Renewable Energy in Mexico:
Current Situation and Perspectives

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For:

The World Bank
and
Secretaría de Energía

March 20, 2002

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Introduction

Mexico's energy sector is one of the most important among emerging economies. A major oil producing nation, Mexico ranks 8th in oil production and 9th in oil reserves, while the total capacity of its electricity sector approaches 40,000 MW. In order to respond to increasing energy demand, and taking into account its existing resource base and potential, Mexico has decided to intensify the use of renewable energy sources over a 10 to 12 year horizon as part of its general energy strategy. Although no promising technologies are excluded, Mexico is exploring a strategy to accelerate the commercialization of large-scale grid-connected renewable energy generation technologies through market interventions.

1. Strategic vision

Currently, only a small portion of Mexico's total energy needs are met by renewable energy sources. In 2000, hydrocarbon based generation accounted for 47.7% of electricity plants and for 60.7% of total installed capacity. This, in part, is explained by Mexico's abundance of hydrocarbon reserves and relative scarcity of water resources. The country's dependence on hydrocarbon based generation is even greater, however, when taking into account that while hydroelectric power accounted for 26.2% of total installed capacity, it only accounted around 14% of actual generation, as insufficient water supplies exist for year-round production.

Electricity demand growth during the 2001-2010 period is expected to be strong and greater than the growth rate of GDP. The base case scenario estimated by the authorities using a GDP growth rate of 5.2% is that electricity consumption will grow at an annual

rate of 6.3% and energy demand at an annual rate of 6%. These calculations take into account actual levels of electricity use, the rate of structural transformation of the economy, a gradual phase out of current price subsidies for residential and agricultural electricity consumption, and estimates of the income elasticity of demand.

INSTALLED GENERATION CAPACITY (MW)

DECEMBER 2000

Area	Hydro	Hydrocarbon based					Coal	Nuclear	Geoth	Wind	**Total**
		Thermal	Combined Cycle	Turbogas	Internal Combust	Dual					
Northwest	941	2,162		281							**3,384**
North	28	1,074	722	253							**2,077**
Northeast	118	1,715	828	455			2,600				**5,716**
West	1,798	3,466	218	122		2,100			93		**7,797**
Central	1,524	2,474	482	374							**4,854**
East	5,210	2,217	452	43				1,365	42	1.6	**9,331**
Peninsular		442	696	343	1						**1,482**
Baja California		620		359	2				720		**1,701**
Baja C Sur		113		126	73						**312**
Other				5	39					0.6	**45**
Total	**9,619**	**14,283**	**3,398**	**2,361**	**115**	**2,100**	**2,600**	**1,365**	**855**	**2**	**36,697**

Note: Solar capacity is not reported, as it is not connected to the grid.

Source: Prospectiva del Sector Eléctrico 2001-2010, Secretaría de Energía.

These rates of growth translate into important capacity requirements. Government estimates indicate that it will be necessary to increase capacity by 32,219 MW during the 2001-2010 period, of which 10,854 MW are already committed or under construction. Private sector self supply and cogeneration projects are estimated to account for only 4,862 MW of the total given the current regulatory framework, which will be discussed in detail in section 2. The planning scenario presented by the government also considers retiring 1,661 MW of capacity during this period, for a net addition of 30,558 MW, which represents an 83% increase.

The low rate of capacity retirement estimated for this period, together with the low rate of retirement during the past decade (1991-2000), when only 816 MW of capacity were removed from the system, is a result of government budgetary and financing restrictions.

These short-term constraints have led the public sector to conserve many generating units that have high operating costs and pollution emissions (due to their small scale, age, or both). The costs of these units raise the average cost of the system and are being passed through to consumers and the public sector, either in the form of higher tariffs or increased subsidies.

According to projections, the 27,357 MW of future required capacity to be built or contracted by the public sector during the 2001-2010 period will be overwhelmingly met via the employment of combined cycle gas turbines, given their relative efficiency and fuel price projections. This trend will result in gas-based generation accounting for 52.1% of total generation by 2010, up from 9.2% in 2001, while conventional thermal generation (fuel oil based) will reduce its participation from 46.6% to 13.8%. Renewable energy sources (including large scale hydro) represent around 12% of energy additions.

CAPACITY ADDITIONS (MW)

2001-2010

	Committed	Not committed	Total	% share
Combined cycle	9,344	8,025	17,369	63.5
Repowering	272		272	1.0
Hydro	936	2,255	3,191	11.7
Coal		2,100	2,100	7.7
Turbogas	134	83	217	0.8
Internal Combustion	51	161	212	0.8
Geothermal	118	5	123	0.4
Undefined		3,874	3,874	14.2
Total	10,854	16,503	27,357	100.0

Source: Prospectiva del Sector Eléctrico 2001-2010, Secretaría de Energía.

In summary, Mexico's energy sector is large and rapidly growing. Future required investments are large relative to the current size of the system, and under the existing

regulatory framework will be primarily contributed or financed by the public sector. Under said framework, the sector will continue to be largely dependent on hydrocarbon based generation, although there will be a very significant shift into natural gas and out of fuel oil via the construction of numerous combined cycle generating plants and the elimination of part of the current fuel oil driven capacity. Current renewable energy capacity is small relative to the rest of the system, and virtually non-existent if large-scale hydroelectric dams are not taken into account.

The promotion of renewable energy, however, forms an important part of Mexico's energy policy for the future[1]. The reasons for this are numerous:

- Diversification (long term). Currently the Mexican power sector is heavily dependent on oil, natural gas, and coal. Fossil fuel based generation accounts for 68% of installed capacity and an even larger share of production. It is forecast that under the current growth and regulatory scenario that the share of conventional thermal generation will fall from 47% to 13% of total generation over the 2000-2010 period, while the share of natural gas will increase from 9% to 52%. During this same period, hydroelectric generation is forecast to fall from 17 to 11%. Therefore, while Mexico will diversify out of traditional, fuel oil driven thermal plants, it will do so by creating a new dependency on natural gas via the construction of combined cycle gas turbines. The lack of a diversified generation base is largely the result of abundant hydrocarbon resources and scarce water resources; however, future trends clearly indicate that hydrocarbon supplies (especially natural gas) will diminish relative to total system consumption at increasing rates over the long term. A policy of energy diversification should therefore form part of overall energy policy, even though Mexico is an oil and gas rich economy, as it will reduce the negative impacts of the medium term shift in relative prices. A policy of non-diversification would transform a shift in relative prices into a shock, with potentially devastating costs and losses in sunken asset values.

[1] It is listed as an important objective in the National Development Plan 2001-2006 and the Energy Sectoral Program 2001-2006.

- Diversification (short term). The high dependence of the electricity sector on hydrocarbons also translates into increased risk from price volatility. The prices of petroleum and natural gas are correlated and shocks to the price of one frequently feed through to the other, as evidenced in the US during 1999-2000, when a sharp rise in oil prices shortly preceded a shock to the price of natural gas. Past evidence also shows that the price for natural gas is the most volatile energy commodity price. Therefore, the promotion of renewable energy sources would allow the Mexican power sector to diversify its mix of fuel options, reducing its exposure to volatility in the fossil fuels markets without introducing additional volatility given renewable energy's stable, low, or in many cases non-existent input prices.

- Environmental. It is clear that renewable energy projects have clear environmental advantages, with reduced emissions relative to hydrocarbon fueled projects.

    - The Mexican Senate ratified the Kyoto Protocol in 2000, the first large world economy to do so. Further evidence of the commitment to reduce emissions can be found in the Plan Nacional de Desarrollo 2001-2006, which states that one of the explicit objectives of government policy is sustainable development, and that a strategy to be pursued is the promotion of the sustainable use of natural resources.

    - Mexico ratified the UNFCC in 1993. It has moved rapidly to prepare a national communications report with updated national emission inventories, and a National Action Program for Climate Change (NAPCC) prepared by an inter-agency committee integrated by the Environment, Energy, Foreign Relations, Commerce, Communications and Transport, and Agriculture ministries. Its population of nearly 100 million inhabitants is responsible for nearly 1.48% of global emissions of CO2 (13th worldwide). In contrast, per capita emissions (3.46 tons of CO2 /inhabitant per annum) place the country in the 72nd position worldwide. Mexico's

participation in the UNFCCC reflects that the country's increasing emissions profile is necessary in order to meet development needs, and in this respect Mexico will take actions that limit GHG emissions without restricting its economic development.

- Private sector participation. Renewable energy projects can currently be developed by the private sector for self-supply, and are generally of a sufficiently small scale to be feasible for individual consumers or small groups. If made attractive, they would allow for increased private sector participation in the sector and reduce public sector commitments for new capacity construction. In addition, the promotion of renewable energy projects in Mexico could potentially stimulate the development of domestic suppliers, contributing indirectly to the diversification of the sector (currently the vast majority of generation turbines are imported).

- Rural development. The few current solar and wind powered energy projects in Mexico today have been developed primarily for supplying remote areas for which demand is too small to justify the investments required to connect them to the national grid. Currently, 5% of the population (approximately 5 million people) lack access to electricity. The Program for Rural Electrification in particular seeks to increase coverage in poor rural areas, which have a large concentration of indigenous population, for whom electrification would imply a significant boost in living standards and access to crucial public services such as water and sewerage. This program, which currently targets as a priority 1,200 communities, will be a major source of demand for the development of renewable energy.

- Opportunities in specific sectors. While renewable energy can benefit all users of electricity, it has the potential to become a major source of energy in some sectors, such as the water and municipal sectors. The water sector uses a large number of diesel generators as a source of backup power for water pumping stations. The redundant power supply requires large capital investments and sizeable budgets for operation and maintenance and can be an important source of emissions to the

atmosphere. Hence, the water sector can become a major user of renewable energy for the self-supply of electricity. The municipalities can also become major users of renewable energy for public lightning, solid waste management, and operation of water and sewerage services, among others.

- Experience and capacity A network of public and private institutions has experience with the development of renewable energy projects and the capacity to conduct research and develop technologies.

2. Current situation of renewable energy in the Mexican power sector

Current situation and potential for renewable energy

As seen in the previous section, renewable energy today plays a very small role in the Mexican energy sector. In the *Programa Sectorial de Energía 2001-2006*, the government recognizes the lag in the development of renewable energy in Mexico and stresses the importance of increasing its participation. It also lays out a comprehensive strategy aimed at correcting this situation, which is commented on in greater detail throughout this section.

As seen in the previous section, after taking into account large-scale hydroelectric generation, geothermal power is the second most important source of renewable energy in Mexico today, with a total capacity of 855 MW. It is followed by wind, with approximately 2 MW from La Ventosa and Guerrero Negro. Solar installed capacity, which is not connected to the grid, accounts for 13 MW.

While renewable energy currently plays a small role in the sector, a large potential for the development of renewable energy projects exists. The Ministry of Energy currently estimates that an additional 17,000 MW of renewable energy sources exist. Mexico receives large amounts of sunlight, 5 kWh per square meter on average, which is roughly double the level in the United States. There are also various regions of the country characterized by strong, year-round winds, and CFE has estimated potential wind powered generation capacity to be 3,000 MW. Mini hydro projects also are very promising, both because an important potential exists (3,200 MW) and also because in several cases water control infrastructure is already in place (irrigation and flood control dams). Important opportunities for growth exist in biomass driven generation, primarily in the sugar industry, where cane bagasse is already consumed for the production of steam, and also at the municipal level. It is estimated that cane bagasse alone could supply a capacity of 1,000 MW. Finally, Mexico has an important geothermal generation capacity currently in place, and it is estimated that an additional 837 MW could be added.

Current projections considering available resources and the existing legal and institutional framework estimate that renewable energy capacity will grow by 699 MW over the 2001-2010 period, a small number when compared to the 27,357 MW in total generation capacity which must be built during this period to meet demand.

RENEWABLE ENERGY CAPACITY ADDITIONS (MW)

2001-2010

	Cane bagasse	Mini hydro	Wind	Solar	Biogas	Total
2001	210	92	64	14	11	391
2002	210	152	64	15	11	452
2003	214	160	125	116	11	526
2004	218	168	132	17	12	547
2005	222	176	140	18	13	569
2006	227	185	148	19	14	593
2007	231	195	157	20	14	617
2008	236	204	167	21	15	643
2009	241	214	177	22	16	670
2010	246	225	187	24	17	699

Source: Prospectiva del Sector Eléctrico 2001-2010, Secretaría de Energía.

While the projections of a 699 MW increase in renewable energy over the 2001-2010 period are low, an explicit policy objective laid out by the government in the *Programa Sectorial* is to duplicate the capacity of renewable energy over the 2000-2006 period. This would be carried out via the addition of 1,000 MW of renewable energy to the CFE expansion program, an increase of over 140% from the current projected level. In addition, the national electricity research institute (IIE), has established a 10 year scenario for the development of renewable energy capacity which attempts to present a feasible estimate of what could be built given the appropriate policies and regulation over the 2001-2010 period, which is substantially greater than either the projections described in the previous table or the more ambitious objective set out by the government.

RENEWABLE ENERGY EXPANSION SCENARIO

2001-2010

	MW
Wind	2,000
Small scale hydro	300 – 500
Biomass	150
Photovoltaic (solar)	10 – 20

Source: IIE

Another important factor in gauging renewable energy potential is experience. CFE, IIE, and many universities in Mexico (both public and private) have over 25 years of experience in the development of renewable energy, and have carried out numerous pilot projects, the most important of which are described below. In-country experience with the development and manufacture of renewable energy technologies also exists.

Project	Description
Tonatiuh	30 kW thermosolar project financed with the support of the French government in 1975
UNAM experimental solar project	A 10 kW project designed and manufactured in Mexico at the beginning of the 1980s
Sonntlan	A development of solar houses in a fishing community in Baja California
La Ventosa	CFE 1.6 MW pilot project for wind power in Oaxaca
CFE rural electrification	Over 4,000 separate systems

Source: CONAE

The sharp contrast between the potential levels of renewable energy generation capacity and the forecast expansion in this area can be attributed to a series of factors, one of the most important of which is economic. Although significant technological steps have been taken in past years, renewable energy generation continues to be relatively more costly than other alternatives, such as combined cycle gas turbine, when costs are calculated without incorporating the effect of environmental externalities. Therefore, in the absence of explicit policy incentives, renewable energy alternatives are generally not considered viable options except in remote areas where no conventional distribution

network exists. However, evidence from the international arena shows that policy incentives can have a very important impact on renewable energy development and use. According to the Ministry of Energy, the use of wind power in developed economies has increased by 30% annually over the past three years, while the use of solar power has increased by 15% annually since 1993.

Actors and stakeholders

Numerous actors, both public and private, play important roles in renewable energy:

- Ministry of Energy (SENER: Secretaría de Energía): SENER is responsible for policy, regulation, strategy and coordination of the energy sector.

- Energy Regulatory Commission (CRE: Comisión Reguladora de Energía). CRE is responsible for regulating private operators in the energy sector and interconnection with CFE. Among other functions CRE coordinates and authorizes bidding processes and permits for energy projects, including electricity and gas, and is responsible for protecting consumer interests.

- National Comission for Energy Conservation (CONAE: Comisión Nacional para el Ahorro de Energía). While more focused on energy saving measures, such as Daylight Savings Time and the introduction of efficient lighting and air conditioning systems, the CONAE is also involved with the promotion of renewable energy projects. It serves as a center for information on renewable energy technologies, past experiences both in Mexico and abroad, and current efforts taking place. The CONAE plays an important role as spokesperson of the government with industry and potential end users and also organizes numerous conferences on renewable energy. It is also involved in the issue of Mexican Official Standards relating to energy.

- Ministry of the Environment and Natural Resources (SEMARNAT: Secretaría del Medio Ambiente y Recursos Naturales). SEMARNAT is responsible for

environmental policy, regulation and the issue of Mexican Official Standards regarding environmental protection, many of which have implications for energy related projects. The Environmental Attorney (PROFEPA: Procuraduría Federal de Protección Ambiental), a decentralized agency of SEMARNAT, is responsible for compliance with environmental regulations, except those dealing with water, which are a responsibility of the National Water Commission.

- Ministry of Finance and Public Credit (SHCP: Secretaría de Hacienda y Crédito Público). Among its many responsibilities SHCP is responsible for setting taxes, subsidies and prices and tariffs of electricity, in cooperation with SENER and other agencies.

- Federal Electricity Commission (CFE: Comisión Federal de Electricidad). CFE is the publicly owned electricity company that generates 98% of the electricity considered a "public service" (that is, excluding self supply), and transmits and distributes 91% of electricity. Luz y Fuerza del Centro, the other publicly-owned utility, serves consumers in Mexico´s central region (Mexico City metropolitan area and parts of Estado de México, Morelos and Hidalgo).

Other relevant actors include the National Waters Commission (CNA: *Comisión Nacional del Agua*) in charge of regulating the use of water resources, and the *Instituto de Investigaciones Eléctricas* (IIE) which is the national electricity research institute, and is where most work on renewable energy is performed. The IIE is also closely involved with the various renewable energy projects currently taking place.

The most important private actors in renewable energy in Mexico are the *Asociación Nacional de Energía Solar* (ANES), the *Asociación Mexicana de Economía Energética* (AMEE), and the *Cámara Nacional de Manufacturas Eléctricas* (CANAME). ANES includes among its members most of the national academic community involved in renewable energy issues, as well as some of the equipment manufacturers. AMEE represents the large, transnational energy companies present in Mexico, whose primary

activity is the construction of combined cycle gas turbine plants under IPP contracts with CFE. Finally, CANAME is the national chamber of electricity equipment manufacturers.

In the academic sector, a large number of universities and research centers are involved in renewable energy issues. Of these the most important are the Center for Energy Research (Centro de Investigaciones Energéticas) and the Engineering Institute (Instituto de Ingeniería), both of which are at the National Autonomous University of Mexico (UNAM). The UNAM also runs the University Energy Program (Programa Universitario de Energía or PUE). Other centers are the Center for Advanced Studies and Research (Centro de Investigaciones y Estudios Avanzados or CINVESTAV) of the National Polytechnic Institute (IPN) and several schools within the Autonomous Metropolitan University (UAM).

The use of renewable energy in Mexico has also been promoted by international organizations. The World Bank has participated in GEF related projects on solar thermal power plants, electricity generation with biogas from sanitary landfills and water pumping with solar and wind energy. The United Nations Development Program (UNDP), which has advanced various project initiatives on wind farms, grid-connected photovoltaics and biomass for agricultural processes, all within the framework of the GEF. The UN Food and Agriculture Organization (FAO) working on the issue of firewood and looking into productive applications of renewable energy in rural areas. Bilateral aid agencies, such as the USAID and the German GTZ are also actively involved in this field. For almost a decade now, the USAID with the support from the Department of Energy and other US Government agencies and institutions, has carried out activities to foster the use of renewable energy in Mexico, mostly in off-grid rural applications.

In recent times, growing numbers of national and international private investors, financing institutions, technology manufacturers and project developers have made themselves present in the Mexican renewable energy arena, mainly in connection with the use of wind energy for power generation and small hydropower.

Regulatory and institutional issues

The Mexican constitutional and legal framework establishes that the State has the exclusive power to generate, conduct, transform, distribute and supply electricity related to the provision of electricity for "public service" (Article 27). Private sector participation is therefore limited to IPP projects where the totality of generation is sold to CFE, and self-supply and cogeneration projects.[2]

The legal framework also assigns the federal government responsibility for the formulation of policies relating to the energy sector, and to the national congress for legislation in these fields. State and municipal governments therefore have very few powers in this regard, except for those areas of government activity that can have implications for energy projects, including zoning restrictions, property taxes and some environmental regulations. Currently there is no decentralization process in the electricity sector contrary to other sectors, nor is such a process likely under the current legal and constitutional framework. However, decentralization processes currently in progress regarding some aspects of environmental protection and water related services might have implications for energy projects.

Pricing issues: existing conditions, progress and challenges

There are other institutional and regulatory issues that have to be addressed for the development of renewable energy in Mexico. Of these, the most important is the pricing system for electricity, which places a wedge between the price paid to private generators and the tariffs charged to end users and also creates uncertainty for suppliers. If not

[2] Article 3 of the Law for the Public Electric Energy Service exempts from the definition of public service the following activities, thereby establishing the scope for public sector participation in the electricity business: (i) Generation of electricity for self supply, generation of electricity through co-generation processes, or small generation of electricity (under 20MW for sale to CFE or under 1MW for the supply of remote rural communities); (ii) Generation of electricity by independent producers for exclusive sale to CFE; (iii) Generation of electricity for export purposes, either from co-generation, independent power production, or small generation; (iv) Import of electrical energy by individuals or formally established entities, for the sole purpose of self supply; (v) Generation of electricity in case of emergency caused by the interruption of public service.

corrected or if a market or a market driven pricing system is not developed, the price wedge reduces the profitability of renewable energy projects.

While the Constitution limits private sector participation to IPP projects where all the electricity generated is sold to CFE, and to cogeneration and self-supply projects, no provision exists for the purchase of surplus energy by CFE in the case of self-supply, while in the case of cogeneration CFE is required to purchase surplus energy up to 20 MW.

If a self-supplier wishes to sell energy to CFE, several conditions apply. First, CFE is not required to purchase surplus energy above 20MW, and if it decides not to, no other option exists (by law). If CFE does decide to purchase energy, it does so without a long-term contract or capacity payments, and pays only avoided or marginal cost, which is equivalent to the marginal cost of a new (combined cycle) plant. This occurs even if the cost of the renewable energy alternative is lower than the average cost of the system. These conditions make the development of renewable energy (and almost any electricity plant, for that matter) economically unattractive.

End users of electricity, however, pay tariffs that are determined using the average cost of providing service (except in the cases of residential and agricultural irrigation tariffs, which are heavily subsidized). Given that the rate of capacity retirement is extremely low, a very important difference between system average and marginal costs exists. Therefore, tariffs paid by industry, commercial establishments, and municipalities are very significantly above the marginal cost of combined cycle gas turbines, and clear economic opportunities exist where the willingness to pay of these consumers exceeds the cost of supplying them with renewable energy. However, since the current constitutional and legal framework prohibits direct contact between private producers and consumers, these opportunities cannot be exploited and represent an important barrier for the development of renewable energy sources in Mexico.

Recent regulatory changes that partially offset the disincentives inherent in the pricing system are encouraging. In September of 2001, the CRE published special rules for interconnection contracts between CFE and suppliers of renewable energy. These rules benefit self-suppliers whose consumption point(s) are not geographically adjacent to the production site, and can be summarized as follows:

- Priority dispatch. Renewable energy providers often have little or no control over production, which is governed by the amount of sunlight, wind, water, etc. Therefore the rules establish that CFE must dispatch these renewable energy providers whenever it is required, and not subject to other considerations.

- Discounts. The rules establish discounts on the tariff levied by CFE for transporting the supplier's electricity as a function of availability, which can reach 50%.

- Storage. As the self-supplier in question may not require energy at the same time that its renewable energy source is providing it, CFE is obliged to "return" unused energy to the self-supplier at times where it is required. That is, CFE in effect stores the energy. In the case of a self-supplier with a mini-hydro plant, for example, the electricity generated during the night is supplied to CFE, who then returns it to the self-supplier during the day.

These regulatory changes form part of a global and comprehensive strategy for the energy sector, as laid out in the *Programa Sectorial*. The *Programa Sectorial* establishes 10 key objectives for the energy sector during the 2001-2006 period, of which the fourth objective is to increase the use of renewable energy sources. It lists a series of strategies that together should serve as an important incentive for the increase use of renewable energy in Mexico. Among them are the following:

- Development of a National Fund for the promotion of renewable energy
- Long term investment contracts
- Fiscal and economic incentives

- Regulatory incentives
- Increased resources for research and development
- Education

These proposals form part of a global and comprehensive strategy for the energy sector, as laid out in the *Programa Sectorial*. The *Programa Sectorial* establishes 10 key objectives for the energy sector during the 2001-2006 period, and the fourth objective is to increase the use of renewable energy sources.

In addition to the above changes, further reforms in the form of a market driven structural change are needed to allow for the creation of a competitive market and the introduction of numerous suppliers and consumers. This would have very important benefits for the sector and the economy as a whole, as it would increase efficiency, lower costs and therefore tariffs, and reduce the public sector burden, among others. It would also be crucial for the development of renewable energy, as it would eliminate many of the arbitrary pricing mechanisms currently in place, and allow for prices to be determined through a market or transparent regulatory mechanisms instead of the current administrative system. A reform would allow renewable energy providers to exploit the difference between system marginal and average costs, and would also introduce the concept of consumer choice. It would also greatly reduce uncertainty and the possibility of creeping expropriation brought about by the current system's highly unequal distribution of bargaining power between a monopsony (CFE) and potential private suppliers.

The importance of structural change and the introduction of markets into the electricity sector can not be underemphasized. Without structural change, efforts to promote renewable energy will have a lesser impact and a much more uncertain future. The current restrictive legal and institutional environment also ensures that any efforts made without a prior reform will be more costly. In addition, any resources used to create incentives for renewable energy under the actual framework would partially be used to offset the economic distortions currently present in the sector.

Informational and Educational issues

There are a series of informational and educational issues related to renewable energy in Mexico that need to be addressed in order for it to develop further. The first of these is that site specific, detailed information on renewable energy projects is limited, which is an important barrier that translates into longer lead times and higher project development costs. With the exception of geothermal energy, for which commercial exploratory work has been carried out for a number of years, evaluation of other renewable energy resources has been done primarily for academic and research purposes.

However, activities are currently under way to compile, screen, and organize data into a geographical information system, which has been under development for the past three years as part of a pilot plan to foster renewable energy in Mexico, which is being carried out by IIE in cooperation with the Ministry of Energy, and was originally supported by funds from CONAE. While the quality of some of the data continues to be low, this pilot plan represents a very important step, and is the first systematic effort to quantify, organize, and divulge detailed information on renewable energy projects.

Other challenges are driven by the informational voids that exist with regards to renewable energy. Given Mexico's relative lack of practical experience in this field, little understanding of renewable energy exists. Important incentives such as those established by the CRE for the promotion of renewable energy need to be accompanied by concerted efforts to make their existence and significance known to all sector participants. In addition, a comprehensive national program for the promotion of renewable energy awareness among the general public would create interest in projects and aid in introducing new participants to the sector (municipalities and small enterprise). Efforts to expand and/or update the technical infrastructure of the national renewable energy R&D centers, closely linking them to the needs of the sector, as well as to develop a larger human resource base of experts, are important complements that should be carried out in order to close the information gap.

The lack of hands on experience with renewable energy implies that Mexico has not yet captured the benefits derived from organizational learning. Incentives aimed at promoting the development of renewable energy in Mexico will generate significant positive externalities in this regard. The investments made in learning about and researching different potential projects will have large benefits for the development of future projects. Other benefits will be associated with the configuration, design, scale, and implementation of these projects. Therefore, the transaction and development costs associated with renewable energy project design and implementation will drop over time as more of them are developed and learning takes place.

3. Instruments to advance the use of renewable energy

Previous sections have outlined both the importance of renewable energy to the Mexican energy sector and the current lack of development in this area, the latter due in great measure to the gap between the cost of renewables and the price at which they are sold. In past years, progress on the technological front has resulted in steadily declining costs for renewable energy options, albeit at levels still above the non-environmentally adjusted cost of fossil fuel options such as combined cycle gas turbines. However, consensus forecasts indicate that the growing scarcity of fossil fuel options as stocks are depleted, together with continued technological progress in renewable energy, will make renewable energy alternatives economically attractive in the medium term.

The Mexican energy sector and economy will greatly benefit if the transition towards a greater use of renewable energy sources is more rapid than what is projected under the current legal, regulatory, and institutional framework. In this fashion, Mexico would gain important preparatory experience in a field certain to grow in importance in the future, as well as reduce its dependence (and thus the shock to the economy) on fossil fuel based energy options.

The above rationale justifies the introduction of policy instruments to promote the use of renewable energy in Mexico. Selective intervention is required to ensure that renewable energy is considered a viable option within the energy sector, with the consequent economic and social benefits. The direct benefits are clear, and were laid out in section 1. The indirect benefits are also of importance, in that investments in renewable energy will ensure a smoother transition to a new energy sector configuration and allow for learning and knowledge investments to take place before the occurrence of fossil fuel driven shocks.

Any policy instruments employed to advance the use of renewable energy should be temporal in nature, as market forces (under the assumption of structural reform being

carried out) will make renewable energy alternatives attractive in the medium term. Interventions are therefore not permanent, but serve as the seed for future growth.

Policies aimed at promoting renewable energy sources have been employed in different countries, and can be grouped into two categories: quantity targets, where a certain share of generation must be supplied by renewable energy, and price subsidies, where resources are used to make renewable energy economically attractive. Of the two, price subsidies are better suited for temporal interventions, as they allow for greater flexibility and adjustment than quantity targets.

Policies that mandate a quantity target are rigid in the sense that they can not be adjusted to take into account changes in technology or the legal, regulatory, and institutional frameworks without seriously undermining their credibility. The determination of a quantity target is necessarily arbitrary, and may be markedly different than the first best outcome if uncertainty exists with regard to the behavior of certain key variables. Other problems associated with quantity targets are that they are open ended (if a quantity is fixed a limit on the amount of resources spent can not always be enforced) and suffer from problems of dynamic inconsistency (if the target is not met, the authority prefers to renegotiate the target instead of applying any pre-specified penalties).

Price subsidies, on the other hand, provide greater flexibility and transparency. Price subsidies are not fixed in time, and can be adjusted to compensate for the rate of technological change and the relative cost levels. These adjustments can be carried out via market forces through systems of competitive bids, and can be fixed to make a developer indifferent between conventional combined cycle technology and renewable energy sources, optimizing the use of scarce resources. The amount of the subsidy can be phased out over time, with clearly established targets and timeline.

Legal and institutional issues

It will be necessary to address the legal and institutional issues described in the previous sections, if private sector participation is expected for the development of renewable energy projects. Among others, the reforms should address the scope of private sector involvement and the mechanisms by which electricity is to be sold to CFE or to private parties, including the pricing structure.

Strengthening institutional capacity and provision of technical assistance to the relevant authorities and utilities with regards to renewable energy is also considered a priority. In addition, support of renewable energy projects through IIE and research centers in academia and elsewhere will help improve policies and technologies. It will also increase public awareness of the benefits of renewable energy. Public awareness can also benefit form an information campaign among consumers and communities.

Financial mechanism to promote the use of renewable energy

The development of renewable energy projects requires substantial financial resources. In this sense, the creation of a special fund for this purposes will provide a much needed boost to kick start new projects and strengthen existing ones. The fund will facilitate the transition towards the development of a competitive, efficient and cost-effective market for renewable energy in Mexico. This market will build upon the resources from the fund, other resources, international best practice, growing experience and know-how and an appropriate regulatory and institutional framework. In addition, synergies can be created between the market for renewable energy and the carbon market being developed.

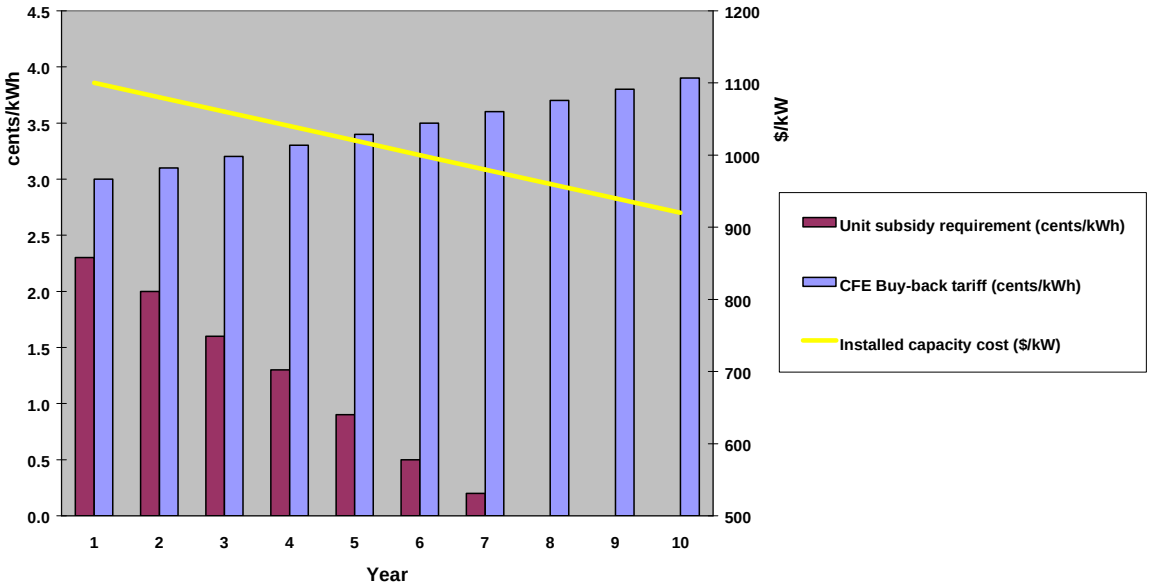
An initial estimate is that the fund will require approximately 100 million USD of which 30% to 35% would be used in the first three years. Among the general characteristics of the fund are the following:

- The fund will provide subsidies through a competitive process and these subsidies will be phased out according to a clearly established timeline.

- The mechanism to define the amount of the subsidies should force recipients to reveal their true costs.
- The fund will include mechanisms for its replenishment, including resources obtained through bidding process for electricity generation and the development of "green certificate" programs for businesses that purchase electricity from renewable energy sources.

A preliminary exercise carried out for the analysis of wind power shows that a fund of 95 million USD would directly stimulate 650 MW of capacity. In addition, technological change and organizational learning, along with proposed changes to the CFE powering purchasing tariffs and a projected increase in the price of natural gas, would effectively reduce the subsidy to zero by year 8. Therefore the fund, while directly increasing capacity by 650 MW, would also indirectly contribute to capacity additions by contributing to organizational learning and technological change, thus reducing the cost of installed capacity. If carbon offset sales were to be recognized (at an average price of $6 USD/MT of CO2) the cumulative subsidy could be reduced from $95 to $83 million USD.

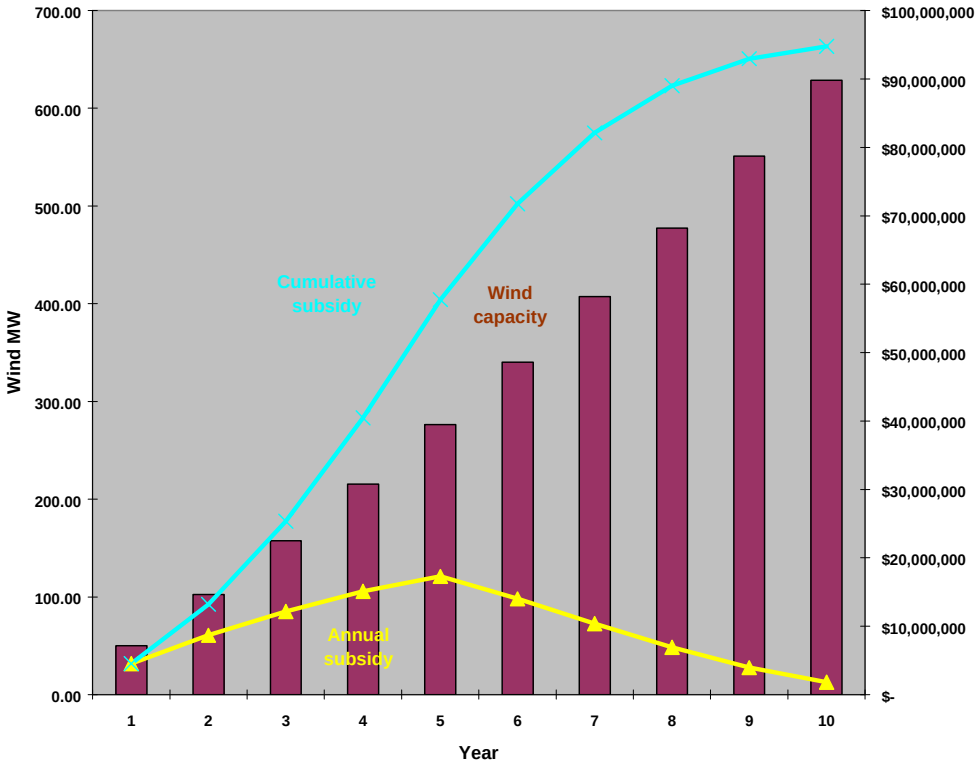
Wind Costs, Tariffs and Subsidies



The above calculations are based on the following series of assumptions: an initial installed cost for wind power of 1,100 USD/kW which would decline to 900 USD/kW over a 10 year period; and an increase in the CFE buy-back tariff rate from 3 to 4 cents/kWh over the same period. Given these assumptions, the unit subsidy requirements start out at 2.3 cents/kWh and then decline significantly, approaching zero by year 8.

The implications of the above scenario for fund operations are as follows: during the first three years 35% of the resources will have been applied, and the year with the highest annual subsidy would be year 5. After year 5, the annual subsidy would gradually fall towards zero for the rest of the ten year period, as the declining installed cost and increased buy-back tariffs would start to take effect. The effect of the subsidy coupled with these cost and tariff trends would be to increase annual capacity additions by 5% per annum, and a final cumulative capacity of 650 MW.

Green Fund Flows and Outputs



This brief and preliminary exercise serves to demonstrate that a targeted fund with clearly defined objectives and rules of operation will aid in the creation of renewable energy capacity in Mexico. This fund must form part of a global renewable energy strategy that incorporates the diverse pricing, regulatory, institutional, and informational issues outlined in this concept note in order to achieve maximum impact. In conjunction with these measures, the fund will provide the necessary impetus for the expansion of renewable energy, creating important benefits related to diversification, the environment, learning, and development.