7	41,630.7
Sub-transmission	43,617.2	3,213.0	46,830.2
Distribution	573,204.9	27,368.2	600,573.1
TOTAL	**658,063.1**	**30,970.9**	**689,034.0**

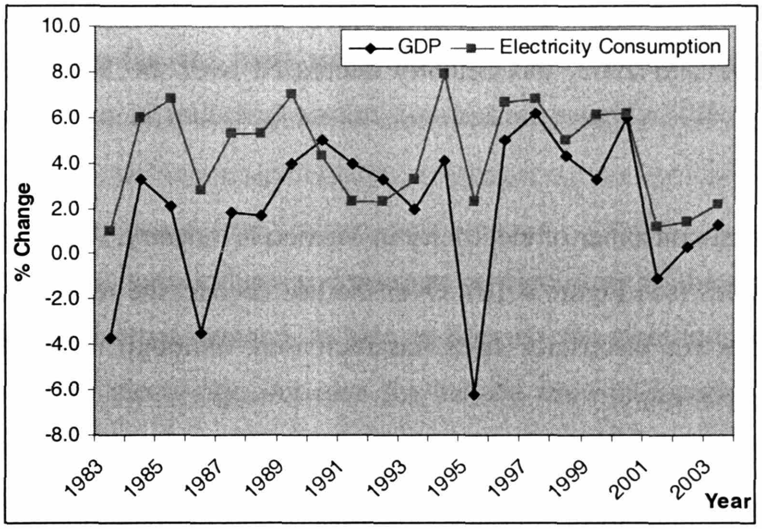
Source: INEGI, 2003.

4.4.2 Demand Side

The consumption of electricity in Mexico seems to evolve in close relationship with the evolution of the national GDP (see Figure 4.8), although, even when GDP annual change has been in the negatives, as it has happened a few times over the last 21 years, reaching its worst year in 1995, when the last national financial crisis came about, still, the demand for electricity has always grown, even if little. In the last three years seen in the plot in Figure 4.8, for instance, in which the economy was stagnated, the demand of electricity was still growing. This implies, among other things, that the electricity intensity per unit of GDP has increased over the last couple of decades, even when there have been public programs to improve energy efficiency among practically all types of consumers in the Mexican economy.

The growth in electricity demand that has occurred over the last two decades, from 1992 to 2002, has been, in average, 5.4% per year, although during the last decade, from 1993 to 2003, it decreased to 4.7% per year in average. The decrease in demand growth is explained by smaller increases in the demand of practically all sectors, but particularly of the services and the agricultural sectors, which grew only 1.6% and 2.2% annually, respectively, during the last decade (SENER, 2004b).

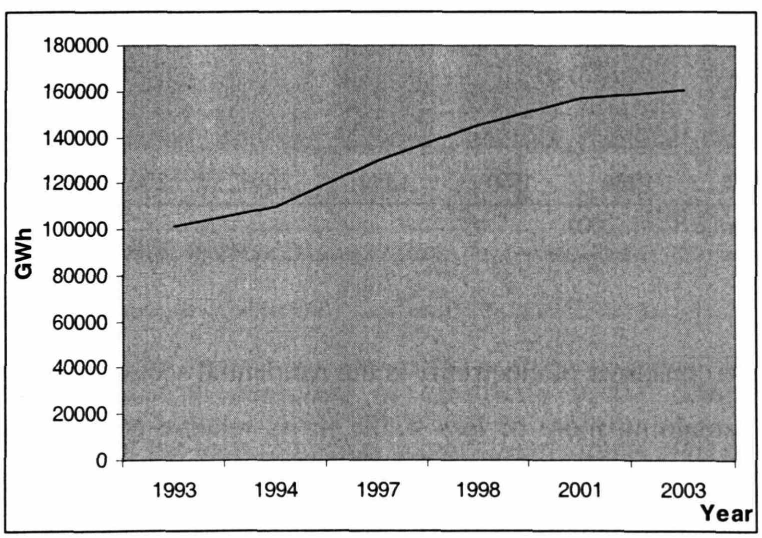
FIGURE 4.8
EVOLUTION OF GDP AND ELECTRICITY CONSUMPTION
1983-2003



Source: SENER, 2004b

In 2003, which is the last year for which there is data available for comparison, total sales of electricity within the country grew only about 2% (see Figures 4.8 and 4.9), although, considering the increases in net exports of electricity, we see that total production grew in fact a little more than that.

FIGURE 4.9
TOTAL ELECTRICITY SALES OF THE NATIONAL ELECTRIC SYSTEM

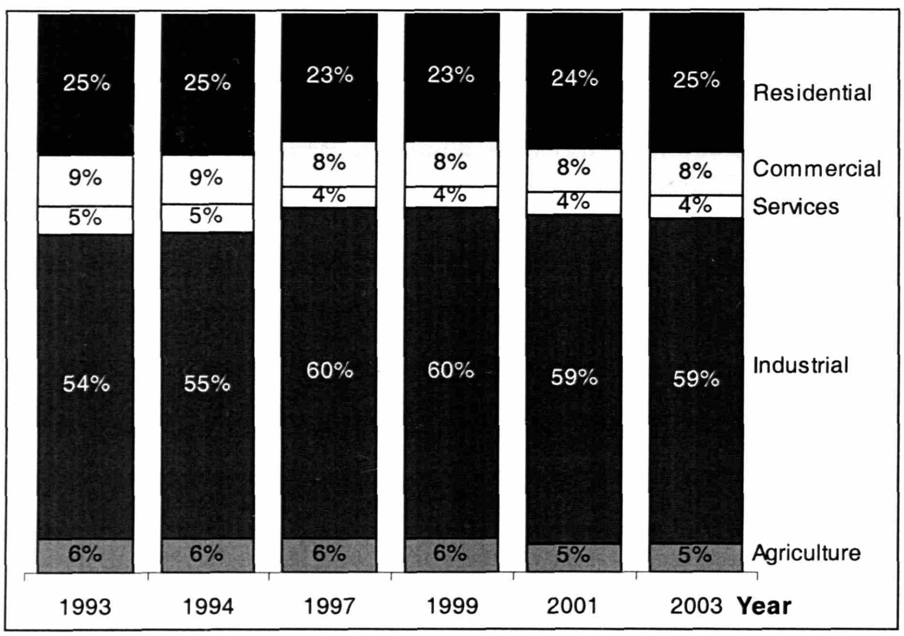


Source: CFE, 2004.

Electricity consumption is growing at a faster rate than the population, which can be translated into saying that the electricity intensity per capita is growing. The same cannot be said, though, about energy intensity per capita, which, although it increased about 1.8% between 2002 and 2003, has actually decreased over the last decade (SENER, 2004a).

Currently, the largest consumer of electricity in Mexico is industry, which absorbs almost 60% of the total sales (see Figure 4.10). Over the last decade, the relative importance of the industrial sector for electricity sales has increased, although it actually decreased slightly in the last five years.

FIGURE 4.10
SALES OF THE NATIONAL ELECTRICITY SYSTEM BY GWh CONSUMED PER SECTOR



Source: CFE, 2004.

The second largest consumer of electricity is the residential sector, with about 25% of the total sales, and remaining more or less stable in its relative contribution to electricity sales over the last decade. The commercial and services sectors, together, contribute with roughly 12% of the electricity demand. The relative importance of both these sectors has decreased over the last 10 years. And so has the relative contribution of the agricultural sector, which has gone down from 6% in 1993, to 5% in 2003.

Industry remains, by far, the most important consumer of electricity in Mexico. And within industry, about 10 industrial sectors concentrate roughly 30% of the total demand (see Table 4.7).

The most important single industrial consumer of electricity is the steel industry, with 7.3% of the total industrial demand. In fact, in Mexico, the steel industry is not only the largest consumer of electricity, but also the largest industrial consumer of energy in general, absorbing more than 17% of the total energy consumption of the industrial sector (SENER, 2004a). About 12% of the energy consumed by the steel industry is in the form of electricity, the rest is all fossil fuels.

TABLE 4.7
MAIN INDUSTRIAL CONSUMERS OF ELECTRICITY

INDUSTRY	CONSUMPTION	
	Petajoules (PJ)	%
Steel	24,532	7.30
Chemical	18,271	5.45
Mining	17,400	5.19
Cement	14,255	4.25
Paper	8,843	2.64
Automotive	5,803	1.73
Glass	3,785	1.13
Aluminum	3,148	0.94
Bottled Soft Drinks	2,747	0.82
Beer	2,500	0.76
Other Sectors	233,931	69.79
TOTAL	**335,215**	**100.00**

Source: SENER, 2004a

The second largest industrial consumer of electricity is the chemical industry. It contributes with 5.45% of the total industrial demand, and almost 10% of the total energy demand of industry. For the chemical industry, most of the energy consumed comes as fossil fuels, and particularly natural gas, which satisfies about 65% of the energy needs of the sector. Electricity represents only a little less than 17% of the energy consumption of the chemical industry.

Mining is the third largest industrial consumer of electricity, with 5.19% of the total industrial demand, even when, between 2002 and 2003, the energy consumption of the mining sector decreased by 11.6% (SENER, 2004a). The production of the mining sector includes precious metals, non-ferrous industrial metals, steel industry metals and minerals, and non-metallic minerals. Their main energy source is natural gas, with about 40% of the total, followed by electricity, which satisfies roughly 30% of the energy needs of the sector.

The cement industry is another relatively large consumer of electricity. The energy consumption of the sector is one among a few that actually grew between 2003 and 2004. It increased almost 3% during this year. The cement sector absorbs about 10% of the total industrial consumption of energy, and a little more than 4% of its electricity demand.

The other sectors that complete the list of the 10 largest industrial consumers of electricity are the paper industry, the auto industry, glass manufacture, aluminum production, and finally the production of bottled soft drinks and beer.

Regarding pricing of electricity, it is considered an important instrument of energy policy (SENER, web-page, 2004). Currently, the definition of the different fares that each sector pays, obeys distributive criteria, but also attempts to motivate a more efficient use of electricity.

In all, there are eight different domestic fares, according to the individual level of consumption of a household, and varying also according to the regional climate of the place where this household is located. For commercial consumers, there are six possible fares, according to their demand, with variability also among the three largest urban areas and the rest of the country. There is a special fare for commercial users who are temporary consumers, and for those whose activity is water pumping, which is a perverse incentive, from the environmental perspective. The agricultural sector has four different fares, depending on the use they make of the electricity, and on the hour of day when they consume it. For industry, the electricity fare structure is a little bit more complex. There are 18 different fares, depending on level of consumption, voltage needs, and type of use.

From the several interviews that I carried our in Mexico, it became clear that the quality of the electric service, with constant voltage variability and frequent blackouts, is something consumers are definitely dissatisfied with. People in the public sector and NGOs I talked with, showed their perplexity at the inefficiencies with which the public utilities are run, permanently operating with losses, and with an extraordinarily high rate of employee per customer, which is but one of many indicators of their low productivity.

4.5 The Growing Role of Private Power Producers

The Federal Law for the Public Service of Electricity gives the Energy Regulatory Commission (CRE) the capacity to authorize, through permits, the generation of electricity by private producers. In general terms, the law does not allow private producers to sell their electricity to any private consumer in the open market, but only to use it for self-consumption, or to sell it to CFE, although, in this last case, permits are granted only if there is a previous agreement between CFE and the private producer, committing the fist to buy all the electricity generated by the latter, who commits to sell its production exclusively to CFE.

There are five types of permits granted by CRE related to electricity. A private party can get a permit either to import electricity; to export it; to co-generate it; to produce power for self-consumption exclusively; or to operate as an independent power producer (IPP), via a contract with CFE.

Regarding import and export permits, currently, there are more than five times more of the first than of the latter (see Table 4.8), although, in terms of actual generation, private exports authorized by the regulatory body account for more than 26 times the amount of private imports (see Figure 4.11). This happens, because imports, which are carried out mostly by manufacturing firms in the Mexico-US border, are, individually, relatively small. Most of the power exported, on the other hand, is produced by relatively large power plants operating on Mexican territory, but which are allowed to send their whole production out of the country exclusively.

So far, only 5 permits for such plants have been given by CRE, as of December of 2004. Out of those, 4 were for plants in the northwest, close to the border with California, and the remaining one for a plant operating in the south of the country, which sells power to Central America. All of these plants were funded largely with foreign capital. There is one plant for the export market currently under construction (see Table 4.8), with an estimated investment of US$ 360 million, for 300 MW of capacity. It is a wind-farm in Baja California, which was granted a permit since July of 2002, and was supposed to begin commercial operations by the end of 2003, but still has not.

TABLE 4.8
PERMITS GRANTED TO PRIVATE POWER PRODUCERS

	IPP	Self-Consumption	Cogeneration	Export	Import	TOTAL
In Operation	15	162	30	4	27	238
In Construction	6	21	2	1	0	30
Inactive	0	1	2	0	0	3
TOTAL	21	184	34	5	27	271

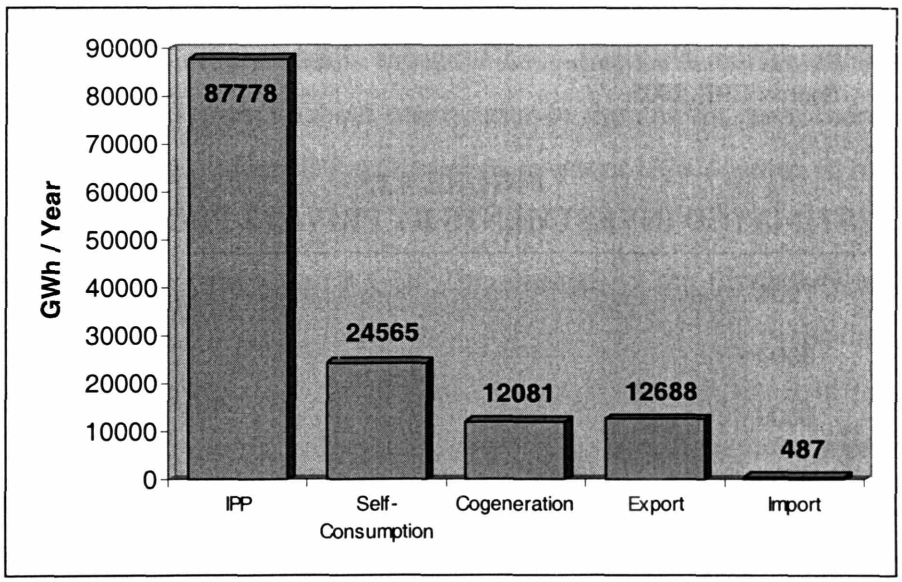
Source: CRE, 2005.

Regarding cogeneration permits, they are mostly given to industrial plants that have thermal processes for their normal operations, and which can use what would otherwise be wasted energy, to produce electricity, be it through steam, or through some other sort of secondary thermal energy source. A few permits have been granted as well to enterprises which, due to their production activity, may have by-products that can be used as fuels for power generation, such as methane from waste landfills, or biogas from cattle raising. In any case, the power all these plants with cogeneration permits produce, can be used for their own consumption exclusively.

Until December 2004, CRE had granted 34 permits for cogeneration, out of which 2 are for plants currently under construction, and 2 more are inactive. In total, about 12 GW of capacity have been allowed for cogeneration.

CRE also grants self-consumption permits, for the generation of power that would satisfy the demand of either a single firm, or a group of industries that are in close proximity to each other, and that share the power produced by a plant they commission as co-owners or partners of some sort. The same as for the case of cogeneration, they are not allowed to sell their surplus to either CFE or to any private parties not included in the terms of the permit granted by CRE.

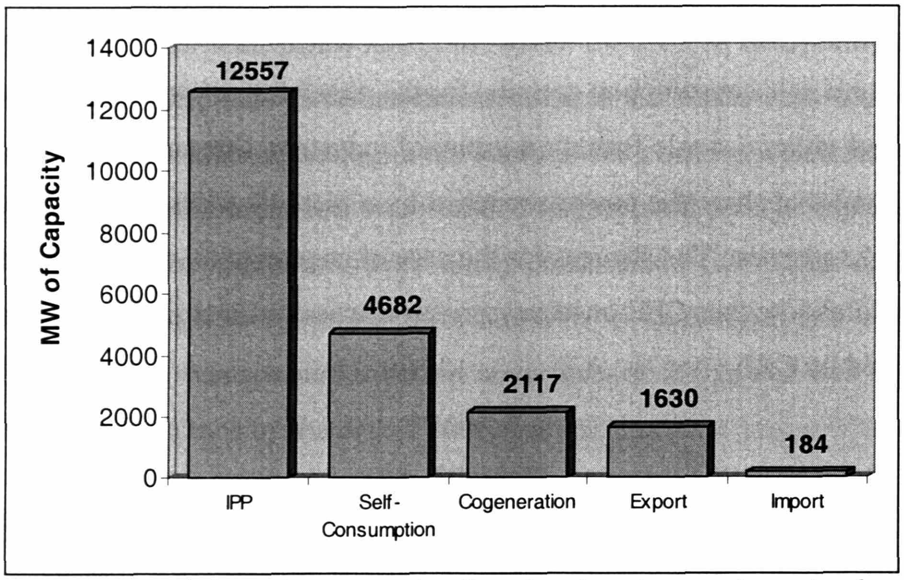
FIGURE 4.11
POWER GENERATION ALLOWED TO PRIVATE PRODUCERS



Note: Figures account for maximum production allowed by permits, both to plants in operation and under construction.
Source: CRE, 2005.

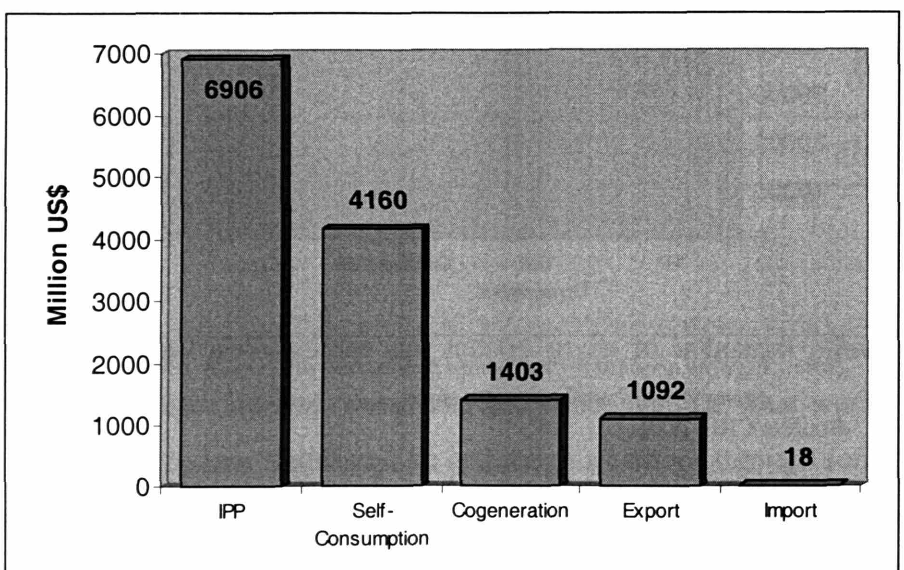
So far, 184 self-consumption permits have been granted, and they go from backup equipments of relatively small capacity, to more substantial power plants that serve a pool of industrial clients. In total, considering the plants currently under construction and one whose permit is inactive, there have been about 4.7 GW of installed capacity allowed for self-consumption.

FIGURE 4.12
GENERATION CAPACITY ALLOWED TO PRIVATE PRODUCERS



Note: Figures include maximum capacity allowed to plants in operation and under construction.
Source: CRE, 2005.

FIGURE 4.13
ESTIMATED INVESTMENTS BY PRIVATE PRODUCERS



Note: Investments include estimations for plants in operation and under construction.
Source: CRE, 2005.

Permits for IPP were the latest allowed by the law. The first one was granted in 1997, and came into commercial operation until the middle of 2000. Over the last 5 years, a total of 20 more permits have been granted, out of which 6 are for plants currently under construction.

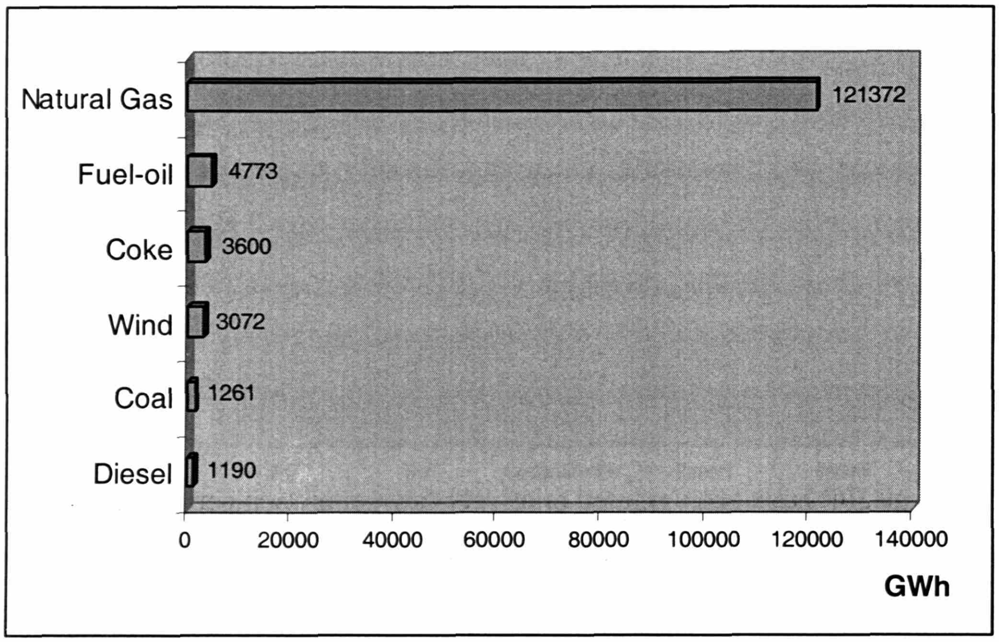
IPP are granted a permit if the technical and economic proposal they presented is the winner in an open bidding carried out by CFE, in which CFE asks investors to participate in a given project, with a set scale (higher than 30 MW) and location. If their proposal is the most attractive to CFE, both would enter a contractual agreement, for certain generation capacity and purchase of electricity. Usually, the terms of these agreements range in average about 25 years. The biddings published by CFE call for proposals for "developing, building, owning, operating and maintaining a power plant and ancillary installations, to be interconnected to the national electric system". These biddings are open to, and have in fact, all of them, been granted to transnational firms.

So far, although IPP have been granted relatively few generation permits, they may reach as much as 12.5 GW of generation capacity, once all plants so far allowed enter in operation. This would represent about one quarter of the current generation capacity of the country. To get to that point, IPP will have made about US$ 7 billion in investments.

In strict sense, a sixth type of permit may be granted by the regulatory authority, for small-scale production, not higher than 30 MW of installed capacity in the case when it is to be sold to CFE or exported, and no greater than 1 MW when it is for supplying electricity to rural communities and isolated areas with no access to the power grid. The figures that I discussed earlier on, do not include these permits separately, although they are considered within other categories, for instance, within self-consumption permits, or within export permits.

Regarding the energy sources that are most common for private generation, the fuel of choice is, by far, natural gas (see Figure 4.14). The amount of consumption of this fuel among private producers is in fact concentrated mostly on IPP, and at a certain extent as well on the largest plants granted generation permits for self-consumption and exportation. These are relatively large plants that operate with combined cycle technology.

FIGURE 4.14
MAIN ENERGY SOURCES FOR PRIVATE GENERATION
(GWh)



Notes: - Only the largest sources of energy are included.
- Power generation per source accounts for estimates of plants in operation and under construction.
Source: CRE, 2005.

The consumption of other fuels among private power producers pales when compared to natural gas, especially when considering that private plants using fuels or sources of energy other than natural gas are mostly very small, and highly scattered around the national territory.

Besides the private generation occurring via permits granted by CRE, there are two other types of private investments taking place in power generation in Mexico (see Table 4.9). They are, most commonly, not officially accounted as private generation, but as private financing mechanisms, and that is what they are in strict sense.

One of these mechanisms, which is in fact applicable to transmission and distribution as well, is called "public funding". This is a scheme by which the public utilities (CFE in all cases) request that a private investor develops a generation facility or some other related project that they require, only to buy it back from those private investors once the project is ready to begin operations.

The other scheme, by which there is in fact actual private ownership of generation facilities that are in operation, is called the "build, lease and transfer" (BLT) scheme. It is also applicable to transmission and distribution, and it consists of asking bids from private investors to develop specific projects to be leased to the public utilities for predetermined periods (usually 20 to 25 years, just as for IPP). The facilities developed are operated and maintained by the utilities that lease them, and this may be the main reason why they are not considered as private, although they are so in strict sense until the end of the leasing period, when they are transferred to the utilities that leased them. By 2002, there were at least 10 large BLT plants in operation (see Appendix D). Like IPP, they all use natural gas as their main fuel, and have combined cycle technology. Their aggregate generation capacity is in the range of 3,700 MW, with actual generation, in 2002, of almost 21,000 GWh. These plants are, practically all of them, owned by foreign investors, among which some of the same names of the investors in IPP repeat.

In the following chapter, among the cases that I will look at, I have included, besides three cases of public generation facilities, three that have some sort of private financing mechanism. One of those cases, which I would say has a "mixed" ownership structure, is that of a BLT plant, owned mostly by transnational investors, but operated by CFE, and officially considered as part of the SEN. The last two cases of private investment that I will analyze, refer to plants that operate under the IPP scheme. Both of them, like all other plants that have been granted IPP generation permits by CRE, belong to transnational firms.

I expect that the cases that I will discuss next, provide enough evidence to support the analysis that I will attempt to develop subsequently.

TABLE 4.9
FINANCING SCHEMES FOR THE MEXICAN POWER SECTOR

Scheme	Description
Independent Power Producer (IPP)	The project developer designs, finances, builds and operates the plant and delivers the energy generated to CFE. The associated capacity and energy are purchased by CFE for a period of 20-25 years through a bidding process. The plant remains the property of the private investors.
Public Funding	The project developer (public or private) carries out all necessary investments required by the project, and when the corresponding facilities are ready, CFE must liquidate the total amount invested. In order to carry out this liquidation, usually CFE must obtain long term financing. There exists the possibility of utilizing the public utilities own resources for funding generation facilities, but apparently this scheme is not viable due to insufficient investment funds.
Build, Lease and Transfer (BLT)	Consists in the design, financing and commissioning of a power plant financed by private investors to CFE (or LFC) technical specifications and through a bidding process. Once in operation, the plant is leased to CFE (or LFC) for a period of 20-25 years, at the end of which ownership passes to CFE (or LFC). During the leasing period, CFE (or LFC) is responsible for the operation and maintenance of the plant. This scheme usually operates under a "Long-Term Productive Infrastructure Project" (PIDIREGAS) contract, which the federal legislation first allowed after the financial crisis of 1994-1995, to differ the payment of necessary infrastructure developments that the government had no capacity to pay for at once.

Source: Breceda, 2002; Cámara de Diputados, 2003.

5. IN SEARCH OF EVIDENCE: SIX CASES

I have selected six cases of electricity generation plants, to carry out two types of comparisons. One, a comparison across technologies, regardless of ownership. The other, a comparison across plants that have different ownership structures and belong to different corporations as well, but which have similar (or at least comparable) technology. I selected six of the most representative cases among those that may have the combination of technology and production structure that would be relevant for my research.

The first case that I will look at, is that of a traditional state-owned and -operated fossil-fueled plant. This is a case of traditional technology and ownership, which I would say is typical of "the old archetype" of electricity production in Mexico, which is still the dominant one. The second case is that of a generation plant that operates with more modern technology, comparable to that which is commonly used by private power producers in Mexico, although it is publicly owned. The third case represents what the future may bring more of, if and when the "right" policies are put in place. It is a case of a renewable power generation facility, which in this case is also publicly owned. The following three cases that I will analyze have, all of them, a natural gas combined cycle generation technology, and are privately owned. One of them, my fourth case, is operated by CFE, under the privatization scheme called "build, lease and transfer" (BLT). It is in strict sense a privately owned plant, although it is considered as part of the national electric system. The last two cases operate under the independent power producer (IPP) scheme. The main difference between these two cases is that they are owned and were developed by different companies, which is a fact that may have consequences on their performance in many respects.

I do not expect the cases that I selected to be necessarily representative of the whole electricity sector in Mexico, not sufficient either to get the whole picture of electricity generation technologies and practices existing in the country. What I expect them to be, is illustrative of some of the most relevant combinations of generation technology and ownership structure currently operating in the country. Not fortuitously, the cases that I selected could illustrate, on the one hand, the movement from traditional fossil fueled generation technologies to new generation technologies still relying on fossil fuels, which is a movement that could be expected with a reform of the energy sector that further opens the generation market to private investment; and on the other, the movement from either one of these two technologies to renewable generation technologies, which at this point we could expect, as I mentioned earlier and will discuss later on in more detail, practically only if public policy pushes in that direction, regardless of whether there is a reform or not.

A more practical criterion for the actual selection of the case studies that I will discuss, was that of having sufficient access to them. For the first set of cases, the public ones, access to CFE, which is the utility that owns and operates most publicly owned generation plants in Mexico, proved a little difficult. It was through alternative sources, that I could get very relevant information about the environmental performance and technological deployments of a few of the plants owned by the public power utilities. For the particular case of a renewable technology, I chose to analyze a site that, even though it is still relatively small in terms of its generation capacity, is believed to have a great potential. For this case, I talked to some of the investors that have shown the greatest interest in participating in renewable generation in this particular region, if and when the conditions are there for its development. Finally, for the cases of privately owned generation plants, I was very fortunate to establish a very good relationship with key people in one of the companies that are dominant among IPP in Mexico, and was in fact able to visit one particular plant, which became one of my cases.

For my first case, I selected a thermal generation plant owned by CFE, which is relatively old, and operates with fuel-oil. It is located in the Southeast region of Mexico, in the state of Veracruz. Its name is Central Adolfo López Mateos. It is located in the city of Tuxpan (see Figure 5.1), and it has been signaled out as one of the biggest emitters of atmospheric pollutants among all power plants in Mexico, having it also one of the worst combinations of technology and fuel, at least in what refers to its environmental implications. The generation capacity of this plant is 2,100 MW, being it one of the two largest power plants in Mexico in terms of capacity, together with Central Petacalco, in the state of Guerrero, which has the same capacity, although a different technology, being this one a dual plant whose main fuel is coal.

My second case is that of another CFE plant, but this one with more advanced and much cleaner technology than the previous case. The name of this plant is Central Termoeléctrica Valle de México. It is located in the Mexico City Metropolitan Area (MCMA), in the municipality of Acolman (see Figure 5.1). This plant used to operate with a thermal steam technology fueled with fuel-oil, and it was until relatively recently that it was converted to natural gas, mostly to help abate air pollutant emissions, which are a big concern in the MCMA. The plant has a generation capacity of 750 MW.

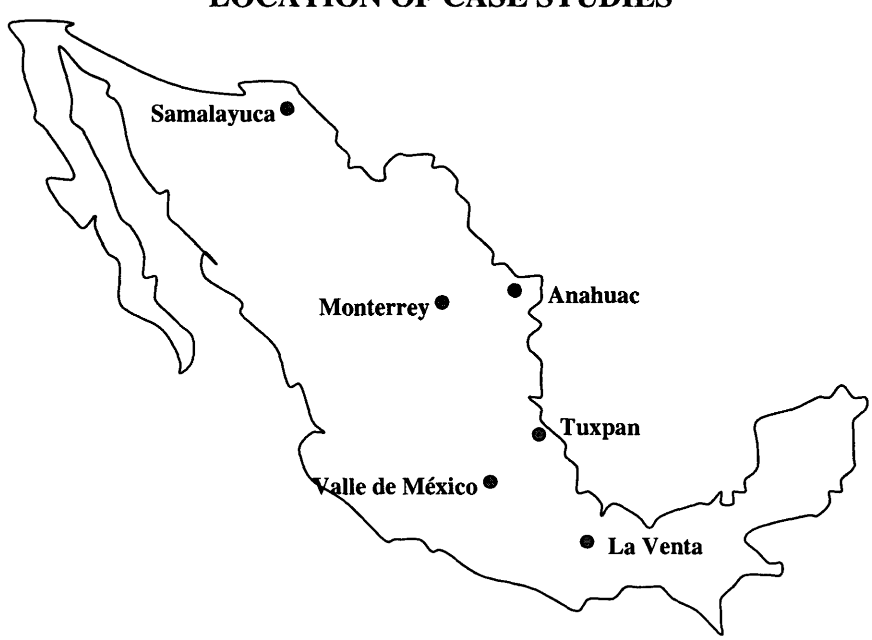
My third case focuses on a wind power facility already in operation in the state of Oaxaca, in the South of the country, in a region with the highest potential for wind resources in Mexico (see Figure 5.1). In this region, several new projects are being planned and developed, although the generation capacity currently installed is very small. The facility which is already operating and that my case focuses on, is called Eoloeléctrica La Venta, and has a generation capacity of 1.58 MW. There are plans to have it grow by more than 100 MW over the next few years, through contracts with private investors. I will describe the current status of these plans when I discuss this case.

The next case that I will present is that of a privately owned plant operated by CFE under the BLT scheme. This is a natural gas combined cycle plant located in the north border of Mexico, close to the city of Ciudad Juárez (see Figure 5.1). It is called Samalayuca II, and was, back in 1998, the first plant with mostly private funding that came into operation in Mexico. It has about 700 MW of capacity, and it is jointly owned by Intergen, General Electric, El Paso Energy Co., and the Mexican construction company ICA.

For my fifth case, I selected a plant, which is in reality a complex of three units in the Northeast region of Mexico, close to the border with the US, in the town of Anahuac, Tamaulipas (see Figure 5.1). The whole complex, out of which only two units are currently operating, since the third one is under construction, is owned and operated by Electricité de France. The plant operates with a thermal process, and a natural gas combined cycle technology. Its three units will have a generation capacity of 495 MW each, for a total of 1,485 MW. Currently, its capacity in operation is in the order of 990 MW, and it is planned to reach full capacity when its third units begins commercial operations, which is expected by mid-2005.

Finally, the sixth case that I will look at is that of another IPP, also running with a natural gas combined cycle technology. It operates in the metropolitan area of the industrial city of Monterrey, in the north of Mexico (see Figure 5.1). The main owner of this plant is the Spanish energy company Iberdrola, who, with new contracts still under construction, will soon become the dominant firm among IPP in Mexico. In the plant that I will analyze, Iberdrola has half of the plant working as an IPP, and the rest under the self-consumption scheme. The total generation capacity of the plant is 1,140 MW.

FIGURE 5.1
LOCATION OF CASE STUDIES



My approach to the case studies, is to "enter" into them through their technological component and its environmental implications, to then, in the following chapters, look back and see what is it in the policy sphere, in their business strategy, in the market, or in technological development itself, that may be causing changes on it towards more environmentally sustainable technologies, and to, after that, analyze what external conditions favor or hinder these changes.

For each of the six cases, I took a brief look at the history, technical characteristics, production structure, socioeconomic impacts, and environmental performance of the plant being analyzed, particularly attempting to establish and explore the relevance of each case for air pollutant and GHG emissions. As much as possible, I also tried to establish how much the environmental performance of each of the plants analyzed varies in response to environmental policy pressures. I present the main characteristics of the six cases in Table 5.1. Their complete description, case by case, comes in the following sections (sections 5.1 and 5.2).

TABLE 5.1
MAIN CHARACTERISTICS OF CASE STUDIES

Case	Main Owner	Technology	Generation Capacity (MW)	Production (GWh/year)
Tuxpan	CFE	Steam / Fuel-oil	2,100.0	15,030.7
Valle de México	CFE	Steam - Combined Cycle / Gas	750	3,894.1
La Venta	CFE	Wind Power	1.6	5.9
Samalayuca	Intergen-GE-El Paso-ICA (CFE operated)	Combined Cycle / Gas	700	3,613.9
Anahuac	Electricité de France	Combined Cycle / Gas	990[1]	6,093.0[1]
Monterrey	Iberdrola	Combined Cycle / Gas	1,140[2]	7,370.0[3]

Notes:
1. *Includes two units in operation, and not the third one currently under construction.*
2. *Includes both the IPP and the self-consumption units of the plant.*
3. *Considers generation allowed by CRE to the IPP part of the plant, plus generation for self-consumption, which was assumed of the same amount.*

Source: CFE, 2004; Miller and van Atten, 2004; López et al., 2004.

5.1 State-Owned Plants: Three Cases with Little in Common

The next three cases have in common that they are owned by CFE. Other than that, there is little point of comparison among them. The three plants I included in this section have significantly different scale, and operate with different technology. The main reason for comparing them, is to try to perform a longitudinal analysis, in which I will try to establish the development of their technology, and, more importantly for my research, of their environmental performance, linking it to my variables of interest across time. Later, for my comparative analysis, I will look at these three cases, and contrast them to the three I will discuss in section 5.2, which are cases of privately owned plants.

5.1.1 Tuxpan: The Old Archetype

Central Eléctrica Presidente Adolfo López Mateos (that I will refer to as Tuxpan) is not only one of the two largest power plants in Mexico in terms of its generation capacity, but it is also the single largest in the country in terms of actual generation of electricity, fuel consumption, and total emissions of the most relevant atmospheric pollutants, except for NOx, for which the two coal-fired plants and the dual plant operating in the country, whose primary fuel is also coal, have higher total emissions. Total generation capacity of Tuxpan is 2,100 MW, which is equivalent to nearly 5% of the current total national capacity (see more detail on national figures in Chapter 4). In 2002, it produced 15,030.7 GWh (Miller and van Atten, 2004), which was roughly equivalent to 7.6% of the national production of that year.

The facility is located within the municipality of Tuxpan, which, according to the last general population census, has 126,616 inhabitants (INEGI, 2001). The plant is located right by the Gulf of Mexico, some 10 km. away from the city of Tuxpan, and also in the vicinity of a few other medium-sized towns and several rural communities. Its influence, both socio-economically, but also environmentally, may as well extend over a region with roughly 750,000 inhabitants.

The Tuxpan CFE plant began operations in mid-1991. It started with two units, adding two more in 1994, and another two in 1996. These six units are all almost identical.

Additionally, a smaller unit was added in 2003, although this one actually began its commercial operations in the first week of January 2004. This seventh unit, even when it is adjacent to the older plant, is owned by a private producer (Siemens Westinghouse), and has a different technology from that in the older units. In strict sense, it is not part of the Tuxpan CFE plant. The generation capacity of this additional unit is 163 MW.

The Tuxpan CFE electric facility has a thermal generation process, fueled with *combustóleo*, which is some sort of very heavy fuel-oil (No. 6), with average sulfur content of roughly 3 to 4% (Vijay et al, 2004). This fuel is a by-product of oil refining, and is very abundant in Mexico. This, due to the characteristics of the oil extracted and refined in the country, which is very heavy as well, and also due to current refining technologies. It is widely believed that as long as this by-product is available, and especially as long as both the oil industry and the electric utilities are publicly owned, the end-use of all the fuel-oil produced by PEMEX will be guaranteed, mostly for CFE consumption in electricity generation.

As a matter of fact, very recently, in November of 2004, after months of negotiations, CFE and PEMEX agreed on new terms for the supply of fuel-oil, since there were some differences in the application of the former ones. CFE felt that they were overpaying for the fuel-oil that PEMEX was supplying, while PEMEX defended that this was not the case, and argued that CFE had abruptly cancelled purchase commitments previously established, affecting PEMEX' supply schedules. At the end of the day, they both agreed to contract an independent study to determine if there was in fact any overpayment being charged. While that study is available, CFE is obligated to comply with the conditions set by PEMEX. They include that CFE establishes and honors new fuel-oil purchase agreements that would not be subject to any change once they are made. On top the amounts of fuel-oil set in these agreements, CFE may request a variable amount of fuel-oil, to be delivered by PEMEX, over which CFE may get a discounted price. But if PEMEX has fuel-oil surplus, and they wish to do so, they may "sell" the variable amount established in the agreement, even if CFE is not asking for it (Reforma, Dec. 14, 2004).

Currently, in any case, about 80% of the fuel-oil produced by PEMEX is used for electricity generation.

Going back to the Tuxpan plant, the actual technology employed there, is steam generation. Nowadays, the plant has, as I mentioned earlier, 6 units in operation, with a generation capacity of 350 MW each. The actual amount of fuel-oil consumption in the plant is in the order of 3.4 million m^3 per year, having that fuel, in average, a sulfur content of 3.8%. The amount of fuel-oil consumed in Tuxpan is roughly equivalent to 15% of the total consumed by CFE (SENER-SEMARNAT, 2002). Additionally, 1,700 m^3 of diesel are consumed in the plant, used mostly to start-up equipment and for the running of secondary equipment (López et al., 2004).

The region where the Tuxpan plant is located is not among those considered as "critical zones" by Mexican air quality standards, which is explainable because it is not very densely populated, with only 25.7 people per km^2 for the whole region (CEPAL - SEMARNAT, 2004), and not very heavily industrialized either. The air quality standards that apply in the region are consequently relatively lax. Currently, the Tuxpan facility does not have any permanent monitoring of atmospheric emissions, although it reports, on its annual operation certificate (COA), to be in compliance with applicable Mexican federal emission standards for stationary sources and with all relevant environmental regulations. It is also certified with the environmental standard ISO 14001, which means that some of its processes have been certified to be environmentally sound, although that should not be interpreted, by any means, as implying that its emissions are not significant. They certainly are, to a level that is believed to harm the health of the population in the region and to cause a significant economic impact to it as well (López et al., 2004; CEPAL - SEMARNAT, 2004).

To release air emissions, each of the six plants in the Tuxpan complex has a chimney with a diameter of 5.5 m., 120 m. high. The main air pollutants being released from the Tuxpan plant are sulfur dioxide (SO_2), suspended particulate matter of less than 2.5 microns in diameter ($PM_{2.5}$), carbon dioxide (CO_2), and nitrogen oxides (NOx). Other pollutants of concern, given their potential large risk to human health, include mercury (Hg). Even though the Tuxpan CFE plant is, in the case of NOx and Hg, well below the average pollutant intensity of power plants in Mexico, it is still, due to its size, lack of sufficient emission controls, and use of very heavy fuel-oil, the plant in the country with the highest emissions, in absolute terms, of almost all of the most critical atmospheric pollutants (see Table 5.2).

For CO_2, for instance, Tuxpan is the highest source of emissions in the Mexican electricity sector, contributing with more than 11% of the volume of emissions of the sector, even though its emission intensity per unit of electricity production is just marginally above the national average for thermoelectric power plants (see Table 5.2). For $PM_{2.5}$, the emission intensity of Tuxpan is significantly higher than the average of the electric sector, with Tuxpan alone contributing about 16% of the total emissions of $PM_{2.5}$ from electricity generation in Mexico. Still, it is SO_2, in any case, the pollutant for which Tuxpan is by far the single largest emitter, not only in Mexico, but in the whole North American region. The Tuxpan SO_2 emission intensity per unit of electricity production is more than 50% greater than the average of all Mexican power plants, and 4.5 times higher than the U.S. average of the electricity sector (Miller and van Atten, 2004), even when generation in the U.S. is dominated by coal-fired plants.

TABLE 5.2
AIR EMISSIONS FROM THE TUXPAN CFE PLANT COMPARED TO THE WHOLE MEXICAN POWER SECTOR

Pollutant	Plant Total Emissions / Year	Power Sector Total Emissions / Year	Plant Emission Intensity	Power Sector Emission Intensity
SO_2	253,430 tonnes	1.6 million tones	16.86 kg/MWh	11.35 kg/MWh
NOx	15,899 tonnes	0.25 million tones	1.06 kg/MWh	1.83 kg/MWh
$PM_{2.5}$	8,000 tonnes	0.05 million tones	0.54 kg/MWh	0.39 kg/MWh
CO_2	10.6 million tonnes	94 million tones	705 kg/MWh	688 kg/MWh
Hg	47 kg	1,313 kg	0.003 kg/GWh	0.010 kg/GWh

Source: Miller and van Atten, 2004; Vijay et al., 2004; Lopez et al., 2004.

The impacts of this level of emissions are considerable. Even with all the inherent uncertainties deriving from the lack of accurate meteorological and health data, from not having sufficient evidence on local dose-response functions, and from differential effects among the population due to socio-economic and environmental conditions, among other, there have been estimations about the health effects related to the Tuxpan CFE plant emissions, at least in what refers to increased mortality related to primary and secondary (sulfates and nitrates) particulate matter concentrations. Some model simulation results (López et al., 2004) show that emissions from the Tuxpan plant could result in approximately 30 additional deaths per year, which could have an annual social cost estimated at US$ 8 million in 2001. This mortality estimation is mostly due (73% of total impacts) to sulfate formation (secondary pollution) resulting from SO_2 emissions. The estimate accounts for the effects of the emissions of the six units in the Tuxpan CFE plant, without considering the emissions from other industrial facilities in the area, and certainly not accounting either the emissions of newer power plants that operate there.

Other estimations, assessing the externalities of power plants in Mexico, have ranked Tuxpan as the one with the highest social external costs among all power plants in the country, accounting for almost US$ 107 million (CEPAL – SEMARNAT, 2004), out of the roughly US$ 465 million estimated for the sum of the 11 largest power generation facilities in Mexico (see Table 5.3), which together contribute with roughly 48% of total national power generation. This estimation accounts for PM_{10}, SO_2, sulfate, and nitrate effects on human health (mortality and morbidity). Again, these estimations find the largest effect on health to derive from sulfate formation, which mostly has a regional rather than a local impact.

An external cost of 0.7 US¢/kWh (see Table 5.3), which is what has been estimated, conservatively, for the Tuxpan CFE plant, is equivalent to roughly 14% of the average cost, per kWh, of electricity produced in a steam generator such as the one in Tuxpan, which is in the neighborhood of 5 US¢/kWh (CEPAL – SEMARNAT, 2004). This means that, if this externality were to be "internalized" in the cost of electricity, roughly speaking, the electricity of the 11 largest fossil-fueled facilities in Mexico would have to increase by 10% in average, and the electricity produced at the Tuxpan CFE complex, by 14%.

TABLE 5.3
EXTERNAL HEALTH COSTS OF THE TUXPAN PLANT BY POLLUTANT (COMPARED TO AGGREGATE OF 11 LARGEST POWER PLANTS)

	US $ thousands / year					External Cost US¢/kWh
	PM_{10}	SO_2	Sulfates	Nitrates	Total External Costs	
Tuxpan	3,503	1,267	98,300	3,897	106,967	0.7
11 Largest	31,981	12,052	372,749	48,157	464,939	0.5
Tuxpan /11 (%)	10.9	10.5	26.4	8.1	23.0	

Source: Modified from CEPAL – SEMARNAT, 2004.

Under current conditions, the *internalization* of the environmental cost would probably not provoke a positive effect to society, because, with the lack of competition in the market, it is likely that the external cost would end-up being paid by society itself, as a higher price. And more than that, this surcharge would probably not even end up improving the environment either, since the Ministry of Finance is against "labeled" taxes, as I will discuss in more detail later on.

Regarding new power generation capacity in the Tuxpan region, besides the seventh unit that I mentioned earlier, which was built with private capital right next to the CFE Tuxpan plant, there are other new investments in power generation in the region, which have been awarded to external producers as well. What is known as Tuxpan II, which is a combined cycle plant with a generation capacity of 495 MW, was awarded to Mitsubishi, and is in operation as an IPP since late 2001. And there are also the Tuxpan centrals III and IV, running as well with a natural gas combined cycle technology, and in commercial operation since May 2003, also under the scheme of independent (or external) energy producer. Together, Tuxpan III and IV have added almost 1,000 MW of generation capacity. Additionally, central V is currently under construction, with an estimated investment of US$ 300 million, to add capacity in the order of 495 MW when it begins operating, if it goes as scheduled, in September of 2006.

At this point, it is not clear whether these new facilities would eventually substitute the older Tuxpan CFE plant, because the construction of these new plants around it seems to be more the resultant of trying to satisfy unmet growing demand, than of updating old technology. The fact seems to be that, even with increasing private investment, the supply of electricity at the national level has not grown as much as the demand, so a technological turnover has not been feasible. At most, some old plants have been updated to improve their efficiency and environmental performance, as the following case will illustrate.

5.1.2 Valle de México: Improved Technology with Traditional Ownership

With almost 18 million inhabitants, the Mexico City Metropolitan Area (MCMA) is the second most populated urban area in the world (SEMARNAT - GEM - GDF - SS, 2002), and by far the largest in Mexico. It has almost five times as many people as either the second or the third largest cities in the country, which are Guadalajara and Monterrey (I will refer to Monterrey in more detail in the sixth case I present in this chapter).

Extending over an area of almost 5,000 km^2, MCMA is located at the southern end of the Valley of Mexico, in the central portion the Mexican territory, at an average altitude of 2,240 meters. Currently, the city has more than one sixth of the national population, and contributes with roughly one third of the country's gross national product (INEGI, 2001. Molina and Molina, 2002). It also consumes about 17% of the domestic energy production of Mexico (INEGI, 2003).

MCMA spreads over two political jurisdictions: the Federal District (DF), which is divided into 16 municipalities (called *delegaciones*), and the neighboring State of Mexico (SoM), of which, according to the Metropolitan Environmental Commission, 27 municipalities are currently part of the MCMA (Molina and Molina, 2002). In terms of population distribution, about half of the population of the MCMA lives in each jurisdiction, although this distribution is likely to change in a few years, with current population growth rates being significantly higher in the SoM than in the DF. In terms of extension, presently, the DF occupies about 30% of the extension of the MCMA, and the remaining lies in the SoM, which is more suburban, much more industrial, and far less service-oriented than the DF.

Historically, the years of greatest expansion of MCMA occurred over the second half of the 20th century, although at the end of this period the city tended to stabilize, particularly after the devastating earthquakes of late 1985. In any case, the population of MCMA went from less than 3 million in the middle of the 20th century, to 17.8 million in 2000 (INEGI, 2001).

For MCMA, at least at the present moment, the years of explosive population growth seem to be over. This is evident when seeing that, in the period going from 1995 to 2000, for instance, the MCMA population grew at an annual rate of 1.4%, while the national annual population growth rate for the same period was 1.6% (INEGI, 2001). Still, with its current rate of growth, according to some projections, the city could reach about 20 million by the year 2010 (SEDESOL-INE, 1995).

In order to reduce the impacts of unplanned population growth and rapid industrialization, among which air pollution is an important one, several policies have been put in place in MCMA, as much as possible through coordinated action among its political jurisdictions. One of these policies has aimed to abate pollutant emissions from industry, in some cases by closing down or relocating industrial plants, and in most cases by forcing, through regulation, direct government expenditure, or some sort of market-based "incentives", their implementation of cleaner technologies.

In part thanks to these and other environmental policies put in place since the late 1980s, it is widely agreed, nowadays the air quality of MCMA is significantly better than in the past. Among the indications of the improvement in air quality that have been recorded in recent years in MCMA, the reduction in ambient concentrations of lead, and also the reduction in ozone peak concentrations are particularly significant, even though the latter has not translated yet in fewer days of non-compliance with ambient standards (INE, 2000; CAM, 2001; Molina and Molina, 2002). In general, these improvements are in good part the direct result of changes in fuel composition, fuel switching and stack controls in industry, and new vehicle technologies, among several other measures promoted, as mentioned, by environmental policymakers.

Still, even though the air pollution problem of MCMA is progressively ceding, there is a long way to go to declare it solved. And even though air quality has improved significantly over the last decade, MCMA often reaches pollutant concentration levels that pose a risk to human health.

Among the industrial sources of pollution in MCMA, according to the preliminary data for 2002 from the most recent of the city's emissions inventories available (SMA, 2005), electricity generation is one of the most important. Electricity production is responsible for about 6.24% of the NO_x emissions of the whole MCMA (of which the main source is the transportation sector, with almost 84%), and it is also a relatively important source of $PM_{2.5}$, with about 3% of the total emissions in the city. However, the power sector is no longer a significant source of SO_2 emissions in MCMA, as it used to be before the generation plants in the city switched from fuel-oil to natural gas, and as it still is in the rest of the country. Nowadays, power generation, with 39 tonnes emitted in 2002, contributes only 0.19% of total SO_2 emissions in the MCMA.

Amid the power plants located in MCMA, *Central Termoeléctrica Valle de México* is the largest, and also the single largest publicly owned gas-fueled power plant in the whole of Mexico. It has a generation capacity of 750 MW, which would be roughly equivalent to 1.6% of the national total, and production of almost 3,900 GWh in 2002, which represented a little less than 2% of the national that same year.

Traditionally, the Valle the Mexico plant has been important to support the increasing power demand of MCMA, particularly in the past, at the time when both population and industry were growing fast, which was especially the case, as I mentioned, since the 1960s until the mid- 1980's. Currently, the amount of production of the Valle de México plant satisfies only about 16% of the demand of electricity of MCMA, 80% of which is met with electricity generated outside the city.

At the time when electricity was nationalized in Mexico, in the early 1960s, Mexico City consumed about half of the electricity produced in the country, while the whole of Mexico had a generation capacity of only 3,021 MW. At present, with a national capacity of more than 45,000 MW, MCMA absorbs about 12% of the total national consumption of electricity (INEGI, 2003; GDF-INEGI-GEM, 2002).

In what regards to final consumption in MCMA, industry is nowadays the largest electricity consumer, with about 55% of the total demand (measured in volume of sales). It is followed by the residential sector, with about 24% of the sales, and then by the commercial sector, which consumes about 14% of all power sold in the city (GDF-INEGI-GEM, 2002).

Of the electricity demanded in MCMA, LFC commercializes a little less than one quarter nowadays, although its contribution to generation is much lower, not reaching even 2% of the total produced nationally, and about 4% of what is produced for the MCMA market. It is, by far, CFE the one in charge of producing and commercializing most of the electricity consumed in MCMA. And the most important facility they own there to achieve that, is the Valle de México thermoelectric plant.

The Valle de México plant is located in the municipality of Acolman, which has a population of about 60,000, and is situated in the part of the SoM that lies within the confines of the MCMA. The plant has four units, which began commercial operations at different times. The oldest unit in the plant has been working since 1963, and the remaining three were put in place in 1970, 1971, and 1974 respectively. Most, recently, particularly over the last 20 years or so, all these units have been updated substantially.

Three of the units in operation in the Valle de México plant have a capacity of 150 MW each, and use a conventional Rankine cycle process to generate steam and produce power thermally. Nowadays, this process is fueled with natural gas, as I hinted earlier, and not any more with fuel-oil, as it happens in most other CFE plants operating with a similar process. The fourth unit in the plant has 300 MW of capacity, and a combined cycle process, consuming also natural gas.

The Valle de México plant, like most other industrial sources of pollution in MCMA, is obligated to comply with the strictest environmental standards anywhere in Mexico. This, because the city is, especially for air quality purposes, considered as the most critical area in the country. For NOx emissions, for instance, for a source of the size and characteristics of the Valle the México power plant, the emission standard is set at 110 ppm, the same as for other critical areas with heavy industry and large population, whereas for the rest of the country, the standard is at 375 ppm. For SO_2 and particulate matter, which are other pollutants of concern at fossil-fueled power plants, there is no applicable emission standard in Mexico for plants that use gaseous fuels, like the Valle the Mexico plant, regardless of their location. Still, for other stationary sources, including those that use diesel or fuel-oil, the standard is the most stringent for MCMA, then a little less so for what the air quality regulations call "critical areas", and then at the lowest allowable level for the rest of the country.

In order to meet environmental standards and to respond to some political pressure, CFE has updated the Valle de México plant substantially. In the past, up until 1991, the whole plant used to run with fuel-oil, but due to its high air pollutant emissions, particularly of SO_2, it was converted to natural gas, whose combustion is generally cleaner and more efficient than that of the heavier fuel-oil. At the time when the conversion occurred, it was believed that the switch to natural gas would decrease NOx as well, and in fact this was an important reason to promote the switch, but, unexpectedly, the emissions of NOx did in fact increase, and the same happened in other plants that burn natural gas (Bravo and Torres, 1994). To offset the increase in NOx emissions, low NOx burners were later on installed at the Valle de Mexico plant.

When it took place, the conversion of the Valle de Mexico plant to natural gas became one of the first major measures to abate emissions in MCMA, whose pollution problem was already a major concern, even rising to national attention, by the late 1980s. It happened also at the time of the administration of President Salinas, which perceived that some major action had to be taken to preserve the environment, mainly for two reasons. First, because the issue was becoming a public concern, and so it would be a popular policy to tackle it, and second, and probably most importantly, because a strong commitment to environmental improvement would increase the chances of signing the North American Free Trade Agreement (NAFTA), which was fundamental for the administration (Garcia-Johnson, 2000).

In this context, CFE needed to take visible action to improve its environmental performance, and nowhere was the problem of environmental degradation more visible than in MCMA, where the largest plant they had was the Valle de México plant. At least in the beginning, the "greening" of the plant was the consequence of a policy dictated by the highest spheres of the federal government, with little internal thrust within CFE.

The main reason to switch to natural gas, as CFE itself has stated, was to "help achieve the goals of the air quality program of MCMA". So, contrary to its most prevalent practices at the time, CFE implemented a major technological change to improve the environmental performance of one of its plants, even when they needed to make major investments to do that.

Paradoxically, even before the switch to natural gas took place, the three smallest generation units in the plant were in compliance with NOx and SO_2 emission standards, and it was only the fourth unit the one whose emissions were well above the applicable emission limits. Still, it was decided to switch all four units to natural gas, and to make a major improvement immediately only to the fourth unit, the largest one, changing its process to a combined cycle. All this, in order to improve efficiency, but also to achieve a visible change that would prove CFE's commitment to the environment, especially as criticism about the company's poor environmental performance had increased.

The improvements planned for the Valle de México plant are still underway. Just recently, in the second annual presidential inform (the annual presidential state of the union address to Congress and the country), presented by President Fox in September 2002, it was mentioned that the three smallest of the four units of the Valle de México plant were being *re-potentiated.* The purpose of this technological improvement is that these units could generate power with a combined cycle process, and to add them up to the fourth unit already operating there, which had been modernized beforehand.

The funding scheme used to *re-potentiate* and modernize all the units of the Valle de México plant has been the "public funding" scheme that I described at the end of chapter 4, by which a private investor is in charge of an infrastructure development, and once it is ready to operate, the government (in this case CFE) "buys" it from her. The total investment to be made in the *re-potentiation* of the three smallest units of the Valle de México plant was estimated at about US$ 170 million, and was included as part of what is called CFE's Contingency Plan, aimed at "satisfying increasing demand in the MCMA market, and at backing up existing generation capacity in the national interconnected grid".

Thanks to all the technological improvements that have taken place at the Valle de México plant, it is no longer the high polluter that it used to be, and it produces relatively "clean" power, at least when compared to other CFE thermoelectric plants, like the Tuxpan plant that I discussed on the previous case. Still, the Valle de México plant remains as a relatively large source of atmospheric pollution among industrial sources in MCMA.

In 2002, the Valle the México plant produced emissions of about 3,096 tonnes of NOx (see Table 5.4), for instance, out of a total of 11,626 tonnes that the whole power sector contributed to total MCMA NOx emissions, which in that year are estimated at 186,169 tonnes (SMA, 2005). This means that the plant alone contributed with almost 27% of the total NOx emissions of the power sector, and about 1.6% of total NOx emissions in the MCMA, out of which, as mentioned earlier, the transportation sector is the largest source.

The NOx emission intensity of the Valle de Mexico plant, measured in kilograms emitted per MWh produced, is less than half the average of the whole thermoelectric power generation (see Table 5.4), which, as I will discuss later on in the cross-case analysis presented in Chapter 6, has increased its average NOx emissions intensity over the last years, as a consequence of the inclination to switch some old plants to natural gas, and to build the new ones to be natural gas-fired as well. The Valle de México plant's NOx emissions intensity is also significantly lower than the average for gas-fired power plants (see figure 5.5), which is explainable since the Valle de Mexico plant has been partially *re-potentiated*, and has had some low-NOx burners and other emission control equipments installed.

For $PM_{2.5}$, the electric sector emissions in the MCMA were in the order of 202 tonnes per year in 2002 (SMA, 2005), contributing a little above 3% of the total annual emissions in the city, which are at about 6,729 tonnes. The Valle the México plant contributes with about 34% of the $PM_{2.5}$ emissions from the power sector (see Table 5.4), and roughly 1% of the total in the MCMA. Regarding the plant's emissions intensity for $PM_{2.5}$, it is far below the sector's average (see Table 5.4), having the Valle de México plant about 5% the level of the average Mexican thermoelectric power plant.

In regard to SO_2, the city's annual emissions are in the order of 8,549 tonnes, of which the power sector contributes about 0.19 % (SMA, 2005). The contribution of the Valle the México plant to total SO_2 emissions in the MCMA is negligible, and the emission intensity for this pollutant is also insignificant when compared to the average of the sector. In fact, whereas SO_2 emissions are among the greatest environmental issues for traditional power plants in Mexico, they are not a concern at all at the Valle de México plant.

Currently, the Valle de México plant is certified under the ISO 14001 standard, and is one of 17 CFE power plants that has been awarded the national "Clean Industry Certificate", that the Federal Environmental Attorney Office (PROFEPA) has put in place to reward industry that implements cleaner technologies and processes.

TABLE 5.4
AIR EMISSIONS FROM THE VALLE DE MEXICO POWER PLANT COMPARED TO THE WHOLE MEXICAN POWER SECTOR

Pollutant	Plant Total Emissions / Year	Power Sector Total Emissions / Year	Plant Emission Intensity	Power Sector Emission Intensity
SO_2	10.9 tonnes	1.6 million tonnes	0.003 kg/MWh	11.35 kg/MWh
NOx	3,096 tonnes	0.25 million tonnes	0.795 kg/MWh	1.83 kg/MWh
$PM_{2.5}$	68.7 tonnes	0.05 million tonnes	0.02 kg/MWh	0.39 kg/MWh
CO_2	2.18 million tonnes	94 million tonnes	560.5 kg/MWh	688 kg/MWh
Hg	4.7 kg	1,313 kg	0.001 kg/GWh	0.010 kg/GWh

Source: Miller and van Atten, 2004; Vijay et al., 2004; Lopez et al., 2004; SMA, 2005.

TABLE 5.5
AIR EMISSIONS FROM THE VALLE DE MEXICO POWER PLANT COMPARED TO GAS-FUELED GENERATION IN PUBLIC UTILITIES

Pollutant	Plant Total Emissions / Year	Gas-Fueled Public Generation Emissions / Year	Plant Emission Intensity	Public Gas Fueled Emission Intensity
SO_2	10.9 tonnes	122.8 tonnes	0.003 kg/MWh	0.013 kg/MWh
NOx	3,096 tonnes	14,529 tonnes	0.795 kg/MWh	1.513 kg/MWh
$PM_{2.5}$	68.7 tonnes	n.a	0.02 kg/MWh	n.a
CO_2	2.18 million tonnes	6.38 million tonnes	560.5 kg/MWh	664.1 kg/MWh
Hg	4.7 kg	14.4 kg	0.001 kg/GWh	0.002 kg/GWh

n.a.: not available
Source: Miller and van Atten, 2004; Vijay et al., 2004; Lopez et al., 2004.

It seems as though, as some of my interviewees who occupy positions in energy offices of the federal government defended, the switch of electricity production to natural gas has been by itself a good step towards improved technologies, which is consequently positive also from the environmental perspective, particularly as it may be a good step towards even cleaner generation technologies, like renewable ones, of which I will discuss more in the case That I present next.

5.1.3 La Venta: The Future?

La Venta, in the southern state of Oaxaca, is a small *ejido,* which means rural land that has some form of communal ownership, established with the Agrarian Reform of the second quarter of the 20^{th} century. It is located in the municipality of Juchitán de Zaragoza, which has a population of 78,512 inhabitants (INEGI, 2001).

In the vicinity of the village of La Venta, there is currently a relatively small wind farm owned by CFE, interconnected to the grid, and operating as some sort of pilot project. It is, in fact, the first wind farm integrated to the electric grid in Mexico.

In fact, the whole region where the La Venta facility is located, has been assessed as one among a few with the greatest potential for wind power generation anywhere in the world. It is estimated to have as much as 3,000 MW of potential generation capacity, throughout a region that extends over about 1,000 km^2, located at the south portion of the Tehuantepec Isthmus, which lies at the confluence between two atmospheric regions with different atmospheric pressure. With the average wind speeds prevalent in the region, it would be possible to have wind generation with an average plant load factor of 45%, with maximums, in the best sites, at an average 60% throughout the year, peaking during the fall and winter to levels as high as 90% (Caldera, 1999). These factors would be very attractive, both technically and economically.

In the particular site where the La Venta wind farm is located, the wind resource is available at an annual average of 9.5 m/s, measured at 30 meters from the ground, with maximum speeds averaging, from November to February, 14.4 m/s (CFE, 2004). This means the site is one of high wind availability, and of excellent commercial feasibility at current power prices.

The wind farm currently operating in La Venta, called *Central Eoloeléctrica La Venta*, has total generation capacity of 1.6 MW, distributed among 7 wind turbines of similar characteristics. Its total generation in 2001 amounted 5.85 GWh. This facility is really insignificant both in terms of its generation capacity and total generation, especially if seen in the context of the national generation system. It would be, probably, just big enough to satisfy the needs of a small community of two to three thousand inhabitants. Its peculiarity, nevertheless, may lie in it being the only wind generation facility in Mexico connected to the grid, and, more than anything, on its demonstration capacity to prove renewable technologies, since there are so many practical barriers for their more widespread implementation in Mexico.

The seven wind generators operating in La Venta, are of the brand Vestas, which is a Scandinavian technology. They have a capacity of 225 kW each. Each generator has a rotor of a diameter of 27m. and is 30m high. This technology was selected by CFE through an open bidding, for being the most cost effective and reliable.

All seven generators in La Venta began operations at once, in November 1994. The project site was determined by CFE, after more than ten years of taking wind measurements around the south of the Tehuantepec region, looking for a site with the best possible conditions. Wind is, in fact, so abundant in the site selected, that the average plant load factor in the wind farm could reach about 60%, whereas the average in places like Denmark and California, for the same technology, is about 25% (CONAE, 2003).

The technology and the site selected seem to have succeeded in their demonstrative effects. In consequence, after testing the technology within the CFE pilot plant, which has run for over 10 years now, there is currently a project to install new wind generation capacity, in the order of 100 MW. This project will be developed by an external producer through contract with CFE, the tender for which has already been published by CFE in early 2004 (CFE, 2004), and will likely be published again by mid- 2005, since no winning bid was determined the first time it was opened to bidding.

The new project in La Venta has been named La Venta II, and it is estimated that investments for its development could be in the range of US$ 100 million (USDOC, 2003), although there was no official word relating to the costs of the project while it was first opened to bids from private investors. It is expected, by the most optimistic, that this project could become the detonator of even larger projects in the region, and to break some of the entry barriers in the market. Whether it does so, depends at a certain extent on how attractive it is, economically, both to CFE and to the selected external private producer, to invest in wind power in the area. Ultimately, it could depend at a larger extent on how much the existing barriers for this type of technology and ownership give way.

The terms of the contract under which the La Venta II project will be arranged between CFE and an external private producer, differ from the conditions set in most contracts with other IPP that have invested in combined cycle plants, for instance (like the Anahuac and Monterrey cases described below), in which CFE does not intervene in the actual operation of the plants. For the La Venta II project, CFE is calling a private investor to design and construct the plant, with its own funds or with any funding that it can get, to then sell the whole plant to CFE, which will then pay for it at once, and will be in charge of its operation. This type of contract is called *Obra Pública Financiada a Precio Alzado*, which literally translates as financed public works at a risen price. With this type of "private funding" contract (as explained in Chapter 4), CFE will be obligated to buy the plant and pay, at the time of commissioning, the costs associated with the plant design and construction, and the financial costs derived from those investments. According to the terms of the contract, the total cost should be set since the time when an offer made by an external producer, through a bidding open to private investors, is accepted by CFE, with that cost being not subject to any adjustment later on.

The results of the open bidding for new wind generation capacity in La Venta II were announced just recently, in February of 2005. Despite the fact that three companies (Mitsubishi, Vestas and Camesa) presented technically feasible projects, out of four that entered the competition (GE's technical proposal was not accepted, so its economic proposal was not even considered), the bidding was declared void. This happened, because the firms competing for the project requested financial resources above what CFE had set aside and was authorized to spend, according to the allocation made by the federal Congress in the annual budget. The amount allocated to the project, ended up being US$ 111.5 million, which is more than 10% above the US$ 100 million that people in the market and the media speculated were the budget cap set by CFE, before it was disclosed once the bidding was declared null.

An executive from one of the companies in the wind power business, said to me that the terms of reference that were issued by CFE for La Venta II were modified three times, two of which implied substantial modifications, while companies were already working on their proposals. This reflects, according to this person, "how little CFE knows and cares about wind generation technology".

The budget CFE is allocating for the La Venta II project, is roughly equivalent to US$ 1.1 million per MW of capacity installed. The project will be re-opened to public bids, but it is not clear at this point whether any of the firms interested in competing for it will be able to present an economically attractive proposal, since the amount of money CFE is willing to pay would probably not give them enough incentive to risk their own resources, since it is only about 10% above average investment costs.

The level of investment in La Venta II, as proposed by CFE, would be comparable to the international average of US$ 1 million per MW (ENR-302, 2003). That amount, in a project with a life of 30 years, at an optimistic average 60% plant load factor, would imply a cost of about US$ 0.06 per kWh, not including variable costs. This level of costs could be competitive against that of traditional technologies, but only depending on fuel prices. If the cost of environmental externalities was considered, on top of the financial costs, then a project like La Venta, or practically any other with renewable technology, would become much more attractive.

At the end of the day, the most compelling reason for supporting or promoting the expansion of wind energy, or of any of the other possible renewable technologies available, is that it makes environmental sense to do that. And even though some specific environmental impacts would derive from a wind generation facility, in the La Venta region, for instance, or in and around the particular sites where projects are located, one would expect that the environmental benefits derived from these facilities would outweigh, by far, their costs, and that society will be better off, and more "sustainable", with them in place.

One among the most obvious benefits of renewable energies, is the avoided emissions to the atmosphere that their deployment creates, by substituting traditional fossil-fuel sources with cleaner generation technologies. In the case of wind power, it also happens to be, even among the alternative renewable sources of energy, the one with the smallest atmospheric emissions of CO_2 (OECD, 1998a).

Besides, a project like La Venta, like any other renewable generation facility that can be installed in locations not interconnected to the national grid, could serve a social purpose, by providing electricity to isolated communities, bringing the additional benefits associated with it, like water pumping and sanitation, distance leaning, and even the potential to develop some productive activities. One of the government officials that I interviewed pointed out that, given the current legal and technical constraints to large-scale renewable generation interconnected to the grid, the starting point for it may be in these remote places, at a small-scale, to at least reach those who need power the most. And some of these systems have been installed already. Most notably, there are about 1,500 solar photovoltaic systems serving remote communities, with total capacity of about 1.4 MW nationwide, that were installed during the term of President Salinas (that went from 1988 to 1994). The impact of these systems in the whole power generation market structure has been marginal, even when they have helped local development in a few communities. At a larger scale, at the present time solar generation would not be economically competitive against wind generation.

In any case, even if society as a whole is better off with renewable technologies substituting or complementing traditional ones, one issue that remains is that of who is benefited and who has to pay, especially since, no matter how benign a technology is, there may be still those who suffer the environmental effects of having wind turbines in the vicinity of their properties, for instance. This is a fact that should become, even if it is minimal in the overall picture, a concern for policymakers.

In the La Venta region, the major burdens that wind turbines could create relate to noise, vibrations, visual intrusion, the killing of birds, and land use impacts and habitat damages. All of these can remain relatively low, assuming that best practice is in place (OECD, 1998a). One way to avoid some of these impacts, even if low, is by making sure all projected developments for the area, or for the whole country for that matter, comply with environmental standards, and with regulations and procedures regarding the environmental impact assessment of wind farm sites. Proper planning, and the conduction of all relevant tests, would also help to guarantee that environmental impacts are minimized. If , after all due procedures, environmental impacts are still being experienced, mitigation and compensation could be necessary.

A specific social concern for the development of wind power in the La Venta region, is that of land ownership. There is, on one side, as I mentioned earlier, the fact that the land is not, in strict sense, private property, so it cannot be bought and sold. On the other, there is the issue of electricity generation, even if it is renewable, not being compatible with the traditional activities of the area, which is among the less industrialized in Mexico. On the positive side, at least for CFE and investors, there is the fact that the opportunity cost of the land may not be very high, since what makes the region special from the energy perspective, which is its perennial high-speed wind, is also a factor that makes this land pretty much useless, or at least highly unproductive, for practically any of the traditional economic activities of the region, and more so for agriculture. Sorghum is probably the only plant that can be cultivated in the area, but not without effort, as the land is also relatively arid. Furthermore, another factor in favor of the development of wind technologies in the region is that, even when it is true that wind turbines may look imposing, and wind farms would probably extend over vast extensions of land, only a small proportion of that land would in fact be occupied by any facility, so it would be possible for agriculture, cattle rising, or other activities to coexists in the same land where a wind generator is in operation. In this way, the communities that own the rights to use the land can continue with their use of it, getting additional resources by leasing a relatively small portion of it for wind generators to be installed, and/or charging also for allowing the rights of way over their land.

The same way as the currently operating La Venta wind farm has served as a pilot to test the likelihood of larger wind energy developments in the La Venta region, the whole process of penetration of the technology can serve to motivate the expansion not only of wind generation, but also of other renewable technologies elsewhere in Mexico. So far, there are, throughout the country, several regions that have been identified as of great potential for wind generation, as well as for other renewables, as I mentioned in Chapter 4. In regards to wind power, it has been estimated that, by 2030, as much as 25% of the total electricity needs of the country could be satisfied with it, if this technology is exploited to its full capacity (Caldera, 1998). The problem is that to get there, the country should probably start soon, and not enough has happened to move in that direction, with the whole energy sector pretty much at a standstill in many respects, particularly while the electricity reform is waiting to be debated by Congress. So far, more than four years of the current federal administration have already passed like that.

In any case, even when there are some optimistic estimates, there is in reality incomplete knowledge about the true potential for wind energy in Mexico. Some explorations carried out by Mexico's Electricity Research Institute and some other organizations, have shown that the technology would be "technically feasible in some regions of the country", but an accurate assessment is still missing. What is called "probable reserves" of wind power, go anywhere between 50,000 and 100,000 MW (IIE, Web-page). How much of that can be recoverable depends a lot on how wind turbine technologies evolve, what the price of other sources of power is, whether externalities are considered in the costs of electricity, and what locations are really exploitable, given economic, political and social considerations.

Without getting too much into technical detail, I would just mention that the inherent disadvantages of a technology that relies on nature, as wind power does, would impose also a technical challenge. Possibly, through the development of better power storage devices, the problem of the intermittency of the output could be solved, but, in the meantime, Mexico would have to rely on other countries' R&D initiatives to have this issue solved, as there is little innovation occurring in the country.

The availability of trained personnel to install and operate wind farms, if the scale of the generation becomes as big as I am assuming it may if its potential is exploited at a larger scale, poses a further challenge. It may perhaps become less of a problem, anyhow, as the design of turbines gets simpler, with fewer components to worry about (UNDP-UN-WEC, 2000). That would happen, probably, as the technology becomes more widely used, which reveals a paradox prevalent in renewable technologies. They are relatively expensive because they are implemented sparingly, but happen to be used so little, in many cases, because they are expensive.

Finally, a further technical constraint for the more widespread use of wind power generation technologies in Mexico, relates to reaching the demand, not only when it happens, but also where it happens. This, because a technology like wind power is, almost by nature, destined to be located far from major urban and industrial areas. In Mexico, at least, that seems to be the case. And although it is a situation the country has some experience with, since more than 25% of its electricity comes from hydropower, which is also located far from the demand, it still remains as an element to consider, especially since new transmission lines would be required, with the associated costs, impacts, and energy transmission losses.

The intermittency of wind power creates a further problem for CFE technicians, who have traditionally preferred generation technologies over which they have the power to dispatch whenever they need to. This is perhaps the most important technical reason that CFE adduces to sustain strong reservations about wind power interconnected to the grid.

For all the reasons mentioned so far in the La Venta case and the previous chapters, and due also to several other factors that I will discuss later on, among which the political factors are significant, the power generation paradigm in Mexico has not moved to renewable technologies. Instead, the generation technology of choice lately has been the natural gas combined cycle technology, which has mostly been implemented by private investors, as I will discuss in the cases that I have included in the next section.

5.2 Private Power Producers: Three Cases Very Much Alike

This section includes three cases of privately-owned generation plants. All three of these plants operate with a natural gas combined cycle technology, with generation units of roughly similar size and production. The first case centers on what one could call a plant with "mixed" ownership, since it is formally owned by a private firm, although it is operated by the public utility CFE, who leases it. This sort of arrangement may have environmental implications that it is interesting to look at. The other two cases are of purely private plants, owned and operated by transnational firms, although one of them has CFE as its only client, whereas the other has both CFE and a pool of industrial firms buying half of its production each.

The three plants that I will look at belong to different firms, and were funded through different sources and financing schemes. In all, although we can think of them as very similar in many ways, there are also significant differences among these plants, from which I expect to derive interesting and illustrative lessons.

5.2.1 Samalayuca: Private Ownership, Public Operation

The *Central de Ciclo Combinado Benito Juárez*, most commonly known as the Samalayuca II power plant, began commercial operations in 1998. It was conceived under the build, lease and transfer (BLT) scheme, to be leased and operated by CFE, thus formally constituting part of the national electric system (SEN), even though it would be owned by a private investor. As a matter of fact, it is owned not by one, but by a consortium of private companies which includes InterGen (itself owned by divisions of Bechtel and Shell); GE (GE Power Systems and GE Capital Structured Finance Group); El Paso Energy Corporation; and the Mexican construction giant ICA. The arrangement among these investors is that each of the four partners has equal participation in the project.

Total cost of the Samalayuca II plant was in the order of US$ 660 million. This is equivalent to almost US$ 943 thousand per MW of installed capacity, which is significantly higher than the average cost per MW among IPP combined cycle plants later installed in Mexico, which is in average in the range of US$ 550 thousand, according to CRE estimates (see Appendix C). In any case, it is still lower than the US$ 1.1 million per MW that CFE allocated to the La Venta II wind farm project discussed earlier. Of the total investment in the Samalayuca II plant, about US$ 440 million were obtained through loans with commercial banks, and another US$ 75 million came from construction loans with a 10-year term. The Inter-American Development Bank also contributed with a loan of US$ 75 million.

When it was inaugurated by President Zedillo, on August 14, 1998, the Samalayuca II plant became the first large power generation facility funded with private capital to come into operation in Mexico. At the time, it was expected to serve as some sort of experiment of the new model of power generation that the federal government was pushing for, in great part in view of their own inability and unwillingness to make large investments on infrastructure developments of this sort.

According to the terms of the leasing contract signed by CFE and the plant's private investors, when the lease expires, full ownership will be transferred to CFE. The lease is for a 20-year period. Throughout this time, CFE is responsible for the operation and maintenance of the plant, as well as for securing the fuel supply fur running it, while assuming as well the risks associated with fuel availability and fuel price fluctuations. The political risk of the project, on the other hand, was assumed by the private investors that developed it. This fact ended up being no minor issue, especially during the plant's design and construction phases, and also during its first years of operation. Part of the reason for this, as I mentioned earlier, lies in that this was the first large private power generation project in Mexico, so when it was developed, there was even less certitude for private investors than today, as the laws that would later allow the operation of IPP were not in place yet. And to make matters worse, it also happened that during the initial stages of the Samalayuca II project, the financial crisis of late-1994 erupted.

Regarding the plant's site, the Samalayuca II plant extends over a little more than 30 hectares. This land is owned by CFE, who was also the one who decided the site where it wanted the plant developed. Close to the plant, less than one kilometer away, there is the town of Samalayuca, with less than one thousand inhabitants. Both this town and the plant are located within the municipality of Ciudad Juárez, which has a population of more than 1.2 million inhabitants (INEGI, 2001).

The site of Samalayuca II was selected without considering alternative sites. Even for the plant's EIA, there were no alternative locations assessed. And the same was actually the case for the generation technology in place in Samalayuca II. CFE chose it somehow arbitrarily, although they justified the selection of natural gas combined cycle technology by defending that natural gas is cleaner than the traditional fuels they have used in thermoelectric plants (IDB, 1995). This same argument, in fact, has been used by them consistently ever since they started switching power generation to natural gas.

Going back to the question of the plant location, right next to the Samalayuca II plant, there is an older power plant, which is owned by CFE, and operates with conventional fossil fueled technology, although it is running with a mix of natural gas and low-sulfur fuel-oil, imported from the U.S. to be used in the plant so that it meets environmental standards.

As it became common practice later on, when other private generation projects were developed, the site of the Samalayuca II plant is, as mentioned, adjacent to an existing

CFE plant, with capacity of 316 MW, whose name is the *Central Termoeléctrica Benito Juárez*, nowadays most commonly known as Samalayuca I. The main reason for developing new projects next to existing ones, has been to create some economies of scale, especially as existing infrastructure is used. By doing this, it has also been possible to reduce aggregate environmental impacts, although this has rarely been an important criterion, at least explicitly, for site selection.

In Samalayuca, the existing CFE plant used to burn fuel-oil exclusively, until it became one of the CFE plants that switched to natural gas, though gradually, over the first half of the 1990s. Nevertheless, it was again switched back to fuel-oil at some point during the late 1990s. By the mid- 1990s, almost two thirds of the plant were running with natural gas, and the remaining with fuel oil, but for reasons that are not clear, and which probably have to do with CFE's commitment to buy fuel-oil from PEMEX, combined with high natural gas prices, the existing Samalayuca I plant nowadays uses fuel-oil almost exclusively.

At full operation, the newer plant, Samalayuca II, has a generation capacity of 700 MW. It operates with a natural gas-fired, combined cycle technology, and its annual production is in the range of 3,600 GWh. Its location, according to CFE, was decided mainly to satisfy the growing needs of the neighboring Ciudad Juárez, which on top of being highly populated is also heavily industrialized, mainly with *maquila* plants in the electronic and automotive sectors. Part of the Samalayuca II production is also intended for export to the U.S., whose border is about 40 km. away from the plant.

In order to meet the fuel needs of the Samalayuca II and the existing Samalayuca plants, a gas pipeline of 38.3 km., called the Samalayuca-San Elizario pipeline, was built. The trace of the pipeline was established by CFE, who negotiated the rights of way over almost 70 hectares that this development required. Out of that land, almost 90% is desert, and had no commercial use, although some of it expands over sand dunes, which are highly valued by environmentalists. The remaining 10% of the land had some economic use, mostly for cattle rising, and a small fraction, the closest to the Rio Grande, for agriculture. In any case, neither the plant nor the pipeline has created any affectation over any "fragile" ecosystem.

As it has happened with other private generation projects developed later on under the BLT scheme, the decision on which of the bids was the winner among those competing on the open bidding process, was based almost entirely on the cost of MW of capacity installed that they offered to achieve. This differs a little from the criteria that has been used up to date to decide the winning bid among IPP projects that have been awarded through competitive bidding processes, which has also relied at a certain extent on investment cost per MW of capacity installed, but has considered also operation costs, as reflected in the cost per MWh produced that potential IPP commit, through their bid, to achieve.

As I mentioned earlier, all four partners contributed equally with resources for the construction of the Samalayuca II plant, and there was also among them some sort of division of tasks, so each company contributed with what they were the experts on. GE, for instance, contributed the generation technology; Intergen did most of the plant design and engineering; ICA was responsible for much of the construction, and helped a lot to establish the links with the Mexican government, since they are the only Mexican partner in the consortium; and El Paso Energy built the pipeline from the border with the US, to bring in natural gas supplies.

These investors had also to arrange for PEMEX to be in charge of supplying diesel, which is the backup fuel at the plant, whenever it is required. And CFE also intervened in securing fuel supplies, signing a specific agreement with PEMEX so that they are also in charge of the operation, supervision, maintenance and surveillance of the pipeline built exclusively to bring natural gas to the plant from the U.S.

CFE, in summary, was responsible, as I mentioned, for the selection of the site, and was also in charge of obtaining most of the approvals and permits required for the construction and operation of the plant, including its EIA and risk assessment. CFE was also the one deciding the location where they needed the plant developed, within the national territory, as well as the capacity and technology the plant was required to have.

Since the private companies that collaborated for the development of the Samalayuca II plant would not be in charge of the actual operation of it, but would only lease it to CFE, they mostly followed the guidelines that CFE dictated through the open bidding they called for. Although these private investors did in strict sense have some power of decision over technological deployments and the actual design of the plant, they mostly followed CFE guidelines throughout. Concerning environmental controls and technologies, the influence of the corporate practice of the companies in the consortium that built Samalayuca II, was probably felt the most during the design and construction stages of the plant, when there was some division of tasks among the partners in the consortium. Once CFE took control of the plant, there has been far less involvement from the actual owners of the plant on what its operator, CFE, does.

Concretely, the only explicit agreement regarding the environment among the tenants and the lessee of Samalayuca II, is that the latter will comply with all applicable environmental standards while it operates the plant, even though the first have no authority to monitor that that happens, or of imposing penalties if it does not. At the end of the day, CFE has almost complete control over the operation of the plant, and that includes its environmental management.

Ever from the beginning, since the idea came up to build the first large power plant with private investment in Mexico, CFE was pretty much in control over all major decisions. Even the need to locate the plant in the Ciudad Juárez area, out of the whole Mexican territory, for instance, was partly determined by CFE, on the basis of the growing demand of the region, both past and expected, on the capacity to export electricity from there, and also on the availability of fuel and other inputs. Regarding demand growth, before the Samalayuca II plant was opened, it was necessary to import electricity to the Ciudad Juárez region from the U.S., to satisfy as much as 30% of the region's demand, especially during the summer months.

With the operation of the additional Samalayuca II plant, the region nowadays has excess capacity, sufficient to export power, and to respond to the expected increase in demand at least for the next 10 to 15 years. This, since Samalayuca II added more than two times as much capacity as that which was already operating in the region, and since industrial development in the region has not progressed as expected.

In Samalayuca II, there are three natural gas- and distillate- fired combustion turbine generators, of GE technology. These turbines are designed to minimize air emissions, especially of NOx, and also to use less water than comparable technologies, since water is a very scarce resource in the region. The system operating here has an air-cooled condenser, instead of the more common water-cooled. The whole plant has a useful life of approximately 30 years, and operates in compliance with ISO quality standards.

The consumption of natural gas in the plant is estimated at about 650,000 kg. per year, for running the three units. Diesel is also used, as mentioned, as a backup fuel in case natural gas is not available, and for running ancillary equipment. The estimated amount of diesel used in the plant is in the range of 45,000 m^3 per year. Water use, on the other hand, is relatively small for a plant of the size of Samalayuca II, since it has an air-cooled condenser. Currently, average water consumption is 6.3 l/s, and water is extracted from a well located inside the premises of the plant.

For air quality purposes, the Ciudad Juárez region is one of eight regions in the country considered as critical areas. The emission standards that apply in these areas are stricter than for the rest of the country, except for MCMA, which for some pollutants has, as I mentioned when I discussed the case of the Valle de México plant, emission standards even stricter than those of critical areas. Ciudad Juárez is also one of seven cities in Mexico, all with more than 1 million inhabitants, in which a comprehensive air quality program had been put in place. In the case of the Ciudad Juarez air quality plan, it calls for close collaboration with environmental offices on the U.S. side of the border, mainly from El Paso.

Samalayuca II was designed to meet environmental standards applicable both in the location where it is established, but also the stricter ones applicable at the other side of the border, in the El Paso region. When the plant was on its design stages, by mid- 1994, CFE submitted its environmental impact assessment (EIA), together with a risk assessment, to the National Institute of Ecology (INE), which was at the time in charge of environmental impact assessment. INE, in turn, reviewed the EIA, and "conditioned" the development of the plant to a series of terms, which were mostly paperwork requirements, although some concrete measures were also included among them.

Nowadays, there is an office within the Secretariat of Environment (SEMARNAT) in charge of environmental impact assessment. In general, what this office does, which is what INE did for Samalayuca II, is, once it reviews an EIA, to either authorize the development of the project, subject to the compliance of all the measures that had been determined by the proponent of the project. Otherwise, the environmental authorities could approve the EIA, but subject to some mitigation measures, or, when there is no way around it, they could just not approve it. In the Samalayuca II case, INE approved the EIA of the plant, and responded to the project proponent with what looks like a long list of conditions, although in reality, with such response, INE seems to have been trying to establish a commitment with the project developers so that they comply with what they "promised" in the EIA.

Among the measures that INE requested the plant to perform, as conditions for the plant development, there is a regular maintenance program, and a program for accident prevention. INE also requested that CFE installed a monitoring system in the plant, to measure NOx, CO, SO_2, O_2, and opacity of the plume.

In the Ciudad Juárez region, the most important pollutant of concern, especially due to health effects, is particulate matter. Only PM_{10} is regularly monitored there, although PM2.5 is believed to be of greater impact, in great part due to industrial and transportation sector emissions. CO and O_3 concentrations are also often above ambient standards. Ambient pollutant standards are violated about 10% of the days of the year.

Currently, the Samalayuca II plant NOx emissions, at 25 ppm, are well below the emission standard applicable in critical regions, which is set, for the largest sources that use gaseous fuels, at 110 ppm. Still, given the high efficiency with which the plant operates, which is at about 50% or even higher, NOx emissions are higher than, for instance, in the case of the Valle de México plant. In any case, the NOx emission intensity of Samalayuca II is significantly lower than the average of the sector (see Table 5.6), and lower also than the average of all BLT combined cycle plants in the SEN (see Table 5.7 and Appendix C).

SO_2 emissions per MWh produced are also significantly smaller than the average of all thermoelectric plants of the SEN (see Table 5.6), and currently at a level which is roughly equivalent to one sixth the emission intensity of other gas-fired combined cycle plants that are also operated by CFE (see Table 5.7).

The advanced technology implemented and high efficiency achieved in Samalayuca II, have also produced reductions in CO_2 emissions. The CO_2 emission intensity of the plant is significantly lower than that of the sector (see Table 5.6), and of comparable technologies as well, as reflected in the average emission intensity of BLT natural gas combined plants in operation (see Table 5.7). In both cases, the CO_2 emission intensity of Samalayuca II is about 40% lower.

TABLE 5.6
AIR EMISSIONS FROM THE SAMALAYUCA II POWER PLANT COMPARED TO THE WHOLE MEXICAN POWER SECTOR

Pollutant	Plant Total Emissions / Year	Power Sector Total Emissions / Year	Plant Emission Intensity	Power Sector Emission Intensity
SO_2	9.7 tonnes	1.6 million tonnes	0.003 kg/MWh	11.35 kg/MWh
NOx	4,140 tonnes	0.25 million tonnes	1.146 kg/MWh	1.83 kg/MWh
CO_2	1.47 million tonnes	94 million tonnes	405.9 kg/MWh	688 kg/MWh
Hg	3.4 kg	1,313 kg	0.001 kg/GWh	0.010 kg/GWh

Source: Miller and van Atten, 2004; Vijay et al., 2004; Lopez et al., 2004.

TABLE 5.7
AIR EMISSIONS FROM THE SAMALAYUCA II POWER PLANT COMPARED TO SEN COMBINED CYCLE PLANTS

Pollutant	Plant Total Emissions / Year	SEN Combined Cycle Generation Emissions / Year	Plant Emission Intensity	SEN Combined Cycle Emission Intensity
SO_2	9.7 tonnes	350.8 tonnes	0.003 kg/MWh	0.017 kg/MWh
NOx	4,140 tonnes	27,520 tonnes	1.146 kg/MWh	1.324 kg/MWh
CO_2	1.47 million tonnes	9.67 million tonnes	405.9 kg/MWh	665.3 kg/MWh
Hg	3.4 kg	22.6 kg	0.001 kg/GWh	0.001 kg/GWh

Source: Miller and van Atten, 2004; Vijay et al., 2004; Lopez et al., 2004.

For particulate matter emissions, currently, $PM_{2.5}$ emissions are not measured or reported in practically any power plant in Mexico. This makes some sense since a lot of it is in any case of secondary formation, for which case it is the emission of SO2 the one most closely linked to higher particulate concentrations.

After Samalayuca II, there have been several new power generation developments involving private investment. Some of them have followed the same financing mechanism that this plant, although most of the new capacity developed is under the IPP scheme, which is as close as it gets to privatization, except for the fact that construction and operation permits are still granted on the basis of requests for proposals made by CFE and administered by CRE, and except as well for the fact that CFE is the exclusive consumer of all production, determining prices and dispatch. In the following two sections I present a couple of cases developed under the IPP scheme.

5.2.2 Anahuac: Private Generation I

There will be three centrals, one next to the other, in operation nearby the town of Anahuac, in the state of Tamaulipas. They are Central Anahuac (also known as Rio Bravo II), Central Lomas del Real (Rio Bravo III) and Central Valle Hermoso (Rio Bravo IV). These plants are located in a site in the rural areas of the municipality of Valle

Hermoso, which has a population of 58,573 (INEGI, 2001). Their closest town, Anahuac, has a little more than 3 thousand inhabitants, and is about three km. away from the complex site. The Mexico-US Border is approximately 23 km. north.

The Anahuac complex has been working since the beginning of 2002, but has not achieved complete operation yet. The oldest of its plants, Rio Bravo II, began operations in early 2002. It was followed, two years later, by Rio Bravo III, which began commercial operations on February 13, 2004. The newest plant, Rio Bravo IV, is still in its construction phase, and is scheduled to begin commercial operations by mid- 2005. The beginning of operations of each plant has been marked by high profile events, attended even by the President of Mexico.

The three plants in the Anahuac complex run with a natural gas combined cycle process. The technology in operation there is considered, from an engineering perspective, as an advanced technology, with thermal efficiency of about 55%. It includes a combination of several processes. In each plant, there are two combustion turbine generators, one heat recovery steam generator, and a steam turbine generator, that add up to 495 MW of generation capacity.

The Anahuac complex is owned and operated by Electricité de France International (EDFI), through COMEGO, a company created for the specific purpose of competing in the Mexican electricity and gas pipeline management, operation and maintenance markets. In addition, EDFI established a company named COMINSE, to be in charge of the construction of their plants and projects in Mexico.

Paradoxically, EDFI is a subsidiary of Electricité de France (EDF), which is a state-owned utility in France. EDFI alone has assets estimated at about US$ 4.8 billion around the world, out of which they have investments of about US$ 1.28 billion in Mexico, making EDFI, once Rio Bravo IV begins commercial operations, the leading IPP in the country (EDF, 2005), at least when not considering new projects just recently awarded, with which Iberdrola will surpass it in a few years.

The Anahuac plants operate under the IPP scheme, which guarantees private investors the purchase of their electricity, by CFE, for relatively extended periods, as well as the supply of the inputs they require (commonly natural gas) at guaranteed prices. The conditions set in the contracts with CFE that IPP have signed, in the words of some private investors and IPP executives that I interviewed, are, at least in paper, very attractive to private investors.

In the particular case of the Anahuac complex, CFE and COMEGO signed a 25-year contract, by which CFE is obligated to buy all the electricity generated in the complex, at an annual plant load factor of at least 80%. CFE also assumed the risk over fluctuations in the price of natural gas. And COMEGO is obligated in return to sell its output to CFE exclusively, and it is not allowed under any circumstance to provide electricity to any other customer, even if it was a surplus that they were willing to give away for free, to help, for instance, satisfy a particular need of the communities in the vicinity.

COMEGO got some of its funding for the Anahuac complex from the International Financial Corporation (IFC) of the World Bank. For the Rio Bravo II project alone, for instance, which had an estimated cost of US$ 224 million, the IFC financed, through loans given to EDFI, a total of US$ 165 million, which means roughly 74% of the total investment. And more or less the same happened for Rio bravo III and IV, which have roughly the same investment, and in which EDFI had the majority of funds come from the IFC. In practical terms, particularly in regards to the environmental performance and social responsibility policies of the complex, this combination of funding sources implies that COMEGO does not only have to comply with Mexican standards and contracted obligations with CFE, but also that its practices should obey the policies of Electricité de France, its parent company, and of IFC, its main funding source.

The executives and managers of EDFI that I interviewed both in their corporative offices in Mexico City and in the Anahuac site, stressed, and not without certain amount of pride, how much they are doing for the environment (or at least not to affect it), and for the communities in the vicinity of their projects. And they emphasized that they do this, in most cases, to follow what is common practice in their company, and is dictated from France. Currently, for instance, the power plants in Anahuac that are already in operation are certified with the ISO 14001 standard, as it is common among most of the company's facilities. And the EDFI office in Mexico has as a policy to report regularly the environmental and social responsibility practices they put in place, and what it has achieved with them, to both their parent offices in France, and to the IFC. The Anahuac complex is also regularly audited by both EDFI and the IFC, to verify compliance with what is reported or to what the plant has committed to.

The public perception of the Anahuac complex has been an important factor for the plant's executives to get environmentally certified. It is not really a burden, they say, since they already have an environmental management system in place, and already comply not only with Mexican regulations, but also with the corporate dictates from France, with World Bank guidelines, and with CFE contractual obligations regarding environmental controls. In Fact, the ISO 14000 certification they got, is for the whole operation of Electricité de France in Mexico.

Still, no matter how good their practices are and how clean their technology is, a project of the characteristics and size of the Anahuac complex would always have environmental and socioeconomic impacts to consider. These may be minimal if compared to those of comparable plants with dirtier technologies and less developed environmental practices, but they should be acknowledged and addressed just the same.

Among the most relevant of these issues, the environmental impacts of the Anahuac complex include air pollutant emissions; noise from construction activities and plant operations; water supply and wastewater discharges; and municipal and solid waste generation. All of these have been analyzed in the environmental impact assessments (EIA) of the project (one for each plant), with several prevention, mitigation, control and follow-up measures being put in place to address the most relevant ones, as it was a condition imposed by environmental authorities when the EIA was reviewed and the plant's operation permits were issued (Dames and Moore, 2002).

For its operation, the maximum natural gas consumption of the Anahuac project is estimated, when at full load, at about 3.6 million m^3 per day, considering the operation of all three plants. Even when the oldest plant in the complex, Rio Bravo II, is authorized by its contract with CFE to run with either diesel or natural gas, it works exclusively with natural gas, as do Rio Bravo III, and will do Rio Bravo IV, which are only allowed, by contract as well, to run with natural gas exclusively. The use of other fuels in Anahuac, like diesel, for ancillary equipment and as a backup fuel, is negligible. The supply of natural gas comes mostly from the US, through a pipeline that crosses the border with Texas, and which is owned and operated, on the Mexican side of it, by EDFI as well, thanks to another concession contract that they signed with PEMEX. Of all the power they produce, the Anahuac plants consume about 4 to 6% for their own operation (Dames and Moore, 2002).

For assessing the emission of air pollutants, the Rio Bravo II plant has three ambient air quality monitoring stations working since it has been in operation. Besides those, Rio Bravo III and IV have, together, three additional stations. In all these stations, the emissions of the most relevant gas emissions (among them NOx, CO, and O_2) are monitored by continuous systems. To abate emissions, the controls they have in place in Anahuac include low-NOx burners in their combustion turbines. Besides, given the fact that they use natural gas, they have a generation process that is significantly cleaner and more efficient than that of traditional plants fueled with *combustóleo*. Other than that, to allow the maximum dispersion of pollutants, the design of the plants considered the optimum height of the chimneys.

The emission of criteria pollutants at Anahuac is well within the Mexican standards for stationary sources set by the Mexican Official Standard 085 (NOM-085-ECOL-1994), and do also comply with the emission levels set by the relevant World Bank guidelines. In the Anahuac complex, there is measuring equipment at each stack, to verify compliance with standards. This equipment measures PM_{10}, SO_2, and NOx. Besides, they also have an external laboratory carrying out a monitoring campaign two times per year, and so far, until the end of 2004, had also received three inspection visits from

PROFEPA inspectors, without getting any observation or reprimand, since their emissions were well below the standard.

CFE also monitors the plants, since the purchase power agreement (PPA) contract they usually sign with IPP commonly allows CFE to monitor the results of the environmental management system that they require external producers to have in place. In the case of the Anahuac plants, CFE sends inspectors often, and they are even stricter than PROFEPA's inspectors, even though they more or less follow the same procedures. An employee of the plant told me that when CFE comes and inspects them, they always try to make some observation, even if they have to "push it too hard" to find anything not working properly. And this happens even though CFE cannot impose any penalization on them, unless the plant is forced by government authorities to close down as a consequence of a major wrongdoing or even of fortuitous events. In any case, CFE inspectors have also found the Anahuac plant to be in compliance with environmental standards.

Currently, for PM_{10}, emission levels are at about 40 mg/m^3. For SO_2, at 2.7 mg/m^3, which is roughly equivalent to 21.9 tonnes per year, or 0.004 kg/MWh (compared to 11.35 kg/MWh from Tuxpan). For NOx, emissions are in the neighborhood of 82.1 mg/m^3, or 40 ppm, which would be an acceptable level even at a critical zone in Mexico, and even more so in a rural and relatively unpopulated area like the Anahuac region, where the NOx standard is at 141 ppm. These values consider the two units already in operation, and a generation per year, of these two unites combined, of 6,093 GWh.

Considering these emissions, and considering also estimations for CO emissions, Dames and Moore (2002) calculated the maximum impacts on ambient concentrations that the Anahuac operation could have. These calculations were obtained applying an air dispersion model, and the available meteorological data. The model results (see Table 5.8) show that the maximum impact of the complex would derive in pollutant concentrations that would be well within the Mexican and World Bank ambient air quality standards and guidelines.

TABLE 5.8
COMPARISON OF MAXIMUM IMPACT OF THE ANAHUAC COMPLEX TO MEXICAN STANDARDS AND WORLD BANK GUIDELINES

Pollutant	Averaging Period	Maximum Impact [1] ($\mu g/m^3$)	Mexican Standard ($\mu g/m^3$)	World Bank Guidelines ($\mu g/m^3$)
NOx	Annual	11.29	N.A.	100
	24-hr	60.79	N.A.	150
	1-hr	241.59	395	N.A.
CO	8-hr	46.31	12,597	N.A.
SO_2	Annual	0.41	78	80
	24-hr	4.63	340	150
PM_{10}	Annual	5.88	50	50
	24-hr	72.55	150	150

Notes:
1. Maximum impact was estimated with an air dispersion model to evaluate plant impacts on ambient air pollutant concentrations, considering meteorological data for a 5-year period.
N.A.: Not applicable
Source: Adapted from Dames and Moore, 2002.

From the table above, we can see that NOx is perhaps the only criteria pollutant for which the Anahuac complex may have considerable emissions, since NOx emissions are relatively closer to the standard than any of the remaining pollutant emissions are. Maybe PM_{10} could also be of concern (and possibly $PM_{2.5}$, although it is not currently monitored), although, with emissions at about half the Mexican and World Bank standard levels for averaging periods of 24 hours, and much lower in the annual comparison, they are well in compliance with standards.

A further observation derived from the data above is how lax the Mexican standard limits seem to be, especially when observing that, for most pollutants, the Anahuac complex, as it is the situation with the other cases with comparable technology that I am looking at, has emissions which are equivalent to only a fraction of the standard level. This is partly due to how efficient the combined cycle technology and how clean natural gas are, but is mostly the consequence of not having specific air emission standards for power generation plants in Mexico, let alone standards that differentiate across generation technologies. Because of this, roughly the same standard applies to the dirtiest plants, like

Tuxpan, and to the cleaner ones, as long as they are close in size and use the same type of fuel. As I mentioned earlier, in the emission standard that applies to most stationary sources in Mexico, and among them to power plants, acceptable emission limits are established according to the amount and type of fuel consumed, regardless of industrial activity, or type of technology implemented.

Going back to actual missions, currently, with the two plants that are already operating, the CO_2 emission of the Anahuac complex is in the range of 2.2 million tonnes (see Table 5.9). These emissions, considering the operation of its three plants, could reach 3.32 million tones per year (Dames and Moore, 2002), which would represent close to 3.5% of the current total CO_2 emissions of the Mexican power sector. We can compare this to the contribution that Anahuac could have to total generation, when all its plats operate, which could be in the neighborhood of 4.5% of the national.

In comparative terms, for NOx, the emission intensity of the Anahuac plants is significantly below the average of the thermoelectric plants in the SEN (see Table 5.9), and of combined cycle plants that are also part of the SEN (see Table 5.10). And the same happens with SO_2 emissions, of which natural gas plants are not a significant contributor in general.

TABLE 5.9
AIR EMISSIONS FROM THE ANAHUAC COMPLEX[1]
COMPARED TO THE WHOLE MEXICAN POWER SECTOR

Pollutant	Plant Total Emissions / Year	Power Sector Total Emissions / Year	Plant Emission Intensity	Power Sector Emission Intensity
SO_2	21.9 tonnes	1.6 million tonnes	0.004 kg/MWh	11.35 kg/MWh
NOx	2,400 tonnes	0.25 million tonnes	0.39 kg/MWh	1.83 kg/MWh
CO_2	2.2 Million tonnes	94 million tonnes	361 kg/MWh	688 kg/MWh

Notes:
1 Includes only two units already in operation
Source: Miller and van Atten, 2004; Vijay et al., 2004; Lopez et al., 2004; Dames and Moore, 2002; Ruiz, 2004.

TABLE 5.10
AIR EMISSIONS FROM THE ANAHUAC COMPLEX COMPARED TO SEN COMBINED CYCLE PLANTS

Pollutant	Plant Total Emissions / Year	SEN Combined Cycle Generation Emissions / Year	Plant Emission Intensity	SEN Combined Cycle Emission Intensity
SO_2	21.9 tonnes	350.8 tonnes	0.004 kg/MWh	0.017 kg/MWh
NOx	2,400 tonnes	27,520 tonnes	0.39 kg/MWh	1.324 kg/MWh
CO_2	2.2 million tonnes	9.67 million tonnes	361 kg/MWh	665.3 kg/MWh

Source: Miller and van Atten, 2004; Vijay et al., 2004; Lopez et al., 2004; Ruiz, 2004.

Besides air emissions, another environmental issue they face in Anahuac is that of solid waste, although at COMEGO they think it is manageable, and there is in any case a specialized company in charge of it. As for wastewater, they have a treatment facility, and consider that water comes out of treatment in better condition than when they first get it. They do not reuse the water they treat, but leave it to evaporate.

Still, they have had some bad press at least in one local newspaper, where a columnist has published articles blaming the plant's emissions for alleged increases in the incidence of chronic diseases (not specifying which), saying also that Electricité de France built three units, when it was authorized only one (El Mañana, Nov. 14, 2004). The policy of the company has been to always respond to these reports, which it does from the company's headquarters in Mexico City.

Company managers in Mexico told me that Electricité de France applies its ethical codes to all of its plants everywhere. These codes, they said, are those of a public enterprise, since that is what the company is in France. And acting for the public good, they said, is what its inclination is towards and where its good name has been built upon. Furthermore, even though their business in France is mostly with nuclear power, and the environmental issues faced there differ from those they deal with in Mexico, the principles they apply are the same, and respect for the environment is among their top values as a company. Even in the corporate strategy of Electricité de France, there is an explicit commitment to sustainable development, at the core of their efforts to comply with a long-term corporate responsibility work (EDF, 2004).

In Anahuac, they have a social responsibility program in place, which they started because it is common practice in their corporation in France, especially since the company was opened to private investment. As part of this program, they have funded a public library in the municipality of Valle Hermoso, with about US$ 300,000. They cannot support the neighboring towns directly with electricity, as they would have wanted, because CFE does not allow them, but they assigned about US$ 100,000 to help the community with other projects, on the condition that the community itself decided where they needed that money spent, and that the municipal government also contributed funds.

They feel that they are well accepted by the community because they brought jobs, and have somehow created economic spillovers in the municipality where they are located. They made sure to have periodical meetings with the community since the time the plant was under construction. Their approach to the community, in general, has been preventive. In fact, they have as a corporate policy to implement the precautionary principle, and to make it part of the corporate culture. By it, they understand, in practice, "anticipating possible consequences of all their activities" (EDF, 2003), and acting upon them.

The social responsibility plan EDFI has implemented in Mexico, was started by an initiative in their French headquarters, which spread to all their branches worldwide. They apply a European standard of social accountability (SA8000), even though there is nothing similar in Mexico that forces them to do that. Their main principle in this respect, again, is to pursue sustainability, which, as they understand it in practice, involves complying with their social responsibility with the communities where their plants are located, and with their employees.

Part of the reason for applying these principles anywhere they go, is to preserve the good name of their company. To ground their sustainability initiatives, the company establishes a frame of reference from which they derive specific goals that are evaluated every year.

In Mexico, according to what a company manager told me, they are to some extent not allowed to comply with their global corporate social responsibility goals, because of the contracts they have signed with their only client, which is CFE. Their program elsewhere includes, for instance, giving away electricity to the communities that need it and cannot afford it, but they cannot do this in Mexico, since the regulatory framework and the terms of their contracts do not allow that.

In Anahuac, there were public consultations before their plants were built. This, since the IFC, which is one of their main sponsors, required them. And they have also tried to keep an open-door policy and permanent contact with the community, and feel that this, more than being a burden, gives them an advantage.

For the first plant in the complex, CFE was in charge of developing the EIA of the plant, even before the project was out for bidding. For the second and third plants, this has been the responsibility of EDFI. The implication of who among CFE and the private investors is in charge of the EIA, is that, in the latter case, the corporate strategy of the company in question (EDFI in this case) can be of greater influence on the environmental practices and technologies the project will put in place.

Similar to Samalayuca, in the same region where the Anahuac complex is located, although a little farther, some 20 km. away, there is a CFE thermoelectric plant still in operation, although this plant is currently closed, arguably for renovations. The name of this plant is *Central Presidente Emilio Portes Gil*, nowadays also known as Rio Bravo, or Rio Bravo I. This plant began operations in 1964, with two units of 37.5 MW of capacity each. Additionally, another unit came in operation in 1982, to add 300 MW of capacity, and a last one, with capacity of 145.12 MW, was added in 1999. Total capacity of this plant, nowadays, is of about 520 MW. Needless to say, its technology is old, and relatively inefficient and dirty as well.

While this older plant is closed, the emissions of air pollutants in the region have reduced significantly, and that will continue to be the case even with the three plants in Anahuac operating, even when, together, they have nearly three times the generation capacity of Rio Bravo I. This illustrates what the impacts of a technological turnover in power generation could be for air quality, regardless of who owns what.

In the following case, which is the last one I will discuss, I present another example of an IPP plant, which in many respects is very similar to the Anahuac case, although it has singularities from which I expect to derive observations that may help complement the findings derived from this case and from the previous ones, and to develop my further analysis.

5.2.3 Monterrey: Private Generation II

The city of Monterrey is the third largest, and the most heavily industrialized in Mexico. It is located in the northeast portion of the national territory, and has a little more than 3 million inhabitants in its metropolitan area.

The metropolitan area of Monterrey is regarded as a critical area for air quality purposes. The most critical air pollutant there, is particulate matter, and specifically PM_{10}, ($PM_{2.5}$ is not regularly monitored yet), which has reached concentration levels above the standard on about 30 to 90 days per the year between 1993 and 2001 (Mejía, 2002). NOx is another pollutant of concern, both for its health impacts, but also due to its reactivity to form tropospheric ozone. The NOx hourly concentration standard is violated in the Monterrey Metropolitan Area about 10% of the days of the year (Mejía, 2002).

What I will refer to as the Monterrey power plant (commonly known as Monterrey III) is located about 20 km. east of the city limits of the metropolitan area of Monterrey. It is very close, a couple hundreds meters away from the existing Huinalá power plant, which is a 378 MW thermoelectric plant, owned and operated by CFE. The oldest unit of the Huinalá plant is 24 years old, although the plant nowadays runs mostly with natural gas, and not with fuel-oil, as it used to. Contiguous to it, in the middle between the Huinalá and Monterrey plants, there is the Monterrey II power plant, which is a 450 MW plant, operated under the BLT scheme. It is owned by ABB Energy, but operated by CFE. It has been in operation since 2000, running with a natural gas combined cycle technology.

The Monterrey plant operates both under the IPP and self-supply schemes, with half of its total capacity devoted to each. It is owned and operated by the Spanish energy company Iberdrola, who submitted the winning bid in an open bidding called by CFE, and was granted a generation permit by CRE in October of 1999. This permit allowed Iberdrola to finance, build and operate the IPP part of the plant, of 570 MW of capacity, which was set to begin commercial operations in March of 2002. Additionally, the Monterrey plant had a second phase, added after the first one was already allowed. With it, 570 MW of capacity were added, to operate under a self-consumption permit, through a power purchase agreement (PPA) that Iberdrola signed with industrial establishments in the region. Originally, the plant was designed to have two gas turbine units in operation, but ended up with four as it doubled the size it was originally set to have.

In order to get a self-consumption permit, it is customary to demonstrate that there is a guaranteed consumer for the power generated, for at least 10 to 20 years into the future. Besides, the firm or pool of firms that will consume the power generated under this scheme, should enter a bi-lateral PPA with the power producer, and become shareholders of their plant, which they often do, to comply with this legal requirement, by buying one share. Sometimes there are power lines connecting directly to their consumers, but often they have to use the public grid, which belong to CFE. If this is the case, they have to pay for the right to use the grid, at rates determined by CFE, which happen to be among the highest in the world.

The cost of the use of the grid is so high, in fact, that according to what an executive in the IPP business reported to me, Iberdrola has had the problem of having some of the industrialists with whom it has PPA contracts backing off, trying to get out of the purchase agreement.

There were also some other issues around the self-consumption permit that Iberdrola got for the Monterrey plant. One of them was that the company did not notify CRE on time about the opening of the self-consumption unit of the plant, as stipulated in the contract. The notification came to CRE almost eight months after the unit had already started operations, and they were penalized for that. And a more serious issue was that the plant allegedly violated the terms of the contract by selling more power to its private consumers than permitted. According to an audit carried out by the Superior Federation Auditor Office, which is the auditing office of the federal Congress, there was evidence to the fact that, to some of the partners with whom Iberdrola had obtained the self-consumption generation permit, the company had sold more than twice the amount of power allowed by CRE (La Jornada, May 29, 2004).

Nowadays, Iberdrola is the second largest energy firm in Spain, after Union Fenosa, who also owns IPP power plants in Mexico for a total of 1,712 MW. Currently, Iberdrola has about 2,700 MW of installed generation capacity in Mexico. This, after the opening to commercial operations of their fourth plant in Mexico, which is a 547 MW combined cycle IPP plant in the north of the country, called La Laguna II. This plant opened in March of 2005, a month or so ahead of schedule, and was added to the other plants owned by Iberdrola that were already operating in Mexico. They are the Monterrey plant, which is their oldest plant in the country; the Altamira plant, with a bit more than 1,000 MW of capacity operating as an IPP; and the Enertek plant, with 120 MW operating under a self-consumption permit.

Currently, with three plants operating as IPP (half of Monterrey, Altamira, and La Laguna), Iberdrola has a little more than 2,240 MW of capacity under the IPP scheme, according to CRE data (see Appendix C). To this, they will add two more plants that have already been authorized by CRE. They are the Golfo plant (or Altamira V), which is going to be a 1,089 MW plant when it opens in late 2006; and the Tamazunchale plant, which was just recently awarded, in November of 2004, and will have 1,079 MW of capacity, set to begin operations in mid-2007. All these plants will operate with a natural gas combined cycle technology.

Considering both their plants in operation and under construction, Iberdrola will have a little more than 4,400 MW of capacity for IPP production, without considering their additional investments in self-consumption plants, which would add about 600 MW more. Their investments in IPP plants will represent more than one third of the total generation capacity that the IPP sector is expected to have by 2007. By then, Iberdrola will strengthen its new role as the dominant firm in the Mexican IPP market, a position not long ago held by Electricité de France, which would be left with about 1,900 MW of capacity, which means less than half of Ibedrola's, by 2007.

This happens as Iberdrola seems to be getting most of the new projects being opened to bidding, while Electricité de France will have no projects in construction in the immediate future, once they open their newest plant in mid-2005. Part of the explanation for Iberdrola competing more aggressively than other energy firms in the electricity market, according to what I heard from people in the industry, is that they committed to buy generation equipment when the price of natural gas was lower, and the market more attractive, and had some order in progress, and part of this equipment already in stock. This, allegedly, has somehow forced them to try to develop new projects in Mexico, while other firms have been a little reticent to take the risk of fuel price increases, especially since the operation of existing IPP plants has not been as attractive as they initially though, due to high input prices and CFE not dispatching IPP plants at the level they thought they would. At some point, according to what an IPP officer told me, there were up to 15 firms bidding for a project, and all the "big ones" were there. In most recent biddings, especially between 2001 and 2003, not even half as many presented a project proposal, and several of the big power firms were not competing in the "large" biddings, because they were "scared" of having the terms of the PPA and their business plans not respected by CFE.

Still, Iberdrola is doing well in terms of profits in Mexico. Even with the risks and lack of certitude of the market, they have performed financially well, and the Mexican market represented a little more than 12% of the investments the company made in 2004. According to their last financial statements, in 2004 Iberdrola had a net margin in Mexico of about US$ 270 million, which is 57.4% higher than that of the previous year (El Universal, March 17, 2005). Currently, Mexico is the country where Iberdrola has the greatest amount of assets outside of Spain.

Total installed capacity in the Monterrey plant, with the addition for "self-consumption", is 1,140 MW. Iberdrola has a 25-year PPA with CFE, for 570 MW, and devotes the remaining capacity, as I said, to satisfy a PPA with industrial firms. Total estimated investment in the plant is in the range of US$ 604 million, out of which CRE estimates that US$ 313.5 million were required for the IPP part of the plant alone.

Iberdrola got a big proportion of its funding for the Monterrey plant from the Inter-American Development Bank (IDB). In all, out of the roughly US$ 604 million total cost of the whole project, IDB contributed, through two loans, with a total of roughly US$ 450 million, which is about three quarters of the cost of the plant. This has had several implications for the way business is conducted in the plant, since, as a main sponsor, IDB can establish several conditions, among which some relate, for instance, to the environmental management practices applied throughout the construction and operation phases of the plant, the same way as it happened in Samalayuca, where IDB was also a sponsor, although in that case its influence was smaller, since its participation in the funding of the plant was not as significant.

The total investment cost of Monterrey, per MW of capacity installed, is in the neighborhood of US$ 530 thousand. This amount is slightly below the estimated average cost for IPP already in operation, which is close to US$ 550 thousand per MW of installed capacity, according to CRE (see Appendix D). It is also below the average investment requirement per installed MW in a combined cycle plant, which is in the range of US$ 700 thousand (SENER-SEMARNAT, 2002).

For selecting the site where the plant was constructed, CFE conducted an analysis of alternative sites in the region, which represents a huge departure from its practice in some other projects. They determined that the site selected was the most suitable, among four alternative sites that their analysis identified as the most feasible, given a series of technical and socioeconomic criteria, among which environmental considerations were included. As part of the environmental aspects that they analyzed, CFE looked, among other things, at the physical characteristics, the natural value, the air quality of surrounding areas, and zoning regulations of each site.

Even more than that, nowadays, according to the law, private investors who present, in an open bidding, a proposal for building and operating a new power plant, have the prerogative of proposing an alternative site to that which was determined beforehand by CFE, even if this may imply additional transmission costs or other sorts of extra costs, which in any case would be absorbed by the private investor. In strict sense, investors are also free to propose the technology they would implement in a plant, although CFE commonly establishes the type of fuel to be used in any project that they open to private investment, so, in practice, there is little flexibility in terms of the technologies to choose from. In all open biddings for new power generation facilities so far, the site where they have been built has been that which was determined beforehand by CFE.

For the Monterrey plant, the site where it was built has a total area of a little more than 27 hectares. As it usually does with IPP contracts for whose production it is the only client, CFE not only selected the site, but they also bought the land where the plant was to be developed. In this case, which is also common, although not always the case, the plant site is contiguous to existing CFE facilities. This, as I mentioned earlier, is expected to generate some economies of scale, especially as fuel and other inputs like water would be already available at short distances, but also since sub-stations and transmission lines would be more easily accessible as well. For the environment, the consequences of adding new generation plants right next to existing ones are mixed, although case-specific. Some economies of scale may imply a more efficient use of resources, with positive implications for the environment. Still, concentrations of air pollutants, for instance, in places where this is a concern, may increase in and around the particular areas where more point sources of emissions would be added to existing ones, although pollutant concentrations may end up not as spread out. In other words, you may end up with a more serious problem, but localized. Ideally, as in the Anahuac case, on the other hand, there would also be economies of scale for environmental controls, like monitoring stations, or wastewater treatment facilities, for instance, which would provide incentives for improving the environmental performance of these larger power generation "clusters", to give them a name. This, although in Anahuac all three plants in the complex are the property of the same company, and that has been a factor that has certainly facilitated cooperation among them, allowing several administrative and operative economies of scale, whereas in Monterrey, the three plants in the complex are the property of three different companies, so economies of scale are not as important, and even collaboration among plants is not always possible. For monitoring air quality, for instance, each plant in Monterrey has its own equipment, whereas in Anahuac the three plants there share common monitoring facilities.

In regards to fuel consumption at the Monterrey plant, at full operation it is in the range of 4.5 million m^3 of natural gas per day. This fuel is supplied to the plant through a dedicated 6 km. long, 24-inch in diameter pipeline, which is in fact an extension of an existing gas pipeline owned by PEMEX.

Besides fuel, the other major input for the plant operation is water, of which the plant requires about 470 liters/second for operating the turbine units alone, besides having additional requirements in the plant. The water for the turbine operation is treated wastewater, which comes to the plant through a pipeline connecting from one of the city's wastewater treatment facilities, located about 5.5 km. away from the plant. The remaining water used in the plant is pumped up from a well within the plant's site.

The plant is designed as a base-load facility, which means that it operates without interruption, except for maintenance purposes. The four turbine generators of the plant have water-cooled condensers. They are relatively clean, although given the high efficiency of the plant, its technology, and the nature and amount of fuel used for running it, some air emissions result. Besides, the plant's operations generate other environmentally negative spillovers, among which solid waste and wastewater are the most relevant.

Regarding solid waste generated in the plant, a portion of it derives from the plant management activities, but most of it is a by-product of the electricity generation process. Included in solid waste are hazardous and non-hazardous wastes. According to the plant's environmental impact assessment (EIA), the first, of which the plant produces a relatively small amount, are either sent to a treatment facility where they are recycled, whenever this is a feasible option, or they are transported to an authorized site for their disposal. The latter, which include mostly solid wastes deriving from water treatment, as well as innocuous wastes that could be considered as municipal solid waste, are mostly disposed in landfills, but some are sent to recycling facilities whenever that is a feasible option, which means "not excessively costly."

Wastewater is mostly treated within the site of the plant, to meet the national standard for "wastewater discharges to water bodies". Treated water is then released to a creek passing nearby. The effluent released to this creek is about 135 liters/second, which is less than one third of the water intake of the plant. This is a considerable amount of water consumption, particularly since water availability is a major issue in the Monterrey area.

The quality of the water being discharged from the Monterrey plant meets environmental standards, although that does not necessarily mean that it is harmless. Not in Monterrey, but in another one of its plants in the northeast, in Altamira, Iberdrola had a water contamination "issue" just recently. Allegedly, the saline content of the discharge they were making from their plant there to a lagoon nearby was so high, that it provoked a severe affectation to the lagoon ecosystem, killing fish. Still, even when this was an issue of concern to the neighboring communities, the fact is that Iberdrola was not in violation of any standard, since there is none that regulates the saline content of water discharges from industry.

Concerning air emissions, the most relevant at the Monterrey power plant are NOx emissions, and particularly nitrogen dioxide (NO_2). There are also particulate matter emissions of some importance, but not really that significant. The emissions of SO_2 are minimal, and derive from the use of ancillary equipment, and rarely from power generation itself. Only when the need arises to backup natural gas with a "dirtier" fuel, like diesel, due to shortages or operational failures, is when SO_2 emissions can be significant. In any case, this is expected to occur only very rarely.

The NOx emission of the Iberdrola Monterrey plant, with almost 8 thousand tonnes per year, is relatively large, particularly for a densely populated area like Monterrey. And although there are several other industries already operating in the area, including the contiguous Huinalá and Monterrey II power plants, the impact of the Iberdrola plant to ambient NOx concentrations seems to be, nevertheless, relatively significant as well. According to some pollutant dispersion models, the impact of the Monterrey III plant could add to the one-hour concentration of NO_2 of the Monterrey Metropolitan Area, assuming that all NOx emissions are converted to NO_2, a maximum of about 42 micrograms per cubic meter ($\mu g/m^3$) (IDB, 2000). This, with an ambient standard of 395 $\mu g/m^3$, seems relatively large, and could make the difference between complying or not with air quality standards, since the city is often at the limit. Still, the greatest impact of the plant, given meteorological conditions, is probably in the middle of the night, when vehicle emissions, which are the most significant source of NOx in Monterrey, are low.

Looking at the emission intensity of the Monterrey plant, we have that, for NOx, it is significantly lower than the average for thermoelectric plants in Mexico (see Table 5.11), and slightly lower than the average among the country's natural gas combined cycle plants (see Table 5.12). This is explainable partly because the plant is relatively new, but also because it has low NOx units. So is not that the Monterrey plant is "dirtier" than the average power plant in Mexico, but its location increases some of its adverse impacts.

Regarding CO_2 emissions, for which the location of the source is largely irrelevant, the Monterrey plant emits about 2.8 million tones (see Table 5.11). In terms of the emission intensity per MWh produced, CO_2 emissions of the Iberdrola Monterrey plant are a little above half those of either the whole sector's thermoelectric plants, or even those of the sector's combined cycle plants.

TABLE 5.11
AIR EMISSIONS FROM THE MONTERREY III POWER PLANT COMPARED TO THE WHOLE MEXICAN POWER SECTOR

Pollutant	Plant Total Emissions / Year	Power Sector Total Emissions / Year	Plant Emission Intensity	Power Sector Emission Intensity
SO_2	14.93 tonnes	1.6 million tonnes	0.002 kg/MWh	11.35 kg/MWh
NOx	7841 tonnes	0.25 million tonnes	1.06 kg/MWh	1.83 kg/MWh
CO_2	2.8 million tonnes	94 million tonnes	377 kg/MWh	688 kg/MWh

Note: Data for Monterrey was estimated assuming similar conditions to those of the contiguous Monterrey II plant.
Source: Miller and van Atten, 2004; Vijay et al., 2004; IDB, 2000.

TABLE 5.12
AIR EMISSIONS FROM THE MONTERREY III POWER PLANT COMPARED TO SEN COMBINED CYCLE PLANTS

Pollutant	Plant Total Emissions / Year	SEN Combined Cycle Generation Emissions / Year	Plant Emission Intensity	SEN Combined Cycle Emission Intensity
SO_2	14.93 tonnes	350.8 tonnes	0.002 kg/MWh	0.017 kg/MWh
NOx	7841 tonnes	27,520 tonnes	1.06 kg/MWh	1.324 kg/MWh
CO_2	2.8 million tonnes	9.67 million tonnes	377 kg/MWh	665.3 kg/MWh

Note: Data for Monterrey was estimated assuming similar conditions to those of the contiguous Monterrey II plant.
Source: Miller and van Atten, 2004; Vijay et al., 2004; IDB, 2000.

Iberdrola is expanding its business in Mexico, now to renewable energy, although not as aggressively as they have been strengthening their role as the main "external" power producer, through their investment in natural gas- fired plants. Just recently, in any case, by mid-2004, they invested about US$ 600 thousand, to buy a wind generation company called *Parques Ecológicos de México*. This company, allegedly, has a generation permit for developing a self-consumption facility, but it is not in operation yet and it is not clear when it will be. The amount of the transaction done by Iberdrola to buy this plant is, by all means, relatively small, but they are publicizing it widely, to demonstrate their commitment to the environment, especially since they do not have a very good reputation in this regard.

To this reputation, recently contributed an investigation carried out buy a group of NGOs, which revealed that the company was overcharging consumers, supposedly because the power they were selling was "renewable", when that was not the case. Iberdrola had even developed a very aggressive campaign in Europe and Latin America (not including Mexico, though), to convince consumers to buy green power and help achieve the goals of the Kyoto Protocol, but were in reality, according to this investigation, defrauding the public (Perez, 2004).

There are several press reports that speak of Iberdrola's lack of ethics, and even some energy business executives that I spoke to in Mexico commented on the topic. I did not get the other side of the story, so it would be probably unfair to assume that everything negative that I have heard or read about the company is necessarily true, although the evidence that I have looked at makes me suspect that at least some of it is.

At least in what refers to their operations in Monterrey, for instance, there were the issues of them selling more power than authorized, and of not informing the authority on time when they began operations, which I referred to earlier on. In regards to their environmental practices, I did not encounter any major issue pointing out to a failure to comply with commitments established through their operation permits. Perhaps the only observation on this respect is how little beyond what they are required to do they seem to be doing, although, thanks to the technology they have in place, and how relatively lax some environmental standards are, it is not surprising that they are in compliance with standards, often by a wide margin.

The point, again, as in some of the previous cases, is that new generation technology, even when it is far "cleaner" than the traditional one, is added to existing plants, without a turnover taking place. In Monterrey, this has been the case, so the power sector's pollutant emissions have increased (IDB, 2000). It is true that perhaps they have not increased as much as they would have, had the additional generation capacity operating in the city been fuel-oil- fired thermoelectric technology, but still they have been growing.

Possibly this will be reversed a little in the near future, when another plant located in the metropolitan area of Monterrey, called *Central Termoeléctrica Monterrey*, which has been in operation for more than 50 years, closes down. This is expected to occur over the next five years or so, not because the plant is "dirty", but as part of CFE plans to abate generation costs. This fuel-oil fired plant has a generation capacity of over 500 MW, although, as announced in January 2005, it has been gradually reducing its production over the last year, and nowadays operates only as "reserve" capacity, to satisfy peak-hour demand.

Still, whether they are for better or for worse, the changes in technological deployment in the power sector that occur as a consequence of increased private generation, happen with little influence from environmental policymakers. As I will discuss in the next chapter, these changes may have environmental implications, which should be recognized for policy making.

6. LESSONS FOR POLICYMAKING: CROSSCUTTING ANALYSIS

This chapter relies not only in the cases that I have just discussed, but also, at a large extent, in conversations that I had with several stakeholders in Mexico. It also builds upon the issues discussed earlier on in this dissertation, especially in chapters 3 and 4. The analysis, consequently, expands to several aspects that I may have not presented explicitly in my case studies, but which are relevant nonetheless for performing a crosscutting analysis among private and public generation plants in Mexico.

The cases that I have looked at throughout the previous chapter, can be more easily classified according to two variables which are of outmost relevance for my research. They are the technology that is in place in each case, and the type of ownership structure dominant in each of the analyzed power plants (see Table 6.1).

TABLE 6.1
CLASSIFICATION OF CASE STUDIES BY TECHNOLOGY AND OWNERHIP

Technology / Ownership Structure	Traditional Fossil-fueled (Fuel-oil Thermo)	Cleaner Fossil-fueled (NG Comb. Cycle)	Renewable Power (Wind Generation)
Public	Tuxpan	Valle de México	La Venta
Mixed (Privately owned - Publicly Operated)		Samalayuca	
Private		Anahuac Monterrey	

Throughout the analysis of my cases, I have tried to emphasize, selectively, the particular aspects of each case that would be most relevant for the objectives of my research and for the requirements of my analysis (to try to follow as much as possible the method of structured, focused, comparison proposed by George and McKeown, 1985). The intention now, is to make a comparison of these aspects, to develop some propositions that would provide the answers to my research questions. The comparison will not always be easy, especially since I often did not have access to comparable information across all cases. In any case, on the other hand, the cases are in some instances complementary to each other, and the spectrum of observations, although not always comparable, is wide.

I will first center on comparisons on the environmental performance of the plants that I have looked at, but will go a little beyond these comparisons, to look at other aspects, internal and external, that may be, directly or indirectly, influencing this performance. Among them, I will look at technological factors, economic considerations, regulatory pressures, and even corporate practice, among other factors that may explain differences in the environmental performance across the cases I looked at, hoping to derive lessons for policymaking that could be generalized to other plants in the sector as well.

I expect also that, with this analysis, the indications about the factors that may help explain the differential in the environmental commitment of different firms, serve to define some observations for policy design for the environmental sector, which I will attempt to sketch later on, in Chapter 7.

6.1 Comparing Air Pollutant Emission Intensities

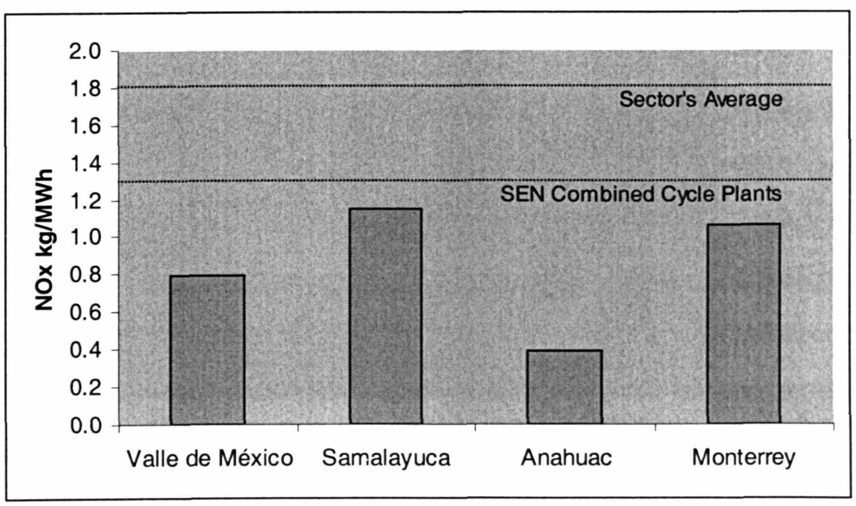
The first comparison that I will make, and probably the one where the variability across cases would be more evident, particularly since it can be evaluated in quantifiable values, relates to the pollution intensity of the plants that I have analyzed in my case studies. It makes sense, first, to look at the four cases of plants that have similar technology.

At least for the most relevant pollutants of concern for which there is also comparable data available, which are NOx, SO_2, and CO_2, we can see that the level of pollutant emission intensity across the 4 cases with combined cycle technology that I have looked at is close to one another (see Figures 6.1, 6.2 and 6.3).

For NOx (see Figure 6.1), all four plants have emission intensities below the average of the power sector's thermoelectric plants, and also below the average of the national electric system (SEN) combined cycle plants. The Anahuac complex is the one with the lowest emission intensity for NOx, which is somehow a pity, since it is, from the four cases, the one located in a very rural area. The Valle the Mexico plant, which is publicly owned, comes next, with about twice the NOx emission intensity of Anahuac, although still below either Monterrey or Samalayuca, which are privately-owned, although the latter is publicly operated. As I mentioned in my case analysis, the Valle de México plant has had large investments put in place exclusively to abate pollution, and they seem to be paying back. In fact, the level of investment in that plant is probably the largest CFE has made anywhere to improve the performance of a plant already in operation.

In regards to NOx emissions, the combined cycle technology, in any case, does not perform as good, in comparison with traditional fossil-fuel technologies in operation in Mexico, because it relies on natural gas, which tends to increase NOx emissions, unless further controls are put in place, which is what happened in all 4 cases that I looked at.

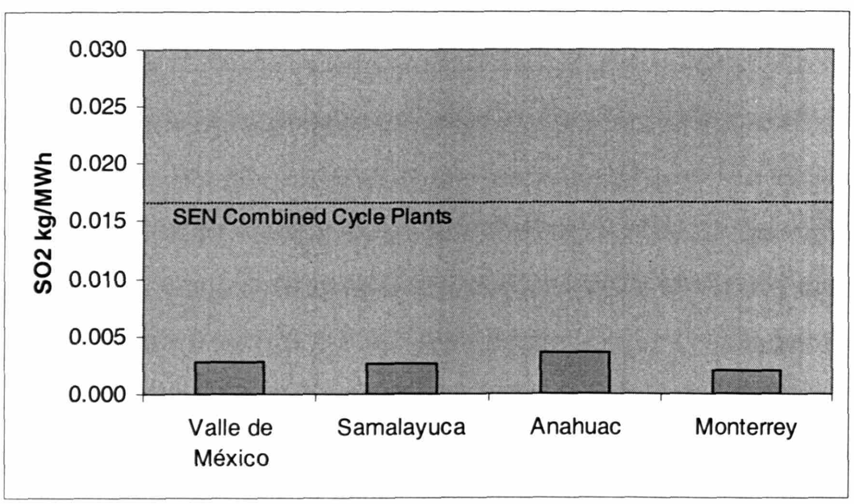
FIGURE 6.1
COMPARISON OF NOx EMISSION INTENSITIES



For SO_2 (see Table 6.2), there is very small variability in the emission intensity across cases. Anahuac is slightly above the other three plants, and this may be due to the fact that one of the two units already operating in Anahuac is authorized to run with either natural gas or diesel, and it may be using more of the latter since natural gas has become scarcer and more expensive. The other three plants that I analyzed are only permitted, by contracts with CFE, to use natural gas, and their use of diesel or of any other fuel is limited to emergency situations. In any case, if seen in comparison with the average emission intensity of the sector, the level of emission of any of the combined cycle plants operating in Mexico would pale, so much that I did not even include it in Figure 6.2, because, at 11.35 kg/MWh, it would be way off the plot.

The huge difference in the SO_2 emission intensity between traditional fossil-fueled plants using fuel-oil, like Tuxpan, with an emission intensity of 16.9 kg/MWh, and the SEN natural gas combined cycle plants, which is at 0.017 kg/MWh, is explainable, more than for the difference in generation technology, for the difference in the sulfur content of fuels. Possibly the greatest environmental impact from the switch towards natural gas that has occurred in the power sector in Mexico, has been precisely the avoided SO_2 emissions.

FIGURE 6.2
COMPARISON OF SO_2 EMISSION INTENSITIES



Concerning particulate matter emissions, I did not have access to comparable data for all plants. Some firms, in fact, measure these emissions, and a few even monitor them, but there is no common practice on this respect. Even for the data that I got, of which I presented some throughout my cases, some is for total suspended particles (TSP), another relates to PM_{10}, and yet another to $PM_{2.5}$. In any case, the particulate matter emission intensity of combined cycle plants operating with natural gas would be expected to be at a fraction of that of conventional thermoelectric plants operating with high sulfur content fuel-oil.

In regards to CO_2 emission intensity, the average of SEN combined cycle plants is just a little below the average of the thermoelectric power sector. Together with NOx, for which the natural gas combined cycle technology tends to even increase emissions in respect to fossil-fueled plants, for CO_2, the emission intensity among combined cycle natural gas- fired and traditional fuel-oil- fired plants, in average, does not vary significantly from one another.

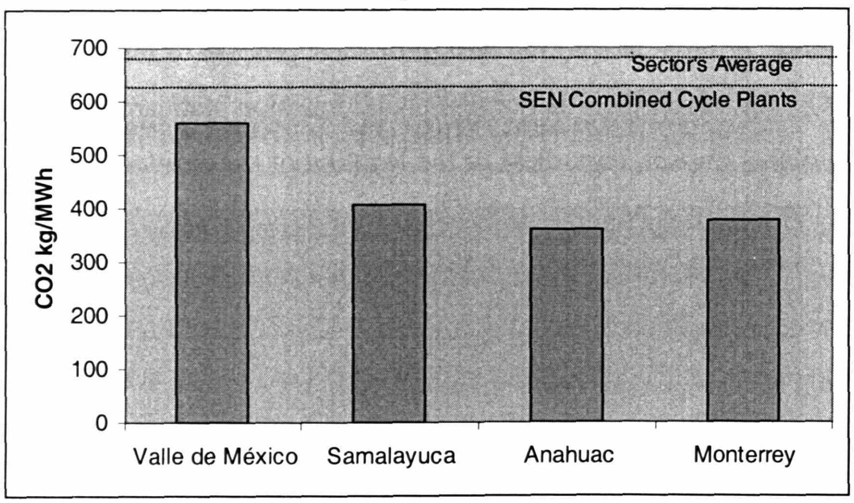
In the case of NOx, at least several of the combined cycle plants running with natural gas have put in place, as I described in some of the cases in Chapter 5, additional emission control equipment, or have altered the design of their process to reduce these emissions. But not for CO_2, for which there is no applicable emission standard, and whose impacts have mainly a global impact, regardless of the location of the emitter.

In fact, often, in Mexico, CO_2 emissions are an afterthought, and are still categorized among the "unavoidable impacts" of economic development that I referred to in Chapter 1. Among CO_2 emissions, those that derive from fossil fuel use are probably the largest part. In total, carbon emissions from the consumption and flaring of fossil fuels in Mexico, in 1999, were estimated at approximately 100 million tonnes of CO_2. And according to data from the National Program on Climate Change, roughly 97% of all greenhouse gas (GHG) emissions in the country are CO_2, and to them the energy sector contributes with around 24% (CICC, 1999).

The power sector is a major source of CO_2 in Mexico, and although the sector's hevier reliance on natural gas combined cycle power plants has produced some avoided emissions as a consequence, the difference from traditional power generation technologies, in terms of CO_2 emissions at least, is not that significant in average.

Still, we can see some variability across combined cycle plants (see Figure 6.3), which speaks to the fact that additional emission controls and "cleaner" generation practices may have an impact on the level of CO_2 emissions, making emission intensity vary even across very similar plants. From the cases of combined cycle plants that I looked at, the Valle de México plant is evidently the one with highest CO_2 emission intensity, more than 50% above the other three plants, even though it is still below the sector's and the SEN combined cycle plant's averages. I do not have a clear explanation of why the Valle de México CO_2 emissions are relatively high, but suspect that that may be due to the fact that it is still not fully converted to natural gas combined cycle technology, and some of it, although with natural gas, still operates with a more traditional steam technology.

FIGURE 6.3
COMPARISON OF CO_2 EMISSION INTENSITIES



If we add to the comparison of pollutant emission intensities the other two cases that I included in Chapter 5, which are the very traditional Tuxpan plant, and the technologically more developed La Venta wind farm, we would probably conclude that they these two cases are at the extremes in terms of emissions, with natural gas combined cycle plants somewhere in the middle, closer to one or the other of these extremes depending on which pollutant we are talking about, and also on what management practices and control technologies are put in place at each particular plant.

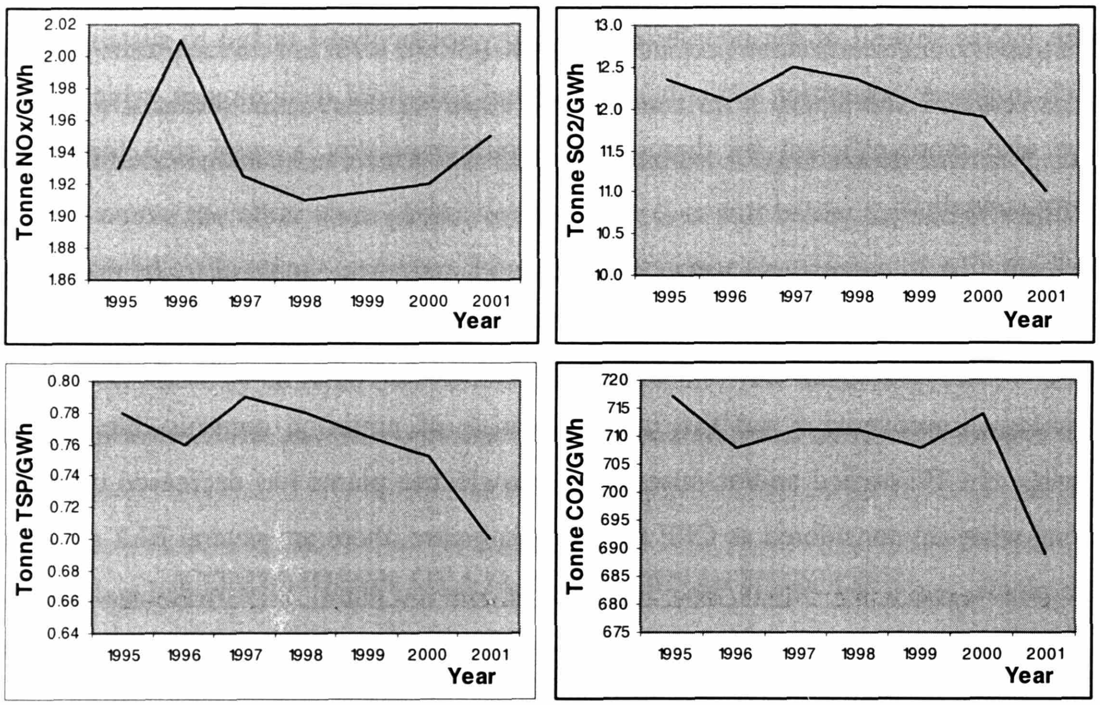
And it is precisely the fact that combined cycle plants represent a departure, in terms of environmental performance, from traditional generation technologies in place in Mexico, which makes several of the people in the energy sector that I talked to sustain that the switch in power generation towards these natural gas- fired technologies, which happen to be also more efficient by themselves, should represent a good step forward for environmentalists.

Probably they have a point, since it has been observed that, in good part because of the implementation of natural gas- fired generation at a large scale, but also thanks to some technology improvement and the implementation of emission controls, the emission intensity of CFE owned and/or operated thermoelectric plants has decreased over time. Among what are considered as CFE plants, in any case, there are several BLT combined cycle plants, and a few others, like the Valle de México plant, fully owned and operated by CFE, but nowadays running mostly with natural gas to meet environmental requirements.

Comparing the emission intensities of different pollutants for CFE plants (see Figure 6.4), my first impression is that, although the emission intensity of practically all of the most relevant air pollutants is decreasing over time, the NOx emission intensity per GWh produced, at least for CFE plants, is actually increasing. The explanation for this lies, in fact, in the switch to natural gas technologies, which even though it implies the use of more efficient processes, has the caveat of them increasing the emission of NOx, as I discussed in Chapter 5. The same fuel switch is to blame for the decrease in the emission intensity of the other three pollutants included in Figure 6.4.

For the private firms in the power sector, there is practically no recorded historical trend in pollutant emissions to analyze, and possibly compare with that observed in CFE plants. Also, the technologies among private power producers are much more homogeneous than in CFE, and they are also relatively new, so significant changes across the relatively short time that they have been in operation are very unlikely.

FIGURE 6.4
EMISSION INTENSITY AT CFE PLANTS



Source: SENER-SEMARNAT, 2002

The comparison between CFE and private firms is not always straightforward, and not only because technology varies, but also because CFE, by being so much in control over the whole power sector, can be determinant over the performance of private firms of whose production it is the only buyer. Still, the emission levels that CFE expects the private plants they put to open bidding among external producers to comply with, are not comparable to those they enforce in their own plants. As an official from an IPP told me, "you can see the difference with a naked eye, just by looking at the smoke plume coming from CFE *thermos* and from IPP plants".

Finally, the link from emissions to health and ecosystem impacts is still little known, and there has not been a study comparing the externalities of traditional power plants and combined cycle plants, or even of renewable generation facilities. At a large extent, environmental authorities often have to rely on common sense, in lack of sufficient evidence to support the design policy.

6.2 Looking at Other Environmental Practices

In the first IPP projects developed in Mexico, CFE assumed the responsibility for carrying out the EIA and for seeing that these private projects complied with other environmental regulations. Nowadays, this is the responsibility of private investors. There may be a direct implication of this in the environmental performance of a plant, which I would expect would be in most cases positive, given that there may be now more involvement from the corporation that is sponsoring a particular project, in the design of environmental controls and the implementation of technologies, even at early stages of project development.

Still, beyond what is commonly requested by CFE to private investors, and what is required by environmental standards, whatever environmental practices power producers put in place is, still, pretty much for themselves to decide. This, regardless of whether they are the ones who perform the EIA or not.

From the cases that I looked at, probably the most significant observation regarding what factors may drive environmental practices among private firms in Mexico, is that the level of "environmentalism" of each firm depends at a large extent on the corporate practices of the firm they belong to, and on the commitments they have made, in each case, with the institutions providing the funds for their projects. We have, for instance, the Monterrey case, in which although Iberdrola has complied with all environmental standards, including those imposed by IDB, which funded part of this project, it has followed far less of a social responsibility program than, for instance, the Anahuac plant, and has less environmental protection practices in place, and has even had some administrative misdemeanors sanctioned. In Anahuac, on the other hand, they have several practices in place in terms of environmental protection and social responsibility, because they are compelled to do that by their parent firm, Electricité de France, and at a certain degree as well by the IFC, which funded part of Anahuac through loans.

A further indication of minimal commitment to the environment in the Monterrey plant, for instance, is that it has water-cooling technology, although it is located in an area where water is scarce, and where there is a high population density. The plant uses treated wastewater, nevertheless, but some of it is not recoverable. And it could use a dry cooling system instead, but that would be costlier, and they are in any case not obligated to do it, so it would probably represent, to them, an unnecessary expense.

Regarding corporate practice (of which I will talk in more detail in section 6.5), it seems that private energy firms try to improve their environmental and social performance, in general, when they need to build or preserve a good reputation, which not all firms in the sector, including the private ones, have at this point.

Still, the impression that some people in the environmental sector in Mexico have, is that private power producers would have, necessarily, good practices in regards to environmental protection and social responsibility. I observed that this is not necessarily true, and would suggest that private power plants keep being monitored closely by environmental authorities, and maybe, knowing that they are capable of implementing more sustainable practices in other countries, that the standard that applies to them is set at a level only achievable with the best available technology, even if this meant a differentiation from what other establishments with older technology, like CFE's, are forced to comply with in Mexico.

Maybe the good impression that some have of private power producers relates to the fact that they compare them to CFE, which has not precisely been at the forefront of environmentalism. Still, I have to recognize that, somehow amazingly, and probably for reasons that have to do with improving their reputation, CFE has achieved some improvements in some of their most visible plants, like, for instance, the Valle de México plant that I looked at as part of my case studies.

In general, CFE is notorious for its lack of transparency. Some of the people that I interviewed in Mexico, and even high-level officials within the Ministry of Energy, agreed on that it is often difficult to get to meet with them to address issues that sometimes are even of common interest. I will refer more extensively to the public perception of CFE later on in this chapter.

6.3 Comparing Technologies

Combined cycle plants have several economic advantages when compared to conventional fossil-fired generation plants. For once, the average investment required, per kW of installed capacity, is about US$ 700 for the first, while it reaches US$ 1,200 for the latter (SENER-SEMARNAT, 2002). This may be the most important criterion to favor the first over the latter in Mexico, where resources for investments are so limited. Besides, the time it takes to develop a combined cycle plant is about half that required for a conventional plant of the same size, which may also be an important criterion, especially since capacity is being developed in response to increasing demand, and not really at the pace that would be necessary to at least leave enough excess capacity as reserve, as it is customary in electricity markets.

The operational costs are also significantly lower in combined cycle plants, which are relatively capital-intensive. This is more the case, though, when compared to conventional publicly-owned plants, in which factors other than efficiency criteria have determined the size of the workforce employed in the sector.

Regarding the cost of fuels, which makes for a large proportion of the final costs per kWh produced, fuel-oil and diesel are cheaper, per caloric unit, than natural gas. Even when accounting for the difference in efficiency among traditional thermoelectric plants, which is in the neighborhood of 40%, and that of natural gas combined cycle plants, which ranges from 50 to 55%, and for the difference in caloric content among fuels as well, the cost differential between fuels is such, nowadays, that it is still cheaper to use the traditional fuels.

Besides, despite them having the lowest capital cost component, their variable cost is relatively high, so combined cycle gas-turbine plants are very sensitive to changes in natural gas prices (IEA, 2004). On top of that, there are other than economic reasons not to switch all fossil-fueled generation to natural gas, the most important one being, perhaps, that the country is not self-sufficient in natural gas.

The price of natural gas has been steadily increasing in Mexico. By late 2004, it was at US$ 7.27 per million BTU, which means an increase of almost 33% in respect to one year earlier, when it was at US$ 5.48. One factor for price increases in natural gas, is its price in international markets, which is set as a reference for determining its domestic price. Also important is the fact that there is a relative scarcity of natural gas in the Mexican market, which makes natural gas imports necessary. With more imports, the effect of price hikes in countries where Mexico gets its gas from is even greater. This is especially the case with the US, which is the main international provider of natural gas imported by Mexico.

Paradoxically, with more investments in natural gas generation, due in part to the economic attractiveness of generation technologies using this fuel, this attractiveness decreases, as the price of the fuel increases with higher demand. The situation with natural gas prices is currently so bad, that CFE is switching back to fuel-oil some of its plants, as I mentioned in the Monterrey case, that are currently running with natural gas. And for private generation, even though it is a common practice among them to have a "coverage" protecting them from fuel increases, through "futures" they acquire up to 18 months in advance, the situation of high natural gas prices still reflects in higher costs, and has also ended up creating some struggles with CFE, with whom there has been some disagreement over who should assume the risk of natural gas price variability and availability fluctuations, since there is some ambiguity on this issue on some PPA contracts.

So far, CFE has had its financial performance negatively impacted, by assuming some of the impact of higher input prices, although, at the end of the day, the increase in the price of natural gas has been in good part transferred to society, since it has reflected in higher electricity prices to end-consumers. During 2004, for instance, the cost at which private producers offered their power to CFE increased by more than 20%, with the explanation for this lying almost completely on the increase in natural gas prices.

New technologies implemented in Mexico, in any case, seem to be developed in addition to existing ones. And even when there are several relatively old plants in operation, electricity demand is growing faster than the generation capacity of the country, so unless substantially greater investments in generation are put in place, a turnover is unlikely. In any case, just a few months ago, in December of 2004, CFE announced that they have plans to close down 30 of their oldest thermoelectric plans, to try to abate increasing generation costs and to reduce their financial problems. These closings would occur gradually, between 2005 and 2012, and, when completed, will result in a retirement of 4,204 MW of fossil-fueled generation capacity, which is roughly equivalent to 8% of the total national generation capacity.

For environmental policy purposes, if the sector has to expand in any case, better that it does so with cleaner technologies. Still, these are in most cases additional to existing capacity, so even if the sector's average emission intensity per kWh produced decreases with these technologies in place, as it is happening for most pollutants, as long as the generation capacity of the country increases by a higher proportion than the reduction in its emission intensity, there will be an issue for environmental policymakers to be concerned about.

Besides, a switch to a relatively clean technology, like that in natural gas combined cycle generation plants, may be positive, but is not the best option for the environment, and the country will still be relying on fossil-fueled technologies for at least 20 to 25 years longer, since the useful life of these plants is at least that long.

What is even worse, from the environmental perspective, is that not all technology changes occurring in the power sector imply a move towards cleaner technologies and practices. More than anything, what seems to be driving CFE technical decisions these days, is the financial struggles that they are going through, and if saving some money means a detriment to the environment, they go ahead with it. As mentioned earlier in the description of my case studies, and again a few lines above, CFE has plans to close several of its oldest facilities down, with the sole purpose of abating costs, and this measure, although nor purposely, may have positive environmental consequences. But at the same time, they just announced, in March of 2005, plans to switch back to fuel-oil, completely, nine of their plants currently using mostly natural gas. The rationale for doing this is purely economic, as fuel-oil is cheaper. They recognize that it is also dirtier, so the effects on the environment could be negative, and foresee that additional investments in pollution control equipments may be required, although in an amount not specified, to "comply with their environmental commitments" (Reforma, 14 March 2005). The list of facilities that will switch back to fuel-oil, includes Monterrey I (which is also included in those to be closed over the next seven years), Samalayuca I, and Río Bravo I.

In general, CFE traditional technical bodies seem to be reluctant to any major change in technology. This fact can often constitute a barrier for technology improvement, and particularly for renewable generation technologies. Not everybody that I spoke with in Mexico shares this impression, but it seems as if the existing structures and capacities of the current state-owned utilities, which are not flexible enough to adapt to new technologies, impede the switch towards technologies they have little experience with in practice. Currently, for instance, there are projects with renewable power already approved, for about 800 MW of installed capacity, that CFE has created barriers to put in place. There is also, for instance, the La Venta II wind power project, which I mentioned in the La Venta case, which is still, and after considerable time, stuck.

Several stakeholders in the sector that I interviewed, recognized that some renewable industry could develop, even at a scale big enough to export technologies, but only if the market for these technologies is created. There is already some national industry, particularly in the solar thermal segment, which has been operating for more than 20 years, and this is enough evidence to some, to demonstrate that the business can be profitable.

There was, recently, the case of some Danish industry that was interested in locating a plant for producing wind turbines in the coast of Oaxaca, both for national consumption in the La Venta region, which has one of the largest potentials anywhere in the world, as I mentioned earlier, but also to export from there. At the end of the day, the lack of certitude over the domestic market conditions for renewable generation, especially in view of the lack of legal certitude, kept this investment from taking place. And a representative from the National Association of Solar Energy (ANES) told me that they were also interested in importing wind turbines, to assemble them in Mexico, but that this investment has not happened yet either, partly for the same reasons.

In all, as I discussed in the La Venta case, wind technology is the renewable power generation technology which seems to have the greatest potential in Mexico, although there is also place for other technologies, especially as renewable resources other than wind are becoming "economic" in certain cases, even more than wind power, which is not available everywhere.

In regards to the barriers imposed by CFE to renewable technologies, there is the fact that they do not know how to deal with them, as I mentioned earlier, but there is also a cultural factor, since they generally do not perceive the "need" to move to cleaner technologies.

As one of my interviewees put it, even within the Secretariat of Energy, the same as in the public energy utilities, "the promotion of renewable energy is done almost as a curiosity, without serious commitment to it". And in general, there is no long-term vision in the national energy model. The current trend in generation is to switch to natural gas, but the country has to import his fuel. Suddenly, without any planning, 5 re-gasification stations were built, and natural became the fuel in fashion. Environmentally, going from fuel-oil or other dirty fuels to natural gas for power generation, could be seen as a good step in the way towards *renewables*, but it could also create structures that it will be difficult to change.

This perpetuation of fossil- fueled technologies may be explainable, at least in part, since the country is an oil producer, and there are strong links between the public oil and power utilities. In any case, it should perhaps be acknowledged that there is also a great potential for renewable energy in Mexico, which is not currently exploited.

6.4 Assessing Economic Considerations

According to the federal budget, in 2005, CFE will use about 36% of its operational budget to buy electricity from private producers. The amount to be paid to external producers during the year is estimated at almost US$ 3.7 billion.

Currently, IPP produce power at a cost of approximately US$ 0.07 per kWh, whereas CFE generation costs are a little more than double that amount, slightly above US$ 0.14 per kWh. The difference in cost is partly due to technical reasons, since IPP have newer generation facilities, and on top of that the combined cycle technology they use throughout is *per se* more efficient than the average fossil-fueled thermoelectric plants owned by the public utilities. Besides, CFE, as well as LFC, carry a high burden with the high financial costs of the large capital investments they made several years, and even decades ago, as well as the costs of maintaining a large payroll. In addition, given the financial struggles they face, and given the fact that they are assigned an operating budget on a yearly basis, the public utilities do not have any "coverage" against fuel fluctuations in the longer term, so they are more directly impacted by price increases when they occur.

Private power producers usually have a capacity payment from CFE that is guaranteed, although the actual payment for energy produced is not. Originally, private producers expected that they would have a dispatch of at least 85% guaranteed, but this has not been the case lately, so the payments they receive are less than expected, and in consequence their interest to bid for new projects has decreased, as I explained in the

Monterrey case, in which I discussed how Iberdrola has become the dominant firm in the market.

The dispatch is lower than expected, because the power demand growth was initially overestimated. The fact is that, during the first three years of the Fox administration, from 2001 to 2003, as I discussed earlier, the economy stagnated, and electricity demand grew accordingly. And on top of that, the country had a couple of years with rain much above the average, so its dams were full, and consequently hydroelectric generation was higher than expected.

In any case, CFE is currently buying less electricity from IPP than anyone expected. And they are currently still discussing the right interpretation of the PPA contracts, since the latter understood that their dispatch, at least at a minimum level, was guaranteed, while CFE defends that this is not the case, and that they can dispatch at their own discretion.

At the end of 2003, dispatch to IPP went, from one day to the other, from about 85%, to 75%. A further issue for IPP was that they, commonly, had purchase agreements for gas supplies, and they had to absorb the costs of canceling some of them, which was another point over which there was some misunderstanding in the PPA with CFE, particularly regarding who should assume the risk over natural gas demand and price fluctuations, as I discussed earlier. As a result, according to an IPP manager that I interviewed, the return over investment that some IPP are getting is 30% below what they expected.

In all, there have been several ambiguities in the contracts signed between CFE and IPP, which have led to contention and litigation, due to differential interpretation of contractual clauses among them. One of the most relevant cases had to do with whether CFE should assume or not the fuel supply risks. In recent generation projects awarded to private investors, CFE no longer took the fuel supply risk through contractual responsibility, but left to the IPP the responsibility to arrange for its fuel, often through direct contracts with PEMEX and its affiliates. This created some additional disenchantment among investors, as the supply of natural gas was not guaranteed, especially if demand grows. For the latest projects, CFE retook the fuel supply risk, being obligated by contract to pay capacity payments to external power plants in those cases where CFE is not able to dispatch them due to natural gas shortfalls.

As an IPP officer put it, "their firms are paid for their capacity, and not for the risks they are assuming, and the change in the rules of the game, has produced a disincentive for them to bid for new generation projects, and may hurt the expansion of private generation, unless CRE protects their business".

Another problem with CFE treatment towards IPP, came up because, even when private producers have a smaller payroll than comparable CFE facilities, so they would have a cost advantage there, they have been "asked", according to an investor in the sector, under their contractual obligations with their only client, which is CFE, to hire unionized labor, who belong to the national union of electricity sector workers. And not only that, but they have been "allocated" more workers than necessary. This, if true, reflects how much control CFE has over the market, and over the practices applied by even external producers.

Regarding the price of inputs for power generation, which is another economic consideration to take into account, as it may have environmental implications, currently, PEMEX and the Secretariat of Finance have almost complete discretion to determine fuel prices in Mexico. The way they do it is often conducive to increase revenues for the public sector, but it impacts consumers, including both final and intermediate consumers, negatively.

Industry, in response to high prices, whenever it has the possibility, is co-generating or entering PPA with private power producers that could operate under the self-consumption scheme. For industry, it is partly the cost of electricity that motivates it to look for alternative options, but also the "generalized inefficiency of the service provided by CFE", as an industrialist told me. The whole industrial sector, this person said, is losing competitiveness due to CFE practices. With privatization occurring, at least in his opinion, "industry has ended up better off".

There is in fact so much resentment towards CFE among some industrialists, according to what another industrialist told me, that some industries that have co-generation or self-consumption permits and end up with generation excess, prefer to waste the power they do not use, than to sell it to CFE at whatever price CFE determines arbitrarily. This reflects, this person said, how upset they are with CFE for the poor service provided to industry, and for the control this company exercise over the electricity sector.

Currently, deficiencies in the power service affect the competitiveness of the industrial sector. The service is not reliable, of poor quality, with constant changes in voltage, and also expensive, in comparison with other countries. As I mentioned in Chapter 5, even domestic consumers have organized to demonstrate against CFE for the poor quality of the service they provide, and at what cost.

As hinted when discussed the case of the Monterrey plant, private investors were initially very aggressive in the open biddings for IPP and other sorts of private investments the government was calling them to bid for, and there was a lot of competition to get the PPA contracts with CFE. The terms of these contracts seemed very attractive to private investors, although in reality the market has not been as good as they expected, partly because of higher fuel prices than expected, but also because CFE and the government in general are not providing clear rules, and exercise too much control over the market.

6.5 Looking at Corporate Practice

In the mission statement of CFE, one of the postulates they have established is the "protection of the environment, the promotion of social development, and the respect for the communities where their projects are located". And among their objectives, which are understood by them as practical steps to accomplish their mission, one relates to "being recognized by their clients as a firm of excellence, which is worried about the environment, and is oriented towards service" (CFE, 2005).

CFE's environmental approach is largely symbolic. It seems to be driven by the need to be perceived as concerned about the topic, and as being active in tackling it, while in reality they do just the minimum necessary to achieve that. In reality, their motivation in deciding whether to implement or not better environmental technologies and practices, in other words, seems to be rational, determined by an estimation of the costs of environmental improvement (or even compliance, in some cases) in comparison with the benefits. The cost-benefit ratio they have came up with, it is clear, is in most cases negative, which is somehow expected since they have the monopoly over power distribution and at a large extent over generation as well. Their market, in other words, is not impacted at all by their environmental performance. And they do not have prestige as an environmentally responsible firm that they would care about preserving either. At most, and not minimizing some important improvements they have achieved, as illustrated with the Valle de Mexico case that I discussed earlier, and with others that we can find here and there, CFE has had to respond to the pressures imposed by higher spheres of the public sector, which in turn may obey several factors when imposing these pressures.

That CFE has a rational approach to environmental protection is explicit in their policy lineaments. One of them, states that they aim at complying with national environmental standards, and although they understand that these standards set only the minimum necessary to comply with, their position will be to do more, but only "as long as this is rationally justifiable" (CFE, 2005). And there is further indication in their policy guidelines, where it is clear that CFE commits to do "as much as the possibilities of the firm allow", to implement environmental policies.

A government officer that I talked to mentioned that CFE is "like a huge monster dealing with several problems", one of which is its environmental practice, and particularly the image that others have of it. It seems, this person argued, that the people in charge of the environment within CFE, believe that their mission is to justify whatever action the company takes, without even attempting to alter it in pursue of more sustainable alternatives. This approach contrasts with PEMEX', the other large public energy firm, whose employees seem genuinely concerned about changing their practices, in order to improve their environmental performance, often achieving even more than what is required by the laws. A reason that may explain the different approach, according to what a SENER official told me, is that PEMEX is an international company, while CFE does not export, and is not "visible" internationally.

The argument that CFE uses to defend its poor environmental performance is the lack of resources. Their reaction to studies that somehow criticize their environmental performance, even if these studies are constructive, like the assessment of the externalities of power plants that I discussed as part of the Tuxpan case, has been to ignore them, for instance by not sending a representative to the meetings where the results of these studies are discussed or presented to the public. It has even happened that they do not attend seminars or workshops where environmental topics are discussed, even when all expenses are paid.

The General Director of CFE himself, stated recently that the Mexican electric sector is stuck in a 30-years old paradigm, which contrasts with the production schemes that prevail in European, and even in other Latin American countries, in which the energy market has been opened to a certain degree, which varies according to their national interest (El Sol de México, Sept. 24 2004).

Possibly, in all, one among the largest problems that CFE faces nowadays, is that of its high labor burden. It would be difficult for a firm with so excessively large a payroll as CFE has, to even aspire to become a competitive firm in the market.

And CFE workers are not only numerous, but very active in defending their interests. Not long ago, for instance, a group of CFE workers sent a letter to Congress to protest against the purchase of electricity for the public service from private producers, and to demand the elimination of the IPP scheme, because it is "damaging to the national interest" (La Jornada, Nov. 29, 2004). With things like this happening, many think that worker unions are trying to defend their power over the company's decisions. Currently, in any case, CFE employees have much more benefits than most workers in Mexico, and do often even "inherit" their jobs to other members of their families.

For the private firms in the generation sector that CFE would compete against if and when the market opens, there seem to be some differences about what motivates their environmental performance. While some may lean towards a more rational approach, driven by profit-maximization, others appear to be driven by the moral obligation to perform at their best, often linked as well with the desire to preserve a good name. In all cases, their actual implementation of environmental practices is partly a reflection of the corporate strategies dictated from the transnational firm, or pool of firms, that own the plant in question, and partly also due to the conditions established by the organizations who provided funds for these plants.

In any case, we cannot be as naïve as to think that transnational companies in the power sector who tend to adopt practices closer to those in their home countries than to those most common in Mexico, do it only because of principle, even when it seems to be at their expense. There is, on the one hand, the fact that, for companies that operate in several countries with variable policy frameworks, it may be more cost-effective to standardize their practices, for instance, and probably most commonly to the level of their home country. And on the other hand, these transnational companies, and not only those in the energy sector, but in other industries as well, may try to establish some sort of competitive advantage based not on cost, but on environmental performance. They can differentiate themselves from their competitors by having a better environmental performance, and would be very forthcoming about this, trying to force somehow the more widespread application of those environmental practices which they have already implemented, even by lobbying for stricter standard, which they would be in compliance with beforehand.

6.6 The Relevance of Regulatory Pressures

All the natural gas combined cycle plants that I analyzed comply, by far, with all applicable emission standards. By looking at the levels of emissions of the private generation cases that I discussed, I suspect that this happens because standards are too lax. They have not put up with advances in technology and with changes in the power generation structure. If standard were stricter, probably there would be a big incentive to improve technological deployments, and to increase environmental practices.

At least in one case, that of the Valle de México plant, the switch of power generation technology to natural gas was partly due to environmental concerns, and was partly driven by environmental regulation. Still, the link between environmental regulation and technology change is not that clear in the other cases that I looked at.

In general, at the present time, the influence of environmental policy concerning the energy sector is marginal, if any. It seems more as if the energy industry, and particularly public power utilities, impose their own standards, influencing environmental policy. This happens, since these utilities control most power generation, and can have whatever standards they can comply with accepted as the common practice of the sector, especially as long as the relative power of the environmental sector is minimal when compared to the power of the public energy utilities.

So far, even when there have been new technological developments in power generation, which have been put in place as the sector has increasingly been privatized, and as it has simultaneously moved to natural gas- fired technologies, these developments have not had any significant effect yet on the environmental regulatory framework.

In any case, the general perception seems to be that, currently, there is a process of environmental de-regulation, and a deterioration of environmental policymaking, which worries several stakeholders, and particularly NGOs, as it has been manifested in several instances.

Several people that I talked to in Mexico, agreed on that regulatory pressures from the environmental authorities seem to have decreased with the current administration. Some think that it is a positive thing, since it has allowed economic growth. But most perceive that, whatever the consequences, this has not always occurred intentionally, but often as a result of lack of policy direction and implementation capacity. A few environmental standards that should have been in place already, an industrialist told me, have not even been discussed, and this hurts not only the environment, but also "clean" industry that would already be in compliance.

For the federal government, it seems, the Secretariat of the Environment has a low level of priority. And, maybe in part as a consequence, it has only a marginal impact in energy policy. Regulatory pressure from the environmental sector, seems to be, is at a low point, and practically any change for the good that is taking place, at least in the power sector, is mostly due to market pressures.

6.7 Weighting Conflicting Perspectives

Firms in the power sector have interaction with a wide array of stakeholders. They are in close contact with, and their decisions are affected by several areas within the government; their corporate structures; financial institutions; communities which sometimes are organized into NGOs or community action groups; worker unions, and of course their clients; among other. They often must satisfy a series of requirements and face pressures from several stakeholders, which in some cases conflict with each other. This is often the case when it comes to improving their sustainability.

Among these pressures, an industrialist that I talked to told me that large industry is well aware, and at a certain extent even a little afraid of the pressure that the civil society can exercise nowadays, which has been strong enough to close down projects underway that have had all the support from the government. In this context, industry, and especially transnational industry, against which there is historical distrust, has to do everything possible to give a good image, or at least to avoid being noticed for any wrongdoing.

The pressure of civil society, often fueled by the media, is something that public utilities in the energy sector seem to be responding to as well, although their approach is still often corrective, rather than preventive. Just recently, for instance, in the first quarter of

2005, PEMEX struggled to repair, at least cosmetically, the damages caused by a couple of oil spills from its pipelines in the east of Mexico, and most recently of an accident at a facility in the state of Veracruz in which more than 60 tonnes of ammonia were released to the environment, killing six workers and affecting a neighboring town, in which several people were intoxicated. PEMEX was so swift in making repairs to the affected areas, that even the state's police department, which was investigating the accident, complained about the alteration of the scene (La Jornada, April 21, 2005).

Nowadays, for industry, including private power producers, lobbying with the civil society may be even more important than lobbying with government itself. The civil society has become very relevant for the implementation of projects, as they have often organized and succeeded in opposing a few of them, even through violence. Recently, for example, a big Dam called Presa La Parota, in the state of Guerrero, in the Pacific Coast, was stopped due to public opposition. And other examples abound.

In all, it is widely agreed that the signing of NAFTA was probably the breaking point for this "democratization" of Mexican environmental policy, in part because it forced the country to try to be at the level of the U.S. and Canada, which at that point had more developed environmental policies, and a much more effective enforcement of them than Mexico. But more than that, some argue, also because, with free trade and increased direct foreign investment, an environmental ideology, particularly among civil society, could be formed and/or strengthened through the interaction with external influences, in some cases coming from transnational firms that "imported" environmental principles from their home countries, and later even from domestic firms who adopted these principles (García-Johnson, 2000).

Nowadays, in any case, it seems that the general perception of the environment puts it low in the priorities of the general population. It is only when there are disasters that it comes back to the public attention. Resources would be needed if environmental or energy policymakers attempted to "convince" people of the convenience and advantages of cleaner energy, and particularly of energy efficiency, which could also bring a concrete economic benefit to them.

Financial institutions supporting firms in privatized generation would probably be a good ally of the government to achieve such a goal, since they are among the most influential stakeholders in the move towards more sustainable practices and technologies among some of these firms, as I discussed throughout my case studies. These institutions have the resources private investors need, so they can pretty much set the conditions for providing them.

For some stakeholders that I talked to, it is not that obvious that the environmental sector should intervene in energy policy, and particularly in the debate over energy reform. While some defended that the promotion of cleaner generation, and particularly of renewable sources of energy, should be "linked" to the discussions over energy reform, others argued that the issue of energy reform was at this point so "demonized", that it would probably be better to separate from it any policy that the government would like to see implemented. The fact is that, currently, there is no official position from environmental authorities regarding privatization of the energy sector.

And more than that, even within the federal environmental offices, there seem to be disagreement on how to proceed on this issue. They try to lobby on matters that touch the energy sector through the Secretariat of Energy, but they have not, at least officially, approached Congress with specific proposals around energy deregulation.

In the following chapter, continuing with this discussion, I will attempt to define some of the major considerations for defining a policy strategy for environmental policymaking, which builds upon the analysis carried out so far. It is not at all intended as a concrete strategy, but more as a checklist in which I include the most relevant issues that, from my research, I have found may be getting on the way of effective environmental policy regarding the electricity sector in Mexico.

7. DEFINING A POLICY STRATEGY: NEXT STEPS

Drawing a policy path, so that what has been for most of the 20th century an oil-dominated economy, can shift to a "softer" energy pathway, requires probably more imagination than skill. In a way, policymaking is about imagining a future, and then figuring out how to get there. I will attempt that sort of exercise here, hoping not to get so "imaginative" that I lose my sense of reality. For my exercise, I this first define and analyze some power sector growth projections. Then, I will imagine a future that is "nicer" than that, start thinking of ways to get there, or at least to create the conditions to get there. For this, I have derived several ideas from the inputs I got from the stakeholders that I interviewed in Mexico (see Appendix A). This exercise is not at all exhaustive, and although I go as far as to even suggest a few particular policy strategies, my evaluation of them is rough. A deeper policy analysis exercise would probably require time and resources that I do not have at this point. Such an exercise would probably require greater resources that I as an individual have at this point.

7.1 Power Sector Projections

As stated in Chapter 4, electricity demand runs very closely to economic growth. This is especially true as long as incentives to change consumption patterns towards more sustainable ones are not put in place. Consequently, even under the most conservative projections, power demand in Mexico will grow, by the year 2030, by at least 100% beyond today's levels.

For the whole world, in fact, it is projected that the economy will grow by 3.2% per year, and electricity consumption by 2.5% (IEA, 2004). This would imply that electricity consumption doubles by 2030 with respect to the level observed in 2004. And these estimations account for the developed world, in whose countries power demand grows at a slower pace than the economy, and lower also, in general, than in most developing countries.

For a developing country like Mexico, power demand would likely stick much closer to

GDP growth. According to some predictions, electricity demand in developing countries will more than triple by 2030 as compared to 2004 (IEA, 2004), although this estimation is driven by highly populated Asian countries in the process of industrialization.

For Mexico, if the country's economy grows at the levels of developed economies, which is the most optimistic assumption I think I can make, it will require significantly more energy than what it currently consumes. Just to get an idea of what level of energy demand could be possible in 25 years, I will roughly construct what I think can be a "realistic but optimistic" scenario, particularly looking at electricity demand for 2030.

As I mentioned in Chapter 4, current electricity generation capacity in Mexico is 45.6 GW, which means a per capita level of installed capacity of a little more than 0.46 kW. If the economy grows to the level of a developed country, it would require, at least, about 1 kW of installed generation capacity per person, which is roughly the level that industrialized countries have nowadays. I will assume that by 2030, energy efficiency has advanced 20%, so instead of 1 kW, capacity should be 0.8 kW per person. I would expect, on the other hand, that life in 25 years will be more dependant on electricity, probably to substitute fossil-fuels, for instance, but also as more appliances are "needed." I will assume this factor increases electricity use by 20%. I would also expect a significant change in energy needs per person, but consider, nevertheless, that any prediction I could make in this respect would be highly uncertain. So, I will not include any assumption to account for that in my calculation and will just keep it in mind. Population, most likely, will grow. According to one of the most rigorous projections available (CONAPO, 2002), there will be 127.2 million inhabitants in Mexico in 2030. With that, I estimate that the electricity generation capacity of the country, by 2030, should be of about 127 GW, which is equivalent to almost three times the current installed capacity.

From the electric sector prospective, practically all new investments in generation over the next decade are going to be done with private investment (SENER, 2004b), and CFE and LFC will only invest in transmission and distribution. With demand growing at the rate I suggest, and with CFE not investing in new generation, even if it does not retire any capacity, it would end up with about 35% of the market in 25 years.

Foreseeing possible technological innovations for the next 25 years is practically impossible, as they depend on something extremely difficult to predict, which is human ingenuity along other equally unforeseeable factors that may drive it one way or another. I should just mention that, currently, there are trends towards major improvements in the electricity sector, so I would expect that, if these trends continue, probably the best chances for achieving substantial changes, towards renewable energy sources and energy efficiency, can happen in this sector. I also see some substantial technological changes in the transportation sector, towards improved energy efficiency, and, though considerably more slowly, alternative energies. Possibly, for both, the continuation of current oil prices, if they continue for long, will have a positive effect on investment in alternative technologies, has happened in previous oil crises. Changes in these two sectors, electricity and transportation, would be most relevant, also, because they are among the highest contributors of anthropogenic air pollution in the country (INE, 2000).

I would also expect, in the next 25 years, and hopefully sooner rather than later, that climate change will become an issue of concern. This will create pressure to improve energy technologies internationally, and that, as the country develops and its democratization process continues, environmentalism will advance and the preference of the population for a cleaner environment will drive policies and technology choice.

There will be a significant amount of new generation capacity installed, and, considering how many of the existing power plants will become obsolete in 25 years, Mexico will most probably have a completely different set of plants in place by then. If, in parallel, the reform of the energy sector currently being discussed in Mexico goes ahead, which I would say is reasonably likely, there will be competition in the sector, and if, on top of all these events, fossil-fuels become scarcer and, consequently, more expensive, I see that the country will have the perfect opportunity to move toward renewable energy sources and to improve energy efficiency. But will it seize it? For that, it would be probably necessary that the public sector assumes a leading role, supported by civic organizations, the private sector.

Recently, the Mexican power sector has been investing in generation technology that relies on natural gas, and that is, if not the best, at least much better than existing technology, at least from an environmental point of view. If things go as projected, as much as half of all the generation capacity installed in the country by 2015 will be natural gas-fired, and most of it will operate with a combined cycle technology. A major concern is that it is not certain whether natural gas will be available for long, or at what price, so it may be necessary for the sector to switch back to dirtier fuels, like fuel-oil. All the new thermal capacity being installed will be already there, and the switch is technically not that difficult to perform. Mexico is not self-sufficient in natural gas, so it has to import it from the U.S. It has been estimated that by as soon as 2015, there will be not enough natural gas reserves to satisfy the overall North American demand and that would translate into higher prices, and most likely an energy crisis (Chevron estimation published in Reforma, March 7, 2005).

Maybe the answer will be to import natural gas from elsewhere. There are, in fact, plans already concretizing to import natural gas from Russia, by ship, beginning in 2007 (El Financiero, Nov. 16, 2004). This, nevertheless, does not seem like a sustainable policy in the long term, and would probably have as a consequence an increase in prices as supply decreases. On the other hand, it is likely that the production of fuel-oil will decrease, thanks to the reconfiguration of refineries that PEMEX is currently carrying out.

One solution to these challenges, at least in part, could lie in the abundant potential for renewable generation that Mexico has, although there are still several barriers to the more widespread implementation of renewable technologies, among which there are technical, legal, institutional, economic, social, political, and even environmental barriers to surmount.

Much of the real potential for renewable power to reach a substantial supply level in

Mexico, nevertheless, has to do also with how the markets and the technologies evolve worldwide. There are reasons to be optimistic, in any case, looking at the fast growth of the market for renewable energy so far, and at the learning curves of some particular power generation technologies, that renewable power technologies will become even more competitive in the near future.

Environmental concerns are very important when assessing the potential for renewable energy, as they may be important factors in the move of energy technologies towards cleaner and more sustainable forms of production, distribution and consumption. The energy sector has been responding, to a certain extent, to the environmental concerns of the society, and to environmental regulations imposed by government. Even in Mexico, with its developing economy, a few changes in extraction practices and production processes are occurring; some changes in product specifications have been seen; the "switch" to cleaner fuels, mainly in major urban areas, has been implemented; renewable sources of energy are being supported; and end-of-pipe control equipments are more widely used. Still, as long as pollution problems and the depletion of natural resources persist, more decisive actions will be necessary.

7.2 Achieving a Sustainable Power Sector

Most likely, the regulatory reform that the sector is slowly going through, will take place more fully, but hopefully not involve a move from a public to a private monopoly, but to increasing competition so that society ends up better off. Competition would be good for society, and good for all economic sectors. The question is how we can make sure that it is also good for the environment.

My argument, supported by the empirical and theoretical evidence that I have discussed in this dissertation, is that this will happen, at least in the near term, only through public policy intervention.

Defining, first, policy goals, environmental policymakers should aim to push the power sector in at least three directions: first, towards a better balanced generating portfolio, in which renewable sources of energy are more widespread; second, towards greater energy efficiency across all productive sectors and energy consumption activities; and third, which is closely related to the two first "movements", towards a decrease in the pollutant emission intensity of the power sector.

Some of the most obvious benefits of moving to cleaner energy and improving energy efficiency is environmental, but *renewables* would also be relevant for fighting poverty, which for Mexico is a significantly more urgent issue. This presents an opportunity for environmentalists, both in the civic society and the public sector, to build on the existing efforts of those groups fighting to improve the socioeconomic conditions of the poor. It would be a mutually beneficial partnership, and, more importantly, it could impact positively throughout poor communities, especially in remote marginalized areas of the country.

There is great potential for the expansion of renewable technologies and energy efficiency in Mexico. There are, to begin with, abundant resources, like wind, and solar energy, with which, as technology progresses, and as the environmental costs of traditional energies are internalized, producing energy will become more "economical." To exploit that potential, a shift in current energy production, distribution and consumption patterns is needed. I see this, in the next quarter of a century, as achievable, but it will probably not happen "naturally." So, the intervention not only of the public sector, but also of several other elements in society, pushing for change, will be crucial.

The major barriers to renewable energy have been political and legal. The problem is not technological or economic, although some charge that renewable energy is not economically competitive yet. Still, renewable technologies have been proven at large scale in several countries, when supported by public policy. In Mexico, where the market is moving towards natural gas combined cycle plants, there is an opportunity to go further, to wind generation, for instance, which could be economically competitive against natural gas-fired technologies, under current market conditions. But this is difficult to achieve because, so far, practically all changes in the supply side of the electricity market have been dictated by the government. The government (particularly SENER and CFE) does not seem willing to deal with generation sources that are not fully under their control, to dispatch them whenever they want. They seem to prefer a big sector, with big generation sources, rather than a distributed generation scheme.

Without public intervention, electricity reform may actually complicate matters even more for renewable technologies. If and when it comes, these technologies will have to compete with technologies that are subsidized, and this will happen just when some momentum was being created for *renewables* to be further explored as an option in Mexico, as I discussed in the La Venta case.

7.3 The Path from Here to There

The emission of air pollutants in Mexico, is a problem of national scale, with a complexity that demands responses on several fronts. Decision makers in the environmental field face the dilemma of responding to these pollution problems, trying to protect human health and the natural ecosystems, while balancing the social, economic and political interests of the several stakeholders involved in or affected by policy implementation. The choice of what to give priority to is not always straightforward. Furthermore, to that, which is already a complex decision, we must add the fact that there are several institutional limitations in the availability of resources and capacity among environmental organizations, which complicate policymaking, particularly within government agencies. As noted by Molina and Molina (2002), institutional capacity is often linked to financial capacity, and in Mexico, agencies not directly linked to the budget and to economic development tend to be politically and financially weak, so they have to sacrifice the implementation of their proposed policies in favor of those that promote economic growth. This, as I discussed earlier on, is often the case for environmental policies.

Currently, the work of environmental agencies in Mexico is constrained by a tight budget and the pressure of other government agencies, whose agendas seem to take priority over the environmental one. It is then understandable that environmental policy design and implementation are deficient. The lack of internal capacity and the existence of multiple external factors operating against it, contribute to this deficiency, and the consequences of this are in great part paid by society.

In particular, the main challenge for environmental policy makers in their pursue of sustainable energy, is achieving enough influence so that they can in reality cause a significant impact on the energy sector, and most especially over power generation. It is widely suggested, at least by some environmental officials that I talked to, how little they can do to affect the practices of CFE, with whom it is often even impossible to establish contact. This remains a great concern, especially considering how big a source of environmental degradation CFE plants have consistently been, and how little the firm does to improve its environmental performance.

There should be a natural partnership between environmental and energy offices, for instance, on the topics of climate change and renewable energy, and through that, to possibly impact the energy sector via national environmental policy. The partnership, nevertheless, has not been established in practice. In fact, the energy and the environmental sector "fight" over who should be in charge of the issue of promoting renewable energy. And for climate change policy, an environmental sector official said to me that, so far, "energy policy reflects in climate change policy, but not so much the other way around".

So far, the relationship between the environmental offices within SEMARNAT, and the energy sector, at least with regard to air quality and climate change policy, occurs more on personal grounds, and is not institutionalized. Recently, there has been a good level of cooperation, at least at the Secretariat level, but if different people come to the relevant offices, the situation will probably change. Besides, not even SENER has enough influence over the public energy firms, and especially over CFE. SEMARNAT has even far less influence than them.

When facing the particular challenges for the development of renewable generation, perhaps it would be good to look at the experience of a country like Spain, with which Mexico has strong historical, political, social and economic links, to try to emulate their experience with wind power, for instance, and perhaps to share some of the technology and capacity building in collaboration with them. I understand that only rarely can we transfer directly experience from one country to another, but I am certain that a lot could be gained from at least looking at the Spanish development of wind energy, which has reached cumulative installed wind power of 880 MW by 1998 (UNDP-UN-WEC, 2000). It may still be a limited amount, but it is far greater than the 2.2 MW installed in Mexico, which happens to be a country with total generation capacity close to 85% the size of the Spanish one. So far, several Spanish energy companies have developed power generation projects in collaboration with Latin America and with Mexico in particular, so it may be a matter of creating the legal instruments, and of developing the necessary policies to increase collaboration, or even to foster direct investment by these companies in particular renewable projects in Mexico. Iberdrola, for instance, could be at the forefront of such initiatives, since they have already made some investments in wind power in the La Venta region, under the self-consumption scheme.

The Ministry of Finance has the last word when it comes to creating incentives to promote renewable energy and energy efficiency. An environmental NGO representative told me that "even bringing them in is difficult." They seem to have other priorities far from the environment, and do not seem to understand that improving energy efficiency, for instance, may even have positive impacts on tax collection. A high-level energy official told me that the Ministry of finance is really the main "driver" of energy reform, and that SENER is only an "operator" to achieve it. The reform is nevertheless part of the economic policy principles of the current administration, which is looking to decrease the role of the state in the economy.

In any case, under current conditions, if the Ministry of Finance, or SEMARNAT, or SENER, or any other office within the executive branch attempts to change the law substantially, in order to promote certain policies, they would likely be blocked by Congress. It may make sense, therefore, that these policies be promoted from the non-governmental sphere. For that to happen, however, partnerships between the government and NGOs must be created.

Regarding the partnerships of the public sector with NGOs and the civil society, it seemed to me from conversations I had with the latter, that they are eager to participate more actively and to support the policies that they believe in, although they have some reservations, which come about because they feel that, often, they are taken into account by the government just to try to legitimize policy decisions that have already been taken, and not to get their inputs and ideas For that collaboration to be mutually beneficial, nevertheless, it is probably a prerequisite that NGOs get professionalized.

The power of the media was also mentioned insistently in several of my interviews with Mexican stakeholders. A campaign is much needed to support policymaking, they argued, "especially if we are attempting to implement policies that are innovative". And along with this campaign, public figures could also help achieve policy implementation.

In general, it is widely perceived that whatever efforts to promote renewable energy and energy efficiency in the country are being made, even if few, are mostly done by the energy-related offices in the federal government, but not by the environmental ones. This perception has probably some reason to be, since, so far, not even a coordinated effort on those lines seems to be coming from the environmental sector. Putting that in place could possibly be the first step that they should take, and the sooner the better.

7.4 Defining Specific Policy Steps

There are a few specific policy steps that I would propose environmental policymakers in Mexico should consider, in view of the outcomes of my research, particularly to help improve the environmental performance of both private and public generation plants in the power sector. Among these, I would suggest that environmental regulation makes a differential treatment of power plants, depending on age of the plant, and on its technical characteristics, with the idea of creating incentives for gradual but continuous improvement in their environmental controls and practices. Another particular policy that

I would propose, is the inclusion of environmental considerations among the selection criteria with which CFE and CRE evaluate prospective private investors. A third policy that I would recommend taking into consideration, relates to the implementation of incentives for renewable power generation, among which a renewable generation portfolio would be fundamental, as well as the application of some form of carbon tax (which could take the form of a subsidy for "greener" generation technologies), by which the externalities of traditional fossil fueled plants are internalized. Finally, I would advise policymakers in the environmental sector to intervene in the current debate over deregulation of the power sector, particularly to advocate for changes to the federal law of the electricity service, so that price is not the only criterion by which CFE prioritizes among plants at the moment of dispatch, but instead that the environmental impacts of power generation among plants are also considered. In this way, a renewable generation facility, for instance, could have better chances of being dispatched, even while its cost per kWh is higher than that of traditional plants. Next, I will explain in more detail these policy steps, and some of the considerations that I think should be kept in mind for their implementation.

Before that, a general consideration, first of all, relates to the issue of how much say private firms in the Mexican power sector really have at the moment of taking decisions that may affect their environmental performance, be it measured as pollutant emission intensity (as I measured it throughout my case studies) or through some other indicator of the level of "sustainability" of the particular plant in question. Although the fact is that the market is only partially open, and CFE has a lot of control over private producers, still, even if not directly, I would expect that policy would affect decisions such as location or type of fuel used in a plant, which up to this point are solely the decision of CFE, without much input from private investors. And even more so for other business decisions like the implementation of environmental management systems, or of social responsibility programs, over which CFE has less influence, and the private investors themselves have more decision power.

Treating plants differently according to their own potential for achieving a given environmental performance, which is the first specific policy that I would suggest considering, is an idea that follows at a certain extent the principle that applies in Mexico for the design of air quality emission standards for vehicles. In that case, standard are stricter for new vehicles than for old ones, and this even though the auto industry complained at first that this differentiation would create a disincentive for the renewal of the fleet, which in practice does not seem to be the case, since there are several other factors influencing the purchase of a new vehicle, among which high emission standards seem to be pretty irrelevant. Besides, in fact, for some consumers it may be an advantage that their vehicle complies with higher standards. And the regulation, in any case, is complemented by a policy that rewards better performance of newer vehicles, for instance in the MCMA, where they are inspected every two years, instead of every six months like old cars are, and newer vehicles are also exempted from the Day Without a Car program.

In principle, the same would be the case for new power generation technologies. They are put in place mainly because of the economic advantages that they bring, among which I mentioned a few in Chapters 5 and 6, as well as in response to energy policy dictates, and particularly to recent directives from energy policy that have called for the switch of power generation to natural gas. I would not expect that a stricter environmental standard would create a disincentive to newer plants, because even for plants that operate in an open market (as it may be the case in the near future in Mexico), for which decisions are more rational, compliance with this stricter standard is relatively a minor burden when compared with the benefits of newer technologies. Besides, from the inputs I got from managers in the power sector, it seems that several of the new plants in operation in Mexico, would be complying with much stricter standards even under their current operation conditions, so these plants would see a competitive advantage when other plants in the sector are forced to improve to the levels of emissions, for instance, that they are already in compliance with.

Up to this point, it seems that emission standards, at least, are designed in accordance with the capabilities of the average power plant of the public utilities, if not with those of the worst polluters in the sector. Environmental standards seem to obey, at a large extent, the dictates of CFE, and not the other way around, as one would normally expect. It makes sense, for several reasons, including political and social considerations, not to affect the interest of the public utilities by imposing higher regulations to them, which they would in any case be constrained to comply with, given the age and characteristics of their plants. But to extend this sort of "special" treatment to newer plants, whether they are public or private, simply does not make sense. Besides, environmental regulations can provide an incentive to technological innovation, and in Mexico that is not occurring.

Regarding the decision process through which bidding from prospective private investors is evaluated and decided upon, I would suggest that environmental policymakers intervene in some way, to have environmental criteria included in the selection process, possibly even participating directly in the evaluation of investment proposals. So far, the amount of investment and expected costs for the electricity produced, are practically the only criteria that are considered by CFE and CRE for selecting the winning bid among those private investors that compete to develop a new plant. As I discussed throughout this dissertation, and as the evidence I presented particularly in Chapter 5 indicates, there is significant variation in the level of "environmentalism" of plants, depending on the corporate strategies of the involved firms and sponsors, among other factors. With that in mind, I would suggest that, more than looking at what firm is involved in a proposal and what its previous record for environmental practice is, policymakers could, for instance, advocate so that, in the call for proposals itself, it is determined what environmental technologies and practices the plant in question should comply with. And these requirements should increase with each new plant that opens to public bidding, with the idea that new plants perform at least at the level of the best companies in the sector.

Environmental offices could participate directly in the evaluation of plant investment proposals at various stages. Since they are monitoring and evaluating environmental performance of plants already in operation, they could design the set of "conditions" that project proponents should comply with for the case of each plant that is opened to bidding. These conditions should be progressively increasing, as technology improvement and best practice in the sector advance. Environmental authorities could also be in charge of evaluating the component in the project proposals presented by private investors that relates to the conditions they established. The same way they now evaluate EIA submitted by CFE for developing a private power plant, they could evaluate the environmental management proposals of all firms competing for a project, even before a decision is made, precisely with the intention of influencing that decision. Finally, environmental offices should intervene to monitor compliance with the commitments private investors established in relation with their environmental performance.

Another policy step that I think is very relevant to consider, relates to creating incentives for renewable power, especially since renewable technologies are still not economically and technically competitive against traditional ones, and since there are several barriers for their implementation in Mexico, as I have stressed throughout this dissertation. A particular policy that I would propose, relates to renewable generation portfolios for firms in the power sector. There are several ways to go about such policy, but the one I would suggest would imply that firms in the sector develop renewable generation facilities to a level that is equivalent to a proportion of their generation capacity, and that they gradually increase this proportion over time. Further analysis would be necessary to establish the starting point and how to move from there, but in any case I think that this policy would have good chances of success, but more so if it is complemented by other policies, among which allowing consumers the possibility of buying "green" power would be one worth considering, and, for the moment being, also the creation of incentives to renewable power, for instance through a special fiscal treatment, so that generation facilities are fiscally amortized over shorter periods of time, or so that when they are imported there is no tariff applied.

Another way to improve the chances of success of renewable power is via some form of "internalization" of the environmental externality of its more traditional competitors in the market. I acknowledge that the mere mention of the word "taxes" makes several policymakers, and even those in the environmental sector, a little uneasy, to say the least, but still, even with other names like "surcharge", there is some precedent in Mexico of some sort of carbon taxes being put in place.

For some time, there has been a gasoline surcharge in place in MCMA, although not to reduce driving, since the surcharge is too small to alter fuel consumption, but to create a fund for environmental improvement. For the electricity sector, I can see that something of that sort could be implemented, to tax the consumption of "dirty" electricity, and to promote the use of the "clean" one.

As I mentioned when discussing the Tuxpan case study, the externality of power generation in the oldest plants in Mexico, can be as high as 14% of the cost of a kWh produced, and this amount when considering only some of he morbidity and mortality impacts of the plant's air emissions on humans. If such externality were included in the cost of power, renewable generation technologies would become more competitive than they are nowadays. In any case, the current prices of fossil fuels are creating an additional incentive to develop more renewable power facilities, for instance in the U.S., and those developments could also have a positive effect in the technology's learning curve and economic performance.

A further issue related to renewable technologies, has to do with the legal framework in Mexico. The last of the particular policies that I suggest implies that environmental policymakers intervene in the current debate over power sector reform, at least to achieve a change in the laws, so that one of the prevailing barriers to renewable generation is removed.

Currently, CFE is obligated by law to buy electricity wherever it is cheaper, and it dispatches practically always with that sole criterion in mind. I think environmental policymakers should lobby for Congress to modify the relevant laws, so that some other criteria, and particularly environmental impacts, is considered for dispatch decisions.

Lastly, an issue that comes to mind has to do with whether it is convenient to link environmental policy to the debate over power sector reform, which, as I have discussed earlier on, especially in Chapter 1, is highly political and ideology-driven. I recognize that there are some risks involved in tying both issues, but also perceive that the debate over energy reform has put the energy sector in a high position in the public agenda, much more than it has probably ever been, and this creates conditions to insert in the public debate any topic that has to do with what power sector the country wants to end-up with in the future, and not only in what refers to the ownership structure of the sector, but to its performance in general, including, at a very high level of importance, its environmental performance.

With this general observation I conclude this chapter. In the next one, I present the conclusion of my dissertation, in which I summarize the findings of my research, and attempt to also continue discussing its links to policymaking, but also to theory.

8. CONCLUSION

With my dissertation, I have addressed the following fundamental question: "Does it make a significant difference for the environment, currently and in the foreseeable future, whether the ownership of electricity generation in Mexico is public or private?" If it does so, a further question is whether there are differences in the environmental performance across private firms in the sector, and what factors may determine them. And a last question driving my analysis relates to whether environmental policymakers can and/or should do something to force the electricity sector to become more sustainable, in light of the answers to my fundamental question.

With my research, basically, I am trying to prove that there is a link between an independent variable, which is the privatization of the power sector, and a dependent variable, which is the degree of environmental sustainability of firms in the sector.

My research approach has relied on the most part on case studies. I looked, in total, at six cases of power generation plants in Mexico, to perform mainly two types of crosscutting analyses. One, was the analysis across public and private firms, of roughly same size and same technology, to assess whether there is some significant difference in the environmental performance of plants, depending on their ownership structure, or possibly of some other observable variable. The other analysis was across plants with different technology, to assess how much the deployment of more advanced technologies, may be the factor that determines environmental improvement to the largest extent.

For data collection, I relied on interviews with several stakeholders in Mexico, especially from industry, the government, and the non-governmental sector. Besides, I also relied on the review of the most relevant literature relating to my topic, and on empirical evidence, which I analyzed and processed to produce a profile of the Mexican electricity sector, which is included in this dissertation, as well as my case studies, which are at the core of my research, since most of my conclusions derive from the observation and analysis of those cases.

Since the purpose of my research was not only to be descriptive, but also to lead my analysis towards a more prescriptive mood, I also attempted to derive lesson for policymaking all throughout this dissertation, and particularly at the later stages of it, in my crosscutting analysis, and in a further step in my research, in which I attempted to delineate a series of considerations that may be relevant for environmental policy making that aims at affecting the Mexican energy sector. This last step, which I included in Chapter 7, is only a sketch to start delineating a policy path.

8.1 Main Findings

I found that, most likely, under prevalent conditions, the free market would not help the development of renewable power generation technologies. In fact, although privatization would increase competition, bringing some environmental benefits, particularly with technology improvements, it is likely to have mixed environmental consequences, especially with the current cost structure of inputs like fossil-fuels, and with the lack of consideration of externality costs on the costs of energy. Competition may still help promote the implementation of better and more efficient technologies, which are commonly also cleaner, but would not be favorable for achieving even cleaner technologies, like renewable ones, since they are still at a large extent not competitive economically.

So far, technology deployments in the power sector have progressed towards cleaner technologies, of smaller-scales than the traditional steam fossil-fueled thermoelectric plants, of which there are several still operating in the market. The point is that, although this new generation model is mostly relatively clean, since it burns natural gas and operates with combined cycle technology, the applicable emission standards that they have to comply with are too lax, because the environmental regulatory framework has not been updated at the pace that the technology in the sector has progressed. It seems as if the standards are set at such level so that the dirtiest plants in the sector comply with them. Since they do not differentiate across technologies, the current environmental standards do not create a regulatory pressure for technological turnover, or for innovation in the sector.

And the same applies for renewable energies. Environmental offices are not using the policy tools they have at hand to promote these technologies, or to help remove the barriers for their implementation that exist in Mexico, even when there is consensus about how positive these technologies would be for the environment. And this happens even though it is perfectly justifiable for environmental policymakers to intervene in the power sector to try to "induce" the move towards renewable technologies, for instance, since they are perhaps the only generation technologies currently available, and economically and technically feasible, that may reduce GHG and other pollutants to the lowest possible level, decreasing environmental risks at the same time.

In general, it seems that the environmental sector, whether willingly or not, is not very proactive when it comes to policies that may affect the interest of the state-owned utilities in the energy sector, and particularly those in the power sector. The energy sector is overzealous when it comes to designing energy policy, willing to control even those aspects that relate to the environmental performance of the sector, and allowing little involvement from environmental authorities. And further than that, the environment is not even an issue in the discussion of the energy reform that is taking place in Mexico.

Summarizing the current situation of the Mexican electricity sector, I would say that although the sector has gone through some privatization, there are still no market conditions in operation. So although there are private investors in the sector, they do not assume some of the financial risks normally associated with a business in the open market, since these risks are largely absorbed by CFE. And besides, prices paid to private producers for their electricity are also set by CFE, based not only on costs, but also on capacity investments, so the pricing scheme applied by CFE does not induce competition. Perhaps the only point at which private producers in the power sector really compete with each other, is at the time when they present their project proposals in the open bidding processes which are called by CFE and operated by CRE, to have investors compete for additional projects, which are assigned at a large extent on the cost per kWh that each proponent offers to achieve.

With increasing private investment, the power sector is only expanding, but there has not been any major capacity retirement, and it is not likely that a significant turnover may take place anytime soon. CFE has some plans to progressively shut down some of its oldest and dirtiest plants, but so far not much on that respect has taken place.

8.2 Propositions

The evaluation of the questions I posed at the beginning of this dissertation, has resulted in a series of propositions, that are sustained mainly by the evidence I found through the case study analysis and the interviews that I had in Mexico.

i. My first proposition, deriving from my literature review and from empirical observations from my case studies and interviews, relates to the fact that under current conditions, and even more so if privatization and open competition move forward, the public sector intervention, through policy and coordinated action with other stakeholders, is fundamental for achieving sustainability in the Mexican power sector.

ii. A second proposition that has been sustained with my analysis, relates to the fact that there is no substantial difference among private and public plants in the Mexican power sector, in terms of their level of "sustainability", at least when comparing similar technologies and production scales. In any case, some particular plants seem to perform better than others for each particular pollutant analyzed, and CFE, although it is in average far "dirtier" than private generation plants, is more or less as "clean" as they are when it owns or when it operates similar technologies. And although there is some variability in environmental performance across the cases I looked at, there is no evident differentiation between private and public cases.

iii. A third proposition, related to the previous one, is that the variability in the level of "sustainability" across firms, is largely explainable by the corporate practices of the parent firm, and at a certain extent by the dictated of its financial sponsors.

iv. Finally, a last proposition that I have found evidence trough my research to support, relates to the fact that technology seems to be the determinant factor in the level of "sustainability" of the power plants that I have looked at, at least as long as we understand sustainability as a proxy of air pollutant emissions.

8.3 Research Implications for Policymaking

The process of restructuring of the electricity sector presents an opportunity to establish policies that promote the development and implementation of sustainable technologies and practices in the sector. So far, the environmental sector has had practically no intervention in the debate over the privatization of the power sector, and even its influence in the sector's environmental performance, through policy, has been very limited.

The evolution in technology seems to be among the most influential factors for achieving substantial improvements in the power sector in Mexico. These changes include both the move in the generation technology that is in place at a given power generation facility, which may go from the relatively "dirty" traditional thermoelectric plant, all the way to a wind farm, with combined cycle plants somewhere in the middle. And besides the change in the actual generation technology, the switch in the fuel with which it is operated is probably as equally relevant, at least from the air quality perspective. That a plant runs either with *combustóleo*, or with natural gas, makes a tremendous difference on the its environmental impact.

The foreseeable expansion of the country's electricity production capacity, brings an opportunity to diversify its generation portfolio, to include more sustainable technological options, among which renewable sources of electricity, for instance, would be important ones, mainly because of three reasons: 1) given the continuous improvement of these technologies, by which they are increasingly becoming competitive against traditional generation technologies; 2) given the availability of their required inputs in several regions of Mexico, under conditions that would make them economically and technically useful; and 3) given their environmental attributes, especially as air quality concerns spread throughout the country, and as greenhouse gas emissions remain as a great concern internationally. A second major policy strategy, by all means complementary to the diversification of generation sources, would be the implementation of energy efficiency technologies. Together, policies to move forward in these two fronts, among others, would help abate emissions. The main issue for policymakers is, besides defining what technology changes would achieve the most in the future, determining how to implement them in the most effective way.

The potential for the expansion of more sustainable electricity technologies is there, and although there may be several challenges on the way of their development, it is possible to surmount them, as long as the will and the pressure exist to move to a more sustainable power generation market. An important component in this pressure should come in the form of environmental policy.

From what I have found with my research, it seems that the issue is not whether the environmental sector has a stake in the debate over electricity sector reform or over the sector's deployment of environmental technologies and practices. The question seems to be about whether the environmental sector can become strong enough, possibly through alliances with social actors and other governmental officials, so that it can in reality influence the sector's move towards more sustainable generation technologies. Currently, it is not achieving much in this respect.

One way for environmental policy makers to influence the structure of the power sector, would be through their involvement in the discussion of the reform of the sector. If they are successful in inserting some environmental considerations in the discussion, they could for instance try to put in place policies that would motivate the shift towards renewable technologies, or towards energy efficiency. In any case, it would perhaps be easier and less costly to insert these policies in the set of "rules" of the new "game", so whoever enters the market is aware of the expectations set by policy makers. And besides, it would perhaps be easier as well to influence the shape of the restructured electricity industry while that shape is being delineated, and not when its structure is already in operation.

8.4 Linking Research to Theory

The findings that I derived from my case studies challenge some of the postulates defended in the prevailing theories, particularly in what regards to the expected distinctions in the level of "sustainability" among private and public firms. Whereas, according to these theories, private firms would be better than public ones for society (including the environment society lives in), since resources would be optimized with them, as defended by market economy advocates like Milton Friedman and his followers, I found no conclusive evidence to sustain that there is a difference in the level of environmental sustainability (measured as emission intensity, environmental management practices, and social responsibility policies) among private and public firms, which could be explained merely because of them being so.

Instead, I found differences across the cases I analyzed, both private and public, but that are due not to ownership, but to other factors, like technology development, regulatory pressure, and corporate strategy, among other. The case of the Mexican power sector, nevertheless, has several singularities, beginning by the fact that the market is only partially privatized, so what I call private plants in the sector, operate in a market that is not fully open to competition, as we would traditionally understand it, and certainly as Friedman conceives it, to the point of idealizing it as a model of a perfectly competitive market tending to full employment and the efficient use of resources by the firm and the individual (Wolf, 1988). Private investors in the Mexican power sector, instead, are constrained on their choices by the public sector, and particularly by CFE, who takes almost all major decisions regarding plant location, inputs, and technology, and even interferes to determine the size of the labor force of private plants, in order to "accommodate" their union workers in those plants. Under these conditions, we can talk of privatization, but acknowledging all these caveats.

When confronting stakeholders in Mexico with the question of whether the privatization of power generation would be good or bad for the environment, I got the people I talked to defending both views, and not necessarily because of the ideology of the person interviewed, but, it seemed to me, because of her reference to other cases of privatization, which, depending on several conditions, had positive or negative implications for the environment.

My case studies and empirical observations around them, suggest also that the implications of privatization, at least for the cases that I looked at, can be mixed, and are also contingent to several internal and external conditions. In any case, I found that the free market would not be the best alternative for environmental preservation, and, more on the line of Gilbraith postulates than on those of Friedman, that the public sector must intervene in this market in order to achieve the best possible use of resources, both for the sake of the environment, but also of social equity.

8.5 Limitations of the Analysis

The data that I had access to was sometimes vague, and even contradictory. On some occasions, I had to decide on who to believe, although when I encountered contradictory data, I tried to corroborate with some other source, as much as this was possible. In some cases, there were inconsistencies within the same source, so, again, I had to exercise some judgment about what data was more "believable", given other sources and my previous analysis.

A further issue with the data, was that of finding comparable information for my case studies. Although I tried to make my case studies comparable as much as possible, I often struggled to obtain the necessary data to achieve that. I suspect that it is evident when reading this dissertation that I had more information (or different information) for some cases than for others. At the end of the day this may have resulted in a positive thing for my analysis, since it is designed not to rely only on the comparison across cases, but also on as broad a spectrum of observations as possible.

Another issue that I encountered was that of assessing, from my interviews, what was value free factual information, from what may have been an opinion or ideology. In many cases, I leave it to the reader to decide, and just inform her of who is saying what, and in which context.

Finally, a general limitation of my analysis relates to the difficulty of assessing qualitative comparisons across different cases, for different variables, and then trying to weight observations on these diverse fronts. I struggled to try to determine what plant, for instance, could be deemed as more "sustainable" than others, when it may have had a better environmental performance for a certain criteria, but worse for another. I considered the possibility of developing a matrix, giving a value to each criteria, and a level of priority, but then thought that I had limited data, but, more than that, also that such evaluation approach would have been too arbitrary. At the end, I decided to leave my comparison largely at the qualitative level.

8.6 Recommendations for Further Research

I often struggled throughout the process of writing this dissertation, whishing that someone had done this or that analysis, so that I could "build" on it, or at least, most often, so that I could obtain some data or piece of information.

Most clearly, and I would say even urgently, I found that a study that assesses the emission of private power plants in Mexico, and the externalities of these plants, is necessary. So far, there are some emission or concentration estimates, calculated with emission models, or with pollutant dispersion models, but only for public plants, and no comparable data is available for private ones. This analysis would be of outmost relevance for policymaking.

I also find that studies that assess the market for green electricity would be necessary to sustain policymaking. Probably they could rely on an evaluation of the willingness to pay of consumers for cleaner energy.

A detailed map of renewable energy potential in Mexico is also lacking. All there is, is some estimation and a few studies here and there, but a serious and comprehensive assessment is not available yet. For the La Venta region, for instance, I got estimations for the plant load factor for wind generation that ranged from 40%, all the way to 90%. The most optimistic were from analysts and organizations in favor of developing this technology, and the most conservative from those who are more "cautious" about its potential. While there is no independent mapping of the renewable resource potential, the question about the impartiality of the studies that came up with this or that estimation, besides the question of the methods used to get them, could be put into question.

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Appendix A

List of Interviews

Confederation of Entrepreneurs of the Mexican Republic (COPARMEX)
- Héctor Sepúlveda Valle
  Former President of the National Environmental Commission
  October 13, 2004

Eléctrica del Valle de México
- Ricardo Whaley Rodríguez
  Technical Manager
  December 17, 2004

Electricité de France - Mexico (EDF)
- Cintia Angulo de Lesseigneur
  General Director
  October 8, 2004

- Jerome Callens
  General Director – Río Bravo Power Plants
  December 29, 2004

- Sylvie Chezaud
  Head of Communications and Information
  October 8, 2004

- Juan Carlos Ruiz Velazco Ramos
  Head of the Environment
  October 11, 2004

- Mario Molina
  Head of Environmental Control – Río Bravo Power Plants
  December 29, 2004

- Eduardo Alvarez
  Information Office
  October 8, 2004

Energía, Tecnología y Educación (ENTE)
- Odón de Buen Rodríguez
  President (former General Director of CONAE)
  October 12, 2004

Energy Regulatory Commission (CRE)
- Francisco Barnés de Castro
  Commissioner (former Undersecretary of Energy)
  October 15, 2004

- Alberto de la Fuente
  General Director of the Unit for Electricity Restructuring
  October 11, 2004

- Alejandro Peraza García
  General Director of Electricity
  October 11, 2004

Fuerza Eólica
- Carlos Gottfried Joy
  President
  December 13, 2005

Generadora Eléctrica San Rafael
- Eduardo Zenteno
  General Director
  December 17, 2004

Greenpeace Mexico
- Alejandro Calvillo
  General Director
  October 5, 2004

- Arturo Moreno Vega
  Coordinator of the Campaign on Energy and Climate
  October 5, 2004

Mexican Center for Environmental Law (CEMDA)
- Tania Mijares García
  Coordinator of the Air and Energy Program
  October 11, 2004

National Association of Solar Energy (ANES)
- Enrique Caldera Muñoz
  Secretary for Policy and Legislation
  October 7, 2004

National Autonomous University of Mexico (UNAM) - University Energy Program
- Gerardo Bazán Navarrete
  Researcher and Head of the Information Center
  October 7, 2004

National Commission on Energy Conservation (CONAE)
- Gaudencio Ramos Niembro
  Coordinator of Electricity Supply, Thermal Processes and Transportation
  October 6, 2004

National Confederation of Industrial Chambers (CONCAMIN)
- Daniel Basurto González
  President of the Environmental Commission
  October 6, 2004

National Council of Environmental Industry (CONIECO)
- Carlos Sandoval O.
  President
  October 5, 2004

National Institute of Ecology (INE)
- Adrián Fernández Bremauntz
  General Director of Research on Urban, Regional and Global Air Pollution
  October 14, 2004; January 6, 2005

- Julia Martinez
  Director of Research on Climate Change
  October 6, 2004

Secretariat of Energy (SENER)
- Juan Mata Sandoval
  General Director of Technology Research and the Environment
  October 13, 2004

- Noé Navarrete González
  General Director of Electricity Generation, Conduction and Transformation
  (former Federal Congressman from PAN: 2000-2003)
  October 7, 2004

Secretariat of the Environment and Natural Resources (SEMARNAT)
- Fernando Tudela Abad
  Undersecretary of Planning and Environmental Policy
  January 6, 2005

- Ramón Carlos Torres Flores
  General Director of Energy and Extractive Activities
  October 6, 2004

- Manuel Estrada Porrúa
  Director of Climate Change
  October 13, 2004

- Carlos García Moreno
  Director of Energy
  October 6, 2004

- Alejandra López Carbajal
  Assistant Director of Climate Change
  October 13, 2004

- Citlalin Martínez Córdova
  Assistant Director of Renewable Sources
  October 6, 2004

Appendix B
Interview Objectives and Key Questions

Objectives

1. To get interviewee's positions on electricity sector reform (technical, economic, social and political issues), and their assessment of its likelihood.

2. To get their view on the possible environmental implications of the reform.

3. To get their perspective on the effectiveness of current environmental policy (particularly air quality and climate change policy), and why it is that it does or does not work.

4. To get suggestions for improving the environmental performance of the sector (towards a diversified portfolio that includes renewables, and towards energy efficiency) whether there is a reform or not. What policies? What technologies? How to implement them?

5. To get data (ideas for case studies that serve as empirical basis of research, sector data in general, references, other contacts).

Key Questions
(Not all apply to all interviewees)

Do you, or the sector or organization you belong to, have a defined position regarding energy reform?

What factors have stopped energy reform?

Do you perceive that electricity sector reform would have an impact on your sector? How about other sectors? Do you foresee impacts to society, the economy, the political sphere?

Do you perceive business opportunities for your sector in case there is a reform? Do you foresee any technological improvements?

Do you or your sector have any complaint about the service currently provided by electric utilities (electricity supply, reliability, prices, etc.)? Do you think electric utilities are effective and efficient?

Do you think the quality of the electric service has impacted the country's productivity? Would that change with privatization?

What is your perception about the environmental performance of the energy sector (and public power utilities)? Do you think it has improved? How could it be improved (further)?

How about private firms? Are they cleaner? Why do you think they are (or are not) so?

What is your perception about environmental policy –particularly regarding air quality and climate change policy? Is it effective? What works? What does not?

How has it impacted the energy sector (and power utilities)?

Do you perceive any change in environmental (air quality, climate change) policy in the latest years?

What do you think may be missing in terms of environmental policy? How can policy design improve? How about policy implementation?

How is your sector (organization, firm) impacted by environmental regulations (or policy in general), in comparison with other sectors and other countries?

What is your sector (organization, firm) doing to comply with environmental regulations? Do you think it should do more, or less?

Is your sector (organization, firm) involved in the design of environmental policy? How? Do you think it should it be involved more?

What incentives could be effective to improve the environmental performance of your sector (organization, firm)?

What do you think may be effective to promote the development of renewable energy and energy efficiency? What can the environmental sector do? How can they achieve their goals on this matter?

Appendix C
Modes of Private Participation in Power Generation in Mexico
(As Stated by the Secretariat of Energy)

The new legal framework allows the private sector to participate in activities previously reserved for the state alone. In this regard, the activities not considered as public service are:

Self-consumption: The use of electrical energy for one's own consumption, as long as this electricity comes from facilities destined to provide it for satisfying the needs of a single user, or a given group of co-owners or partners.

Cogeneration: Production of electrical energy as well as steam or other types of secondary thermal energy, or both; direct or indirect production of electrical energy based on thermal energy not utilized in those processes in which it is a byproduct; direct or indirect production of electrical energy using fuels produces in those processes involved.

Independent Production: The generation of electrical energy at a plant with a capacity higher than 30 MW, exclusively for sale to CFE or for exporting.

Small-scale Production: This modality refers to the generation of electricity at a plant with a capacity of less than 30 MW, for sale to CFE exclusively. It should be located at a site determined by the Secretariat of Energy.

Export: Permit holders for cogeneration, small-scale production, and independent production could use part of their generation for selling it abroad.

Import: To satisfy the permit holder's own needs, they can import electricity from sources abroad.

These modalities allow the private sector to participate in the development of projects for the generation of electricity for sale to CFE as well as for satisfying the energy needs of national industries through partnerships for self-supply. The law also allows state government and municipalities to generate electricity for public lighting, water works, and other uses.

The different modalities of private participation require a permit for generation of electricity. The Energy Regulatory Commission (CRE) is the entity responsible to grant such permits.

In what refers to transmission, the private sector may build and operate lines for its use. In the case of these lines interconnecting with the public service network, contracts should be subscribed with CFE and/or LFC.

To support private projects for electricity generation, permit holders may use transmission lines that belong to the national electricity network, to transmit electricity from their generation facilities to their partners, as long as they are located at a reasonable distance from each other.

Sources: SENER, 2004; Breceda, 2004.

Appendix D

Relevant Data by Generation Plant

TABLE D.1
MAIN CHARACTERISTICS OF PUBLIC COMBINED CYCLE PLANTS

Plant	Units in Operation	Capacity (MW)	*Production* (GhW/yr)	Estimated Investment (US$MM)	Location (State)
C.C.C. Presidente Juárez (Rosarito)	2	496.0	1370.3		Baja California
C.C.C. Chihuahua II (El Encino)	3	423.3	2450.1		Chihuahua
C.C.C. Benito Juárez (Samalayuca II)	6	521.8	3613.9	660	Chihuahua
C.C.C. Gómez Palacio	3	200.0	842.2		Durango
C.C.C. Francisco Pérez Ríos (Tula)	6	382.0	2669.3		Hidalgo
C.C.C. Huinalá	5	377.7	2543.6		Nuevo Leon
C.C.C. Huinalá II	2	450.2	1765.4		Nuevo Leon
C.C.C. El Sauz	4	218.0	1482.1		Querétaro
C.C.C. Dos Bocas	6	452.0	2721.0		Veracruz
C.C.C. Felipe Carrillo Puerto (Valladolid)	3	212.0	1330.9		Yucatan

Notes:
C.C.C.: Central de Ciclo Combinado.
Listed in alphabetical order by state.
Source: INEGI, 2003

TABLE D.2
MAIN CHARACTERISTICS OF IPP PLANTS

Plant	Main Owner	Max. Capacity (MW)	Max. *Production* (GhW/yr)	Estimated Investment (US$MM)	Permit Given (mm/dd/yy)	In Operation (mm/dd/yy)	Location (State)
Mérida III	AES - Nichimen	531.5	3400.0	292.3	02/19/97	05/31/00	Yucatan
Fuerza y Energía de Hermosillo	Unión Fenosa	252.7	1800.0	139.0	11/23/98	10/01/01	Sonora
Central Anahuac	Electricité de France	568.6	3700.0	312.7	12/16/98	01/18/02	Tamaulipas
Central Saltillo	Electricité de France	247.5	1650.0	136.1	03/19/99	11/10/01	Coahuila
Energía Azteca VIII	Intergen – Bechtel	597.0	4399.0	328.4	06/02/99	01/15/02	Guanajuato
Tuxpan II	Mitsubishi	535.6	3707.5	294.6	06/25/99	12/16/01	Veracruz
Monterrey III	Ibedrola	570.0	3685.0	313.5	10/08/99	03/26/02	Nuevo Leon
Transalta Campeche	Transalta	275.0	2103.0	151.3	04/06/00	05/28/03	Campeche
Aguila de Altamira	Mitsubishi	565.3	3631.5	310.9	04/28/00	05/01/02	Tamaulipas
Fuerza y Energía de Naco-Nogales	Unión Fenosa	339.3	1920.0	186.6	07/14/00	10/04/03	Sonora
Energía Azteca X	Intergen – Bechtel	597.3	4850.0	328.5	08/07/00	07/20/03	Baja Calif.
Fuerza y Energía de Tuxpan	Unión Fenosa	1120.0	7362.5	616.0	12/15/00	05/23/03	Veracruz
Energía Altamira	Ibedrola	1153.7	7797.0	634.5	02/14/01	12/24/03	Tamaulipas
Transalta Chihuahua	Transalta	317.9	2174.4	174.8	04/27/01	09/08/03	Chihuahua
Central Lomas del Real	Electricité de France	541.0	3780.0	297.6	08/16/01	04/01/04	Tamaulipas
Central Valle Hermoso	Electricité de France	547.0	3700.0	300.9	04/22/02	04/01/05	Tamaulipas
Energía La Laguna	Ibedrola	517.8	3704.0	284.8	09/26/02	04/22/05	Durango
Energía del Golfo	Ibedrola	1088.8	8259.3	598.9	12/11/03	11/01/06	Tamaulipas
Cía. de Generación Valladolid	Calpine - Mitsui	563.4	3849.4	309.9	01/09/04	06/01/06	Yucatan
Electricidad Sol de Tuxpan	Mitsubishi	548.4	3787.3	301.6	02/26/04	09/01/06	Veracruz
Energía Tamazunchale	Ibedrola	1078.8	8518.6	593.4	11/26/04	05/31/07	San Luis P.

Note: Listed in chronological order according to date when permit was issued.

Source: CRE, 2005

TABLE D.3
AIR EMISSIONS FROM MAIN PUBLIC GAS-FUELED PLANTS 2002

	Capacity	Production	SO2		NOx		CO2		Hg	
Plant	(MW)	(GWh)	Tonnes	kg/MWh	Tonnes	kg/MWh	Tonnes	kg/MWh	Kg	kg/GWh
C.T. Valle de México	750.0	3894.1	10.9	0.003	3096.3	0.795	2182656	560.500	4.7	0.0012
C.TG. Portes Gil (Río Bravo)	145.1	1031.4	13.6	0.013	3436.8	3.332	1216356	1179.325	2.8	0.0027
C.TG. El Sauz	251.0	1495.6	4.2	0.003	2221.3	1.485	787424	526.504	1.8	0.0012
C.C.C. Presidente Juárez (Tijuana)	210.0	648.4	24.6	0.038	1222.0	1.885	427061	658.619	1.0	0.0016
C.T. Jorge Luque (LFC)	224.0	497.2	1.8	0.004	847.3	1.704	362650	729.442	0.8	0.0016
C.TG. Hermosillo	131.9	507.2	1.6	0.003	875.0	1.725	310190	611.633	0.7	0.0014
C.TG. Chihuahua II (El Encino)	130.8	329.1	1.1	0.003	581.9	1.768	206266	626.682	0.5	0.0014
C.TG. Huinala	140.0	259.7	0.8	0.003	427.2	1.645	151433	583.106	0.3	0.0013
C.T. San Jerónimo	75.0	222.0	0.8	0.003	219.2	0.987	154502	695.925	0.3	0.0015
C.T. la Laguna	39.0	179.6	14.9	0.083	303.1	1.688	129843	722.995	0.3	0.0016
C.TG. Jorge Luque (Lechería) (LFC)	138	145.4	0.6	0.004	326.3	2.245	115683	795.672	0.3	0.0018
C.TG. Nonoalco (LFC)	148.0	131.5	0.5	0.004	280.6	2.134	99471	756.604	0.2	0.0017
C.TG. Valle de México (LFC)	88	104.8	0.5	0.004	241.7	2.307	85676	817.676	0.2	0.0019
C.TG. El Verde	24	29.1	44.5	1.528	114.5	3.932	28391	975.296	0.1	0.0045
C.TG. La Laguna	56	62.3	2.1	0.033	159.4	2.560	56003	899.498	0.1	0.0021
C. TG. Chavez	28	25.3	0.1	0.005	65.2	2.581	23100	914.859	0.1	0.0021
C.TG. Universidad	24	17.2	0.1	0.005	50.4	2.930	17884	1038.561	0.0	0.0024
C.TG. Leona	24	16.6	0.1	0.005	48.3	2.915	17121	1033.233	0.0	0.0024
C.TG. Fundidora	12	4.8	0.0	0.005	13.4	2.793	4762	989.980	0.0	0.0023
TOTAL (Public Gas-fueled Plants)	2638.8	9601.1	122.8	0.013	14529.9	1.513	6376470.2	664.138	14.4	0.0015

Sources: INEGI, 2003: Miller and van Atten, 2004

TABLE D.4
AIR EMISSIONS FROM CFE BLT COMBINED CYCLE PLANTS 2002

	Capacity	Production	SO2		NOx		CO2		Hg	
Plant	(MW)	(GWh)	Tonnes	kg/MWh	Tonnes	kg/MWh	Tonnes	kg/MWh	Kg	kg/GWh
C.C.C. Presidente Juárez (Rosarito)	496.0	1370.3	4.2	0.003	2241.8	1.636	794694	579.942	1.8	0.0013
C.C.C. Chihuahua II (El Encino)	423.3	2450.1	11.6	0.005	3263.6	1.332	1155436	471.587	2.7	0.0011
C.C.C. Benito Juárez (Samalayuca II)	521.8	3613.9	9.7	0.003	4140.0	1.146	1467057	405.948	3.4	0.0009
C.C.C. Gómez Palacio	200.0	842.2	3.1	0.004	1668.3	1.981	591390	702.197	1.4	0.0017
C.C.C. Francisco Pérez Ríos (Tula)	382.0	2669.3	7.7	0.003	4087.6	1.531	1449006	542.841	3.3	0.0012
C.C.C. Huinalá	377.7	2543.6	5.6	0.002	3009.4	1.183	1066807	419.408	2.4	0.0009
C.C.C. Huinalá II	450.2	1765.4	2.7	0.002	1418.3	0.803	502788	284.801	1.2	0.0007
C.C.C. El Sauz	218.0	1482.1	176.3	0.119	1955.2	1.319	645602	435.599	1.7	0.0011
C.C.C. Dos Bocas	452.0	2721.0	7.0	0.003	3711.5	1.364	1315693	483.533	3.0	0.0011
C.C.C. Felipe Carrillo Puerto (Valladolid)	212.0	1330.9	122.9	0.092	2025.2	1.522	685122	514.781	1.7	0.0013
TOTAL (CFE-BLT Plants)	3733.0	20788.8	350.8	0.017	27520.9	1.324	9673595	465.327	22.6	0.0011

Sources: INEGI, 2003: Miller and van Atten, 2004