EIC

FINAL REPORT

RENEWABLE ENERGY AND ENERGY EFFICIENCY IN MEXICO: BARRIERS AND OPPORTUNITIES

US DEPARTMENT OF ENERGY
CONTRACT NO. DE-FC~~01~~-99EE10719
02

SEPTEMBER 28, 2000

PREPARED BY:

ECONERGY INTERNATIONAL CORPORATION (EIC)

Washington Boulder Mexico City

1925 K Street ▲ Suite 230 ▲ Washington, DC 20006 ▲ Tel: 202.822.4980 ▲ Fax: 202.822.4986

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

TABLE OF CONTENTS

TABLES

ANALYSIS OF DEREGULATION, BARRIERS AND OPPORTUNITIES

INTRODUCTION

Rapid economic growth in Mexico has been mirrored by even greater increases in energy demand. The Government, fearful of the dire consequences of shortfalls in meeting energy demand, has embarked upon a policy of energy sector reform that includes deregulation and privatization. Within this context, the country has three strategic choices from which it can choose any combination of one or more: conventional energy sources, renewable energy sources, and energy efficiency measures and technologies. The latter two, although integral to a prudent energy strategy, face significant barriers in Mexico.

Conventional energy sources – coal, oil, and natural gas – today supply 80% of the world's total commercial energy. In Mexico, around 65% of Mexico's electric energy comes from conventional sources. Fossil fuels will undoubtedly form a significant portion of Mexico's energy mix well into the next century. Renewable energy (RE) – electricity generated from solar, wind, biomass, geothermal, and hydropower resources – has taken a back seat to conventional energy sources. It accounts for approximately 20% of electricity in Mexico, the vast majority of that coming from large hydroelectric dams with a small percentage of geothermal power.[1] Energy efficiency (EE) – supply- and demand-side measures and technologies that reduce the amount of energy consumed while maintaining productivity levels – has been pursued more vigorously in Mexico, but its potential use as a tool to alleviate burgeoning electricity demand has also been grossly underutilized.

There are sound economic, environmental, social and security reasons for Mexico to pursue more aggressive investments and development in RE and EE. Investments in efficiency reduce financial pressures on the energy supply sector and are associated with the modernization of products and processes, as well as productivity and quality improvement of industry as a whole. As for renewables, they are already the least cost energy option for many applications in Mexico, especially for those in rural areas of the country. RE and EE also lessen the impacts of both global and regional pollutants by displacing and mitigating green house gas emissions, and reducing local pollutants ranging from NOx released from fossil fuel power plants to particulates emitted from kerosene lamps in a rural household. In general, investment in energy efficiency creates more jobs than investment in the equivalent expansion of supply because the latter is so extremely capital-intensive. Renewable energy is often the only feasible solution to provide rural families with a modicum of electric energy – energy they can then use for life enhancing purposes. Finally, both RE and EE reduce dependence on foreign sources of fuel. Greater efficiency diminishes the amount of fuel needed to furnish the same services, and renewables, which are localized energy sources, eliminate the need to buy foreign fuel at all.

However, significant barriers continue to impede the development of RE and EE. The barriers fall into a broad range of categories but tend to be either regulatory or commercial in nature. Many of these impediments are not unique to Mexico; they are hurdles that RE and EE face around the globe. Nonetheless, Mexico does have some issues particular to its own energy market that affect the market opportunities of renewables and energy efficiency.

The aim of this report is to elucidate the obstacles to renewable energy and energy efficiency development in Mexico within the context of anticipated energy sector restructuring. The report begins with a brief overview of the electric sector in Mexico. The ensuing section considers the current policy

[1] *Prospectiva del Sector Electrico 1998 – 2007*, Secretaria de Energia, México, 1998.

environment for RE and EE, including recent trends, policies and laws. Then, the report explains the most prevalent barriers to the development of RE and EE in Mexico today. A short synopsis of major RE and EE organizations and programs in Mexico is covered in the next section. Finally, the report outlines the near-term market opportunities present in RE and EE.

ELECTRIC SECTOR OVERVIEW

Historical Context of Energy in Mexico

Mexico is the second largest country in Latin America, with a population of 95 million. Mexico is also one of the most prosperous countries in Latin America. Forecasts predict total GDP of US$ 5.59 billion for 2000 with a real GDP growth rate of 5.5%.[2] The economy is as large as Australia and 75 percent of its population is distributed in the urban areas. Most of Mexico's population has electricity, but there are 5 million rural residents who still do not have this service.

The energy situation in Mexico is a reflection of a large economy and a wealth of indigenous resources. Mexico is a country that is largely dependent on fossil fuels to run its economy and, to a lesser extent, to obtain foreign currency. Just in the electricity sector, nearly 75% of the electric power generated each year comes from plants that use fossil fuels.

Energy supply has long been a high priority for the Mexican government. CFE, the national electric utility, and PEMEX, the national oil company, are government owned and operated, and are two of the largest enterprises in the country. In fact, PEMEX is one of the world's leading oil companies, and has developed the country's energy resources to the point that they make up about 8% of the country's exports.

The preponderance of fossil fuels in the Mexican power mix and the monopolistic powers of the state-owned electric utility and the national oil company, have managed to stifle policy geared towards promoting renewable energy (RE) and energy efficiency (EE). Furthermore, steady growth in electricity demand coupled with a budget-conscious government has compelled CFE to seek the lowest-cost expansion possibilities. This generally means the construction of new combined cycle turbine technology powered by natural gas at the expense of other options.[3] This "old fashioned" way of conducting business by issuing requests for proposals for large least-cost expansion is not conducive to smaller investment projects typically associated with renewable energy and energy efficiency. However, it appears that CFE continues to favor these large investments over smaller investments even though CFE recognizes the value of focusing greater efforts and resources on renewable energy and energy efficiency.

On the other hand, Mexican dependence upon fossil fuel makes energy conservation and use of renewable energy important options to reduce depletion of non-renewable energy sources and the environmental impacts from production, transportation and final use of energy. Strides have been taken by the government to increase energy efficiency and the use renewable energy technologies by, for example establishing agencies like CONAE and FIDE (discussed below) that are in charge of promoting the use, application and development of renewable energy and energy efficiency. The Government has also publicly recognized the value of adding utility-scale renewables to the electricity grid. Nonetheless, there remains room for great improvement.

---

[2] *Latin America Monitor: Mexico*, Vol. 17, No. 9, September 2000, p. 5.

[3] The exception to this rule is in rural energy investments where CFE has recognized the advangages of smaller, more modular renewable energy technologies.

POLICY ENVIRONMENT FOR RENEWABLES AND ENERGY EFFICIENCY

Current Trends and System Expansion Plans

Mexico's electric sector is undergoing a period of rapid expansion in its generation capacity and upgrades to its high-voltage transmission and distribution system in order to keep pace with growth in demand and electricity consumption. Since Mexico's economy began its current expansion after the "Peso" crisis, annual GDP growth has averaged about 5% per year, and electric demand and consumption have continued to exceed these growth rates. Even during the economic downturn in 1995, electricity demand and consumption increased. CFE estimates that generating capacity needs to grow by around 3,000 MW every year to match increasing demand. Average annual growth in capacity requirements has increased by 4.9% for peak load and 5.5% for base load, while consumption has increased by 5.3% per year. Mexico's fastest growing markets are the industrialized regions of the northwest (Baja California, with sales growing at 8% during 1988-1997), the northeast, with 6.7% growth, and the Yucatán peninsula (7.7% growth).

Electric tariffs are determined by the government, through a decree issued by SHCP after consultation with CFE, the Energy Ministry, and other agencies. Traditionally they have been subsidized, and Mexico has generally had very low electricity prices compared to other countries in the region. This is gradually changing, the result of government efforts to rationalize pricing. Since 1996, tariffs have been determined using a formula that includes an escalator keyed to inflation as well as the price of fuel used in energy production – which is now priced in relation to international markets. This means that the dramatic decline in energy prices measured in real terms provoked by the devaluation of the peso in 1994 will not reoccur.

More recently, the relative strength of the peso plus higher prices for crude oil have contributed to an increase in electricity prices in real terms. For example, two sets of tariffs commonly used by Mexican companies have increased since 1997, with larger users facing an increase of over 30%, much of this since 1999, as shown in Table 1.

All this is likely to mean that industrial self-supply projects and energy efficiency will be more attractive to Mexican companies, especially ones most exposed to international competition. Numerous studies of industrial plants and overall energy requirements and resource availability suggest that industrial cogeneration facilities already provide about 10% of total capacity in Mexico Based on recent figures provided by the Secretariat of Energy, cogeneration capacity could be expanded dramatically in the next decade ranging from 7,500 to 14,200 MW.[4] In areas where rapid demand growth is forcing CFE and the government to include higher capacity charges and tariffs, there will be even more of an incentive for companies to reduce costs through energy efficiency measures. Furthermore, the competitiveness of renewable energy sources is increased as the reforms in electricity pricing level the playing field somewhat for higher cost sources of power like solar, wind and biomass.

Currently, the national utility CFE regards solar, mini-hydro and wind energy systems as the most

[4] The forecast of potential capacity depends on the assumptions made regarding project configuration and the use of an additional fuel supply. Secretaría de Energía, *Documento de Prospectiva del Sector Eléctrico – 1998-2007* (Mexico City: Secretaría de Energía, 1999): 57-58.

economically viable means of reaching the country's rural villages. Although the country is 95% electrified, there are about 80,000 rural villages or roughly 4.5 million people without power. Secondly, the government also identifies public utilities, industrial areas and individual firms as key solar, biomass and wind power end users. Thus, while the government's focus for renewables is currently on rural electrification, it also recognizes that large-scale applications have an enormous potential in certain areas of the country.

However, current expansion plans for Mexico's generation capacity through 2007 favor additions of natural gas-fired capacity, complemented by some hydroelectric, geothermal and coal-fired facilities. Based on the latest version of CFE's expansion plan the overall increase in generation capacity will be on the order of 21.5 GW, with about 70%, or some 16 GW, provided by natural gas-fired facilities, mostly combined cycle plants. In fact, CFE has stepped up the number of bids it is issuing for new, privately funded generation capacity (IPPs), and has undertaken an emergency investment program focusing on installation of new gas-fired turbines in several locations around the country.

Since 1994, the Comisión Reguladora de Energía (CRE) has issued 107 self-supply permits and 29 cogeneration permits, equivalent to 90% of all permits issued at 60% of total projects permitted in terms of the capacity they represent. Small-scale generation permits, which would typically be used for renewable and other projects that intend to sell electricity to the grid, have unfortunately only accounted for only a handful of the total issued, and several have lapsed due to inactivity.

Table 1: Upward Trend in Mexican Electricity Tariffs

(US cents/kWH)

Region	May 1997	May 1998	May 1999	May 2000	Change, '97-'00
Northwest (OM)*	3.86	3.96	4.01	4.89	26%
Northwest (HM)**	9.52	10.57	10.71	12.95	36%
Central (OM)	3.94	4.04	4.09	4.99	26%
Central (HM)**	9.12	9.77	9.90	12.06	32%
Northeast (OM)	3.67	3.73	3.78	4.62	25%
Northeast (HM)**	9.59	9.36	9.48	11.56	20%

OM is for users with demand up to 100 kW, HM for users over 100 kW.
* Summer tariff. ** Tariff for peak period consumption. Source: CFE.

The rate at which permits are issued, meanwhile, has increased since 1998, and the relationship between permits issued for new investments and those issued for facilities in existence before 1994 that have been brought into compliance with the CRE's permit requirements has shifted to a higher ratio of new investments. All this points to a hotter market for private power ventures of all sizes, utilizing different generation technologies.

CURRENT POLICIES AND LAWS

The 1992 Law of Public Service of Electricity (*Ley del Servicio Publico de Energia Electrica*) sets out the terms and conditions of the agreements through which CFE will purchase power produced by the private sector, the parameters to determine tariffs and provides for a public forum for long-term planning and establishing a bidding process. The law created four basic categories of private power generation:

self-generation, cogeneration, small production, and independent power production. Private interests may also build and operate transmission lines so long as they are not interconnected with the national grid. The private sector activities permitted by the Energy Regulatory Commission (CRE) are as follows: independent power production (IPP) of over 30MW, cogeneration, small-scale production of under 30MW, self-supply.

As previously stated, electricity demand is growing at 6% per year and the country is under enormous pressure to increase its generating capacity or face huge economic losses from inadequate electricity supply to its commercial and industrial sectors. In February, President Zedillo proposed the restructuring of the electric power industry that entails the selling of CFE's generation assets while retaining government control over transmission and dispatch. Generators will compete to sell power to a government managed pool, which will dispatch electricity to distribution companies. International companies, especially from the U.S., are expected to play a major role in bringing online new generating capacity that CFE will need. Among other measures, the plan will permit distribution units to be bid out for long-term concessions to private operators after December 2000.

The proposed reforms to the electric sector drew significant criticism from key figures in Congress as well as public opposition led by the LyFC's workers union (the *Sindicato Mexicano de Electricistas*, or SME), students (especially the strikers at *the Universidad Nacional Autónoma de México* (UNAM)), and the rank-and-file of the CFE's union, the *Sindicato Único de Trabajadores Electricistas de la Republica Mexicana*, or SUTERM). The leadership of SUTERM, which is part of the powerful national union confederation, the *Confederación de Trabajadores Mexicanos* or CTM, and hence is part of the party hierarchy of the governing *Partido Revolucionario Institucional*, or PRI, publicly supported the proposals. The Administration argued that increased private investment in the sector was necessary to ensure a continuation of reliable service throughout the country, given rapid growth and still constrained federal budgets.

Given the significant opposition to the proposal, the electric sector proposal advanced by the administration has been on hold for most of 2000 because of the presidential and Congressional elections. The strong associations between national sovereignty and the energy sector for politicians in the PRI, as well as the right-of-center opposition *Partido de Acción Nacional* (PAN), and the left-of-center opposition *Partido de la Revolución Democrática* (PRD), together with the public outcry over loss of jobs, have made members of Congress wary of any public pronouncements that might be construed as supporting restructuring the electric sector or privatizing CFE.

It is expected that Vincente Fox will press ahead with campaign pledges to prise open the electricity sector, but full-scale privatization remains politically unachievable due to the strong opposition. Fox promised not to privatize CFE or the distributor Fuerza y Luz del Centro (FLC) during his run for election, even though privately he has said they should be privatized. Also, comprehensive reform of the sector would only be possible with constitutional change, which requires a two-thirds majority vote in Congress. Currently Fox's coalition lacks even a 50% majority in Congress. Nonetheless, once in office, Fox may be more aggressive about proposing changes in the energy sector although unlikely to propose outright privatization.

As a result of Congress' criticism of the proposal, the Energy Secretariat (*Secretaría de Energía*, or SE) has undertaken a dialogue with key opposition party legislators to work out a proposal that could gain broader acceptance. While no new proposal has been issued officially – this would have to come from Congress, most likely, since the Administration presented its initial proposal publicly – it is understood that the broad outlines of the restructuring proposal have been modified to the following:

- Break-up of CFE's generation, transmission, and distribution sectors into separate business units (something that has been studied since 1995), with privatization (if approved) limited to thermal generation assets only (nuclear and hydroelectric generation assets would in any case remain in state hands);

- In the event that privatization of CFE's thermal generation assets is not approved, CFE would implement an "incentive-based" management arrangement that would pit thermal stations against one another in what would amount to a competitive virtual market, something that has been studied since 1995;
- Creation of an Independent System Operator (ISO) out of the existing National Electric Load Control Center (*Centro Nacional de Administración de Carga Eléctrica*, or CENACE) to administer a competitive wholesale electric market;
- Change in legal restrictions on sale of electricity by private entities to others;
- Creation of a National Transmission Company that would be administered by a private company under concession;
- Creation of a series of regional concessions for distribution that would be administered by private companies (along the lines of the existing gas distribution concession arrangements in place since 1995).

There is also evidence that the SE is developing a strategy for increasing the participation of smaller-scale, especially renewable, energy technologies in the private power market. While there has long been a research program in place to develop the country's wind and solar potential – culminating in the experimental 1.5-MW wind-power installation at La Ventosa, Oaxaca, and a recently announced solar thermal project undertaken with support from the World Bank, among other projects – the climate for private investment in projects of this type is not yet favorable enough to attract the substantial amounts of investment capital available. The SE's initiative includes efforts to expedite the permitting process for small, run-of-the-river hydroelectric facilities, which could be exploited by industries located in a large part of Mexico's rural regions along the eastern and western watersheds of the central highlands, and also a study for how to increase the revenue generation potential of wind and other less familiar energy technologies. The SE's interest in making smaller, often renewables-based projects easier to implement reflects the significant demand for new capacity at the present time.

With regard to energy efficiency, there has been a concerted effort by the federal government, state and municipal governments, and the industrial associations to promote it since the late 1980s. This support continues today. The effort, spearheaded by the National Commission for Energy Conservation (Comisión Nacional para el Ahorro de Energía, or CONAE) and the Trust Fund to Support the Energy Efficiency Program of the Electric Sector (Fideicomiso de Apoyo al Programa de Ahorro de Energía del Sector Eléctrico, or FIDE), has resulted in a substantial energy efficiency investments. According to CFE's 1998 "Prospectus of the Electric Sector," the activities of FIDE and the Electric Sector Energy Efficiency Program (Programa de Ahorro de Energía del Sector Eléctrico, or PAESE) will yield savings of over 7,500 GWH/year and reduce capacity requirements by over 1,900 MW during the 1997-2006 period. Further activities planned by FIDE and PAESE could yield additional savings of over 3,250 MWH/year and 465 MW of avoided capacity.

Even in 1995, when the economy contracted by 6%, demand and consumption increased. The result is that the pressure on the electric sector and CFE to add capacity, and the demand for private investment in the sector to help do so, will continue. Within the sector there is increasing recognition that restructuring – though perhaps not privatization or existing assets – will be necessary to make it possible for the sector to keep growing. Hence, the objective circumstances of Mexico's energy sector are likely to force changes that are politically acceptable. Efforts to promote more use of renewables, eliminating the CFE's monopoly on sales to the public and business (other than through the existing self-supply provisions), and creation of a competitive market for generation among independent state-owned facilities created by breaking up CFE's generation division, might all be part of the solution – and would create new opportunities for competitive renewable generation capacity.

While it is too soon to arrive at definitive assessment about what the administration of Vicente Fox will do on renewable energy policy issues, and energy policy in general, it is possible to suggest the general direction of overall policy initiatives and the potential implications that it might have for energy and renewables. From what has been seen so far, the prognosis is cautiously favorable.

There is evidence that energy sector policymakers are giving systematic consideration to proposals that would include measures to promote renewables in the context of the restructuring proposal that was submitted by President Zedillo in February, 1999, and has not yet been formally taken up by legislators. The consideration of renewables reflect the administration's efforts to address criticisms of the proposal, which have been partly to blame for blocking the proposal from moving forward (other than staunch political opposition).

On energy policy issues, all the evidence points to a serious effort to convince Congress to take up the proposal that President Zedillo presented in February, 1999, and take action. In the run-up to the elections there was a great deal of media coverage of the impending electricity shortage, something that the Zedillo administration has stressed but was unable to produce results. Since Fox's election, there have been numerous declarations by the transition team that electricity will be a focus of the new administration.

The key to implementing any sort of plan will be the Secretary of Energy and, of course, Congress. It is too soon to say for sure who this might be, although there has been speculation that Luis Téllez, the current Secretary, might be asked to stay on. Téllez is widely viewed as having been quite effective – especially with respect to Mexico's oil production and coordinating output with OPEC to enable prices to recover from the lows of 1998 and early 1999. Téllez has supported efforts in the current administration to find ways to promote renewables and energy efficiency, but these have been limited by the fact that some sort of legislative action would be required, and the administration's legislative proposal was never taken up in Congress.

Investment Climate Issues

With the liberalization of Mexico's foreign investment regime during the de la Madrid and Salinas administrations, improved protections for foreign investors and the negotiation of the NAFTA, Mexico posted substantial amounts of foreign direct investment (FDI) and foreign portfolio investment (FPI).

In the energy sector, restrictions on foreign ownership vary. For example, foreign control of IPP generation facilities is not restricted, nor is this the case for gas transmission and distribution facilities. However, participation of domestic companies in such ventures is deemed desirable. The reverse is the case for the petrochemical assets being spun off by PEMEX in a hotly contested process initiated in 1995. Here, PEMEX must retain a controlling share of the spin-off companies, and this restriction has been largely responsible for the poor reception given the program by the private sector. Elsewhere, restrictions do apply to foreign ownership of land in border regions and along the nation's coastline.

Contractual obligations made by government agencies are viewed with greater confidence than in the past. The government has sought mechanisms to enable state and municipal governments to guarantee payments to municipal service providers, such as wastewater treatment plant owners and operators. State companies, such as PEMEX, have also taken steps to facilitate payment of invoices to contractors. While some concerns do remain regarding creditworthiness and payment reliability, these risks can be addressed through payment guarantees and other mechanisms.

In 1998, the privatization and liberalization programs in the areas of energy, telecommunications and transportation are continuing and are generating new investment flows. While the turbulence in international financial markets may have diminished FPI considerably, it is likely that FDI has declined by a smaller amount, if at all. Although the decline in the value of the peso against the U.S. dollar has dampened business and consumer confidence within Mexico in the last few months, many Mexican businesses remain optimistic about the longer-term outlook. This reflects business confidence in the performance of the U.S. economy, which continues to show steady growth, albeit slowed by the Asian financial crisis, and which, as Mexico's largest export market, remains one of the most important factors determining Mexico's economic health.

Foreign banks have been granted increasing access to the domestic financial sector, and domestic companies and banks have broad access to international capital markets. The only limitation in this regard is on municipal and state governments, which may not contract debt directly with external institutions, but only through one of the national development banks and SHCP. There are no important restrictions on foreign lending to local companies.

BARRIERS

Barriers to Renewables

In addition to the conventional commercial risks inherent in RE projects, there are RE-specific risks that have contributed to the difficulties in securing commercial financing for such projects. They are generally either commercial or regulatory in nature.

- The availability for companies interested in RE and EE investments to obtain local financing from institutional investors and lenders remains one of the largest barriers to the development of these types of projects. In developing countries like Mexico, RE projects are relatively unknown due to the relative lack of completed projects. Further, RE projects involve technical complexities that go far beyond the more routine issues seen in fossil fuel or hydroelectric based generation. Unfortunately, lack of knowledge and technical comfort usually results in a perception of higher than appropriate risk, thus investors have excessive requirements for collateral and very strong financial ratios. From the banks' perspective, the major concerns are creditworthiness, especially for small and medium-sized companies, and business cautiousness regarding fresh loans compelling them to offer high or sometimes floating interest rates with short loan maturities

- There are other limitations on the financing instruments available to companies. There does not appear to be a well-developed guarantee program available to RE and EE projects, although such programs have been implemented by the national development banks to promote financing for wastewater infrastructure. In the case of the BANOBRAS payment guarantees, municipal and state authorities obtain the payment guarantees to enhance the reliability of payments they make under long-term service contracts with private water treatment companies. If the guarantee is exercised due to non-payment, the BANOBRAS recovers its payment from the entity's share of federal budget funds the following year. It does appear that such guarantees could be applied to RE and EE projects, however.[5]

- The lack of private sector and private power market knowledge of and experience with renewables hinders their development. Although Mexico has a strong potential for renewable energy the power sector is still in the early stages of transition from a largely state-run sector to one based on the private sector.

- The extreme difficulty in securing long-term PPAs with CFE for purchase of power. In some cases, as in that of Apasco's wind facility in Coahuila, the developer has avoided dealing with CFE altogether, and the project has been executed with internal resources. In other cases, such as the gas-fired cogeneration projects built by Arancia at its facility near Guadalajara and Grupo Alfa subsidiary Alpek (in a joint-venture with Central and Southwest of the U.S.) in Tampico, the developers limited their involvement with CFE to obtaining a wheeling contract to transfer power from the generation facility to the internal load to be served.

- CFE officials often cite concerns regarding availability of power from RE facilities as another obstacle to being able to approve PPAs for such projects.

- It is very difficult to obtain reliable data on electricity purchase prices from the CFE. While the CFE is required by law to provide the node-based marginal costs for power, which would be used as a reference for sales prices to CFE, it does not provide them to CRE more than once a year.

- The other important consideration is simply one of cost. Gas-fired technologies are generally cheaper than most RE technologies, except for projects in exceptional locations. Furthermore, smaller projects often have disproportionately large transaction costs (as a percentage of total project costs) when compared to conventional projects. Cost has probably been the most decisive consideration in the projects that have been executed in Mexico.

- For many financial institutions, there is a predominant notion that they should not bother financing smaller projects. Instead, they often look for the bigger ones, which provide greater absolute income. This is true for both commercial and public financial institutions. Renewable energy project investments tend to be comparatively small to more conventional thermal projects. Moreover, in off-grid applications, especially in locations where hybrid systems can serve mini-grids, even though there appears to be sufficient willingness to pay for electricity to justify the projects, the investment analysis often does not yield sufficiently attractive rates of return to attract private investment. Such projects typically require at least partial support from development agencies.

- In Mexico there is still a lack of any real supportive regulatory framework, which is an obstacle to greater investment flows into RE projects. The nature of many renewable energy technologies as an intermittent resource and the characteristics of biomass cogeneration linked to agricultural industrial processes make them unconventional for energy planners and regulators. Some developers are attempting to influence the regulatory structure of Mexico to enable IPP development for RE projects. The adoption of supportive regulatory environments takes time, however.

- Lack of a federal mandate for a specific amount of renewable generation capacity, nor is there a clear mandate for CFE to purchase renewable supplies from private producers.

[5] Personal communication, Jorge Padilla de Alba, manager of analysis and financing mechanisms, BANOBRAS, September 11, 1998.

- There is no clearly defined framework for CFE to negotiate PPAs with private entity, much less one that establishes criteria for RE projects (this might be contained in a legislative or administration initiative on RE sources, perhaps in the context of a National Climate Action Plan, which is now under development);

Barriers to Energy efficiency

The key barriers to EE projects are commercial and regulatory in nature as well:

- To begin with, limitations on development resources make it difficult for companies to take all but a few EE projects through the development process. Even when projects do make it past the feasibility stage, there are numerous other obstacles to securing financing: small project size; high transaction costs; often poor creditworthiness of the energy services company coupled with reluctance on the part of the industrial client to take on new debt; lack of guarantee mechanisms; and inadequate development of leasing or other services for EE projects.

- The market success of an EE program is often predicated on the availability and cost of third party finance. For the internationally recognized EE firms there is rarely any difficulty doing this, but even they are reluctant to assume their clients credit risk unless it too is well capitalized. For the bulk of the EE market in Mexico, however, neither party is so recognized. In many markets where ESCO's have not established track records, there is little chance for them to attract the necessary finance. Performance risk is difficult to measure. Beyond the financial obstacles, potential clients are simply unfamiliar with performance contracting mechanisms, or the leasing and other arrangements that could be applied to projects.

- However, aside from successful private industry and some other sectors, there is a lack of credit history for individual consumers as well as smaller-sized businesses. The lack of credit capacity for most of these businesses and the lack of an adequate consumer credit infrastructure is often perceived as too great a risk for most financial institutions absent some form of counter-guarantee. As most governments are moving away from these, it has fallen to the multilateral development banks to consider backstopping some of these loans, or to provide a secondary market for them.

- Industrial energy users tend to consider investments in production equipment, new product lines or other core business activities as having priority over investments in EE when allocating internal resources.

- Electricity prices, especially for industrial customers, are relatively low compared to similar tariff categories for other countries, which is a disincentive to EE investments (prices are higher in certain regions where high demand growth is straining CFE's ability to ensure adequate supplies). Energy prices still remain somewhat distorted in Mexico, which makes it difficult to accurately value energy savings, although progress has been made during the last decade to make pricing more competitive.

- There is no federal law on energy efficiency, which might mandate the deployment of energy efficient equipment in new buildings, factories, etc. This would give impetus to the application of the national standards (NOMs) that have been published in recent years for specific products. NOMs have already been issued for: refrigerators; room air conditioners; AC induction motors; vertical pumps; centrifugal pumps; lighting systems in non-residential buildings; deep-well pumps; electric cloths washing machines; and street and highway lighting fixtures.[6]

RENEWABLE ENERGY AND ENERGY EFFICIENCY ORGANIZATIONS AND PROGRAMS

Public policy decisions in the late 1980's gave place to two agencies with national mandate. One, the National Commission for Energy Conservation (CONAE), is a public institution with a mandate to design and implement national programs on energy efficiency and renewable energy in all sectors of the economy.

CONAE is an inter-ministerial body created by Presidential Decree on September 29, 1989, with the objective to serve as a consultative organization on technical issues regarding energy efficiency and energy renewables for the ministries and entities of the Mexican Federal government, the governments of the states and municipalities, and the private sector.

The other organization, born in the late 1980's, is the Fund for the Efficient Use of Electricity (FIDE), which is private--but depends largely on contributions from the national utility--and has the mandate to finance demonstration projects and operates an incentive program for specific types of equipment.

Other organizations that have important roles to play in the energy efficiency and renewable energy area include:

- Electric Research Institute (IIE) is a national research and development laboratory for the power sector.
- National Ecology Institute (INE) is the governmental organization oriented to the design of the environmental policy and the application of the regulatory mechanisms. Its responsibilities include sectoral and regional aspects in all the country, including Climate Change, among others.

Mexico has completed or has underway a number of successful energy efficiency and renewable projects and programs, but there remains a large estimated potential for further development that, just in terms of the value of the oil that can be conserved (at 10 $US/BO), is close to one billion dollars per year.

Some of the programs that have been implemented include:

1. **Energy efficiency standards (CONAE).** From January of 1995 through September of 1998, 17 standards that apply to equipment such as refrigerators, air conditioners and electric motors, and to systems such as lighting in buildings and water pumping from deep sources, have been issued. As a result more than 5 million products that are sold in the Mexican market each year comply with these standards, thus saving close to 2,000 GWh of energy per year.

2. **Demonstration projects (FIDE).** Trough its lifetime, FIDE has promoted the implementation of more than 800 demonstration projects in industrial plants, commercial buildings and public lighting and water pumping systems. These actions have resulted not only in savings per year near 1,000 GWh, but also in the development of a market for products and services and an avoided capacity near 500 MW.

3. **Daylight-savings time (FIDE).** Started in 1996, this program has resulted in savings of more than 1,100 GWh/year (2 million BOE in generating plants) and avoided generation capacity that reached

[6] See SE, *Prospectiva del Sector Eléctrico*: 114.

550 MW in 1998.

4. **ILUMEX (CFE).** This program has been run by the national electric utility; it started in 1993 and resulted in the installation of 1.8 million CFLs in two regions of Mexico (Guadalajara and Monterrey). The program was an initiative of the World Bank through its Global Environmental Facility (GEF); the GEF participated with 10 $USMillion, CFE with the same amount and the Government of Norway with 3 $USMillion.

5. **Incentives programs (FIDE).** This program is financed by the Inter American Development Bank (43 $USMillion) and helps finance incremental costs for energy-efficient electric motors, commercial lamps and ballasts, and residential compact-fluorescent lamps. The program started in 1998.

5. **One-Hundred Public Buildings pilot-program (CONAE).** Started in June of 1996, this program allowed for a detailed analysis of close to 900,000 square meters of--mainly--office space operated by public agencies and institutions. The program has resulted in the identification of a potential of 19 GWh through the replacement of 94,000 luminaries.

6. **Steam generation and distribution systems pilot-program (CONAE).** Financed partly by the United States Agency for International Development (USAID), this program has allowed the analysis of 37 large-and-small installations that use steam in their processes. Besides the impact it has had in the individual installations, the program has helped identify potentials for a large-scale program.

The organizations and programs have had varying degrees of success addressing some of the aforementioned barriers. A greater analysis of their impact on the RE and EE markets in Mexico is beyond the scope of this paper. Rather, this section only aimed to provide a brief description of the two principal organizations promoting RE and EE in Mexico and six of the major programs that have been implemented in the past ten years. It suffices to say that government efforts have not been adequate to significantly reduce the barriers illustrated in the previous section.

MARKET OPPORTUNITIES

There is an increasing need for private power supplies in Mexico. Beyond the fact that a limited amount of generation capacity will be decommissioned in various areas of the country in the next several years, the rapid growth in electricity demand and consumption must be met by construction of new generation capacity, very likely complemented by increased investment in energy efficiency measures and demand controls. With adequate support from energy policy initiatives, RE and EE technologies could easily fill a significant part of Mexico's capacity requirements in the next decade.

These opportunities for RE applications in grid-connected power projects are augmented by more limited opportunities for RE projects for off-grid applications. Here, there are many communities now served by fossil-fired (mostly diesel) units that could move to RE-based technologies, and there are numerous very small settlements that could obtain regular electric service for the first time through household-scale systems (mostly solar home systems, SHSs). Given the relatively high rate of grid-connection in Mexico – about 95 percent[7] – the rural population requiring off-grid electricity is roughly 4.5 million (Mexico's population in 1995 was about 91.12 million). Of this population, some are served by community-based diesel-fired or other off-grid generation in mini-grids, while the remaining unserved population segment forms the core of the market for SHS and other small-scale RE generation systems.

[7] See Secretaría de Energía, "El sector eléctrico en México."

Experience with such projects indicates that rural populations are keen to acquire RE technologies, but may not understand the technical limitations of off-grid generation installations.

Solar thermal energy is also an abundant resource in Mexico. Recent studies performed by the Institute of Engineering at the UNAM suggest that widespread conversion of LPG-fired residential water heaters to solar water heaters is both technically feasible as well as financially attractive. The major limitation would appear to be education and promotion of a conversion program, combined with the provision of low-cost financing to low-income buyers of such equipment.[8]

For grid-connected applications, there are several major market segments for EE and RE services and technologies that exhibit varying levels of development and activity. In addition to significant variation between sectors in terms of sophistication and interest in RE and EE projects, there is also substantial regional variation. For example, several areas of the country boast climatic conditions and rapid energy demand growth that make EE investments a far easier proposition to sell to clients in any sector. Likewise, specific sectors in specific regions seem more receptive of RE technologies.

In general, the major market segments may be delineated as follows:

- *State and municipal*: EE in lighting and pumping; RE for self-supply generation;
- *Industrial and mining*: EE in electric and thermal energy use; RE for self-supply generation, and cogeneration (also substantial fuel-switching potential);
- *Commercial*: EE for lighting, cooling, and heating; RE for self-supply generation;
- *Hotels*: EE for lighting and cooling; RE for generation and thermal energy needs;
- *Federal government institutions*: EE for lighting, cooling, and heating; RE for self-supply generation and thermal energy needs;
- *Transportation*: EE for fuel use; fuel switching opportunities (this sector is not discussed in this survey).

From a regional perspective, there is substantial variation in terms of the growth in demand and consumption of electricity, a key factor in determining the demand for RE and EE services and technologies, as well as in terms of the availability of RE resources. The regions exhibiting most rapid growth in demand include the northeast, northwest and southeastern regions of the country, as noted in Appendix 2. Meanwhile, the regional distribution of key RE resources is summarized in Appendix 3.

MARKET SEGMENTS - BIOMASS AND COGENERATION: CONAE has prepared an assessment of cogeneration potential in Mexico, but this assessment considers non-RE applications primarily, with reference to a limited set of RE opportunities in the country, especially in the sugar industry. Another study by Winrock International assesses the viability of specific projects in the forest products and sugar industries.[9]

MARKET SEGMENTS - HYDROELECTRIC: With respect to minihydroelectric facilities, CONAE has recently completed a study of potential in the Veracruz-Puebla region, including preliminary feasibility analyses for specific projects, and the CFE has extensive information on the broader potential for hydroelectric generation in the country.[10]

---

[8] See CONAE, "Estudio del potencial nacional de ahorro de gas LP por el uso de colectores solares planos," mimeo, 1998.

[9] See CONAE, *Potencial Nacional de Cogeneración*, (Mexico City: SE, 1995), and Winrock International, "Biomass-Fueled Electric Energy Generation in Mexico," mimeo, February, 1997.

[10] CONAE, *Estudio de la Situación de la Minihidráulica Nacional y Potencial en una Región de los Estados de Veracruz y Puebla*, (Mexico City: SE, 1997).

MARKET SEGMENTS - SOLAR: According to recent information provided by CONAE, there is still a substantial amount of work to be done to characterize the solar resource, and the institutional and technical infrastructure available is not sufficient to complete the characterization and maintain substantially credible records.

MARKET SEGMENTS - WIND: In the case of wind power, the available instrumentation exhibits similar limitations as in the case of the solar resource. Basic research has been performed by the IIE for the Tehuantepec Isthmus region, yielding very favorable results. Still, CONAE contends that further studies are required to adequately characterize the RE resources of several regions, including: the Baja California Peninsula, the eastern coast of the Yucatán Peninsula, the northern altiplano (central highlands) including the area around Mexico City, the Gulf of Mexico and Pacific coastal regions, and the southern part of the Tehuantepec Isthmus.

The economic feasibility of projects in these various RE subsectors is mixed, and may need to be updated to reflect changing exchange rates and international market conditions. However, it appears that some of the sugar mill projects assessed in the Winrock study could be attractive investments, even under the changing financial conditions of the country. In the case of the CONAE minihydroelectric study, the feasibility of certain projects looks equally promising, although the financial analysis does not appear to be totally complete. The technical requirements of the projects are similarly varied, in terms of equipment size and characteristics.

MARKET SEGMENTS - ENERGY EFFICIENCY: Industrial, commercial and hotel companies are becoming increasingly aware of the potential savings that may be generated by energy efficiency programs. This increased awareness is attributable to a large extent to the efforts of FIDE and CONAE, but also to tariff increases. The adjustments in electricity tariffs in the period following the 1994 devaluation, coupled with significant seasonal variations in tariffs in some regions of the country, have made the economic benefits of such projects clear.

At the same time, industrial concerns have become more reluctant to limit their energy efficiency efforts to conducting energy audits, especially at their own expense. A few years ago FIDE conducted a poll in which 60 percent of companies contacted by FIDE indicated they had undertaken audits; of these, some 40 percent reported that energy consumption was higher than necessary, but the scope of measures taken by this segment seems to have been limited. Tight budgets and numerous attractive investment opportunities tend to relegate EE investments to second- or third-tier priority – in spite of the potential savings. Accordingly, interest in performance contracting, or "outsourcing," EE projects has increased.

Compared to the industrial sector, the commercial sector appears to have done far less in terms of identifying energy use patterns through audits (32 percent in the FIDE survey), and of these, 45 percent reported higher-than-necessary energy consumption. Lighting fixture changes and the installation of independent circuit breakers appear to be the most prevalent measures adopted.

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

Local governments also offer very attractive projects, especially in the area of efficient lighting. FIDE has helped finance about $2 million in demonstration lighting and pumping efficiency projects for 135 municipal governments. Figures for these projects suggest an average repayment period of between one and two years, based on investments ranging from $10,000 to $20,000.[11]

Based on these demonstrations, municipalities have financed similar projects using multilateral and private bank resources, the former channeled through BANOBRAS. The total amount financed by BANOBRAS is about $24 million, covering another 100 municipalities. Data on the amount of investment privately financed, covering another 100 municipalities, are not known.

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

To support the development of this market, FIDE has developed a series of publications that guide municipal officials through the process of implementing savings programs. Such activities are complicated by the need to reach an agreement with the CFE (or the LFC) reconciling the data on fixtures (the *censo*) from the municipality with that of the electric utility, and subsequently obtaining the utility's approval of the selected installations.

From a contractual perspective, performance-based projects such as industrial demand control installations are independent of the CFE or the LFC. As such, there is little potential for arranging for collection via the utilities; collection is undertaken directly with the client. Projects have been undertaken, however, where collection via the utility would be applicable, as in the case of the Ilumex project in Monterrey and Guadalajara. However, in the case of Ilumex, the project sponsor was CFE, with FIDE support, and no private third party was involved.

In EE projects for other sectors, especially municipalities, the collection issue has been of greater concern than in the industrial projects. While lease contracts are generally signed in both project types, the potential for political changes to lead to cancellation of contracts is clearly greater at the local level. Some equipment suppliers/developers have addressed this situation by including clauses permitting the owner to remove equipment in the event of non-payment under public contracts. Given the political ramifications of having street lighting removed, incoming governments have tended to seek alternatives to canceling contracts that they do not wish to continue.[12]

Vendor financing for EE projects is available, but generally on limited terms not exceeding six months. Terms of 45 to 90 days were extended on most of the equipment used in a recent demand management project, with one supplier offering up to 120 days. Other equipment suppliers have indicated that terms over 45 days would be extended on a case-by-case basis, but rarely would they go further than 120 days.[13]

MARKET SEGMENTS - CONCLUSIONS: As suggested above, opportunities of varying degrees of immediacy may be detected in each of these sectors and in these regions, for both RE and EE projects. Appendix 4 provides a preliminary review of regional and sectoral markets, based on anecdotal evidence and analysis of studies performed on RE technologies in Mexico.

OPPORTUNITIES:

- Growth in electricity consumption and capacity requirements has steadily outstripped the expansion

[11] Personal communication, Esteban Torres, municipal program director, FIDE, August 13, 1998.
[12] Personal communication, Esteban Torres.
[13] Personal communication, Paulo Alvarado, SLI de México, September 8, 1998.

of the electric system.

- A limited amount of generation capacity will be decommissioned in various areas of the country in the next several years
- There are many communities now served by fossil-fired (mostly diesel) units that could move to RE-based technologies, and there are numerous very small settlements where electricity could be provided for the first time through household-scale systems (mostly solar home systems, SHSs).
- Based on the pre-depreciation tariff levels, companies that develop EE projects in the most promising sectors and regions of Mexico could generate attractive rates of return for equity investors. On a project-by-project basis, the rates of return in the range from 30 to 40 percent appear to be consistently achievable, with many projects exceeding that level.[14] For a package of projects, the rates of return may tend toward the lower end of that range, but the risk associated with that return would also be correspondingly lower.

[14] This is the case, for example, in the load control project undertaken by Empresas ESM at the Navojoa and Tecate breweries of Cervecería Cuauhtémoc Moctezuma (CCM), and inaugurated on September 1, 1998.

ANNEX 1: ENTITIES ACTIVE IN THE RE AND EE MARKETS

Mexico does not have a robust entrepreneurial culture in the technology and energy sectors, as in the U.S., but it does have extensive technical capabilities provided by numerous consulting and engineering companies in the country as well as a well-developed infrastructure of research institute and academic institutions. A partial listing of these institutions and companies is presented below. Some of the entrepreneurs who are active in Mexico in the RE and EE sectors have experienced difficulties with raising the resources needed to complete projects, while others have pursued projects using their own resources.

This pool of companies and technical institutions provides a substantial resource for companies or organizations that are looking for engineering expertise in the EE and RE phases. In the case of public sector agencies such as the IIE, the fiscal discipline practiced by the federal government forces more of the Institute's programs to rely on external sources of funding, either in the form of technical cooperation with overseas agencies or contracts with private project sponsors. Accordingly, such entities are quite ready to work with companies requiring RE and EE expertise.

It is relatively unlikely, however, that any such entity, whether public or private, would be able to access private capital from Mexican sources (or overseas sources) that could be applied in new projects as equity or debt financing. For the most part, the few entrepreneurs active in the market will have access to their own resources, and a larger number are attempting to develop projects with limited resources.

RENEWABLE ENERGY: The market for RE consulting, technology and services is still weak in Mexico, but is beginning to improve.

Table 2: Companies Active in the RE Sector

Company	*Observation*
Energía Renovable	Developer owned by Alberto Garza Santos, related to family that owns FEMSA. Currently developing a windpower project in La Ventosa. See Section 8.
EnPro	Engineering and consulting company owned by Manuel de Diego Muñóz, former CFE official.
Ultra Energía	
Entec / Energía Renovable del Istmo	Companies in which Arturo Whaley was a shareholder and director; a new organization may now have taken the place of these two companies. Entec appears to have developed and implemented the largest number of RE projects in Mexico to date.
EIC Consultores de México	Division of EIC of the U.S. Is not developing projects in Mexico at present,

	but the parent company has extensive experience in bagasse-fired cogeneration at sugarmills in other countries.
Ecoturismo y Nuevas Tecnologías	Run by former Condumex engineer, Arturo Romero. Specialties in solar home systems and off-grid wind projects. Participated in execution of X-Calak hybrid project.
Aquasol	Manufacturer of solar thermal heating equipment.
Celsol	Manufacturer of solar thermal heating equipment.
Energía y Ecología	
Adrian's de México	
Ehecatl Mexicana	
Westinghouse	Formerly had a solar energy division that was active in projects; has been sold. Now a division of Siemens.
Condumex	Major industrial concern involved in production of electrical and electronic components, cable, and other project inputs.
Módulo Solar	
ICA	Major EPC company. Teamed with Fluor-Daniel of the U.S., boasts extensive engineering and project experience in Mexico and throughout Latin America.
Sistemas Racionales de Energía	
Solar Tronic	
TSA	

Table 3: Academic and Research Institutions Active in RE Sector

Institution	*Observation*
Instituto de Investigaciones Electricas	Has a division dedicated to non-conventional sources of energy. Extensive research and development expertise. Has executed numerous projects.
Instituto de Ingeniería de la UNAM	Extensive research and development expertise. Has executed numerous projects.
Universidad Autónoma de Mexico – Iztapalapa	Extensive research and development expertise. Has executed numerous projects, especially in solar thermal energy.
CONAE	Extensive experience in promoting cogeneration and RE applications. Has prepared various surveys of potential and has organized the COFER, a public-private committee charged with promoting RE.
FIUAEM	
CAPFCE	
IPC	

ENERGY EFFICIENCY: The market for EE consulting and outsourcing services is better developed than the market for RE consulting, technologies and services. To a large extent, this reflects the fact that the economics of EE projects are more compelling than for RE projects.

Table 4: Companies and Institutions Active in EE Market

Company	*Observation*
Ingeniería Industrial y Energía (Monterrey)	Formerly Energy Saving de México, has a substantial number of projects to its credit.
EIC Consultores de México (Mexico City)	Division of EIC in the U.S., has participated in financing of an outsourcing type project and is developing another.
Empresas ESM (Monterrey)	Headed by former official of Energy Saving de México, has several outsourcing type projects to its credit.
EnPro (Mexico City)	Engineering and consulting firm with numerous projects to its credit. Will consider undertaking projects on outsourcing basis.
Ultra Energía (Mexico City)	Consulting engineering concern with numerous audits to its credit.
Constructora Tetakahui (Guadalajara)	Consulting engineering concern with numerous audits to its credit.
Corporación de Estrategias Energéticas (Puebla)	Consulting engineering concern with numerous audits to its credit, will consider outsourcing type projects.
kW Controls (Mérida)	Consulting engineering concern in Mérida, will consider outsourcing type projects. Focus on chiller efficiency measures, and has vendor relationships.
Grupo Morphy (Mexico City)	Primarily a RE developer.
Integra (Cancún)	Formerly TAI Comunicaciones, has background in sales of telecommunications equipment to hotels in Cancún. Has begun developing outsourcing type projects.
ASIC de México (Tijuana)	Controls vendor, division of ASI Controls in U.S. Has numerous projects in maquilas to its credit.
SLI de México (Mexico City)	Lighting vendor. Will provide technical support to project developers. Will offer limited vendor financing.
Philips Mexicana (Mexico City/ Ciudad Juárez)	Lighting vendor.
General Electric (Mexico City)	Lighting vendor. Has access to extensive financial capabilities of GE Capital.
SEINPRO	

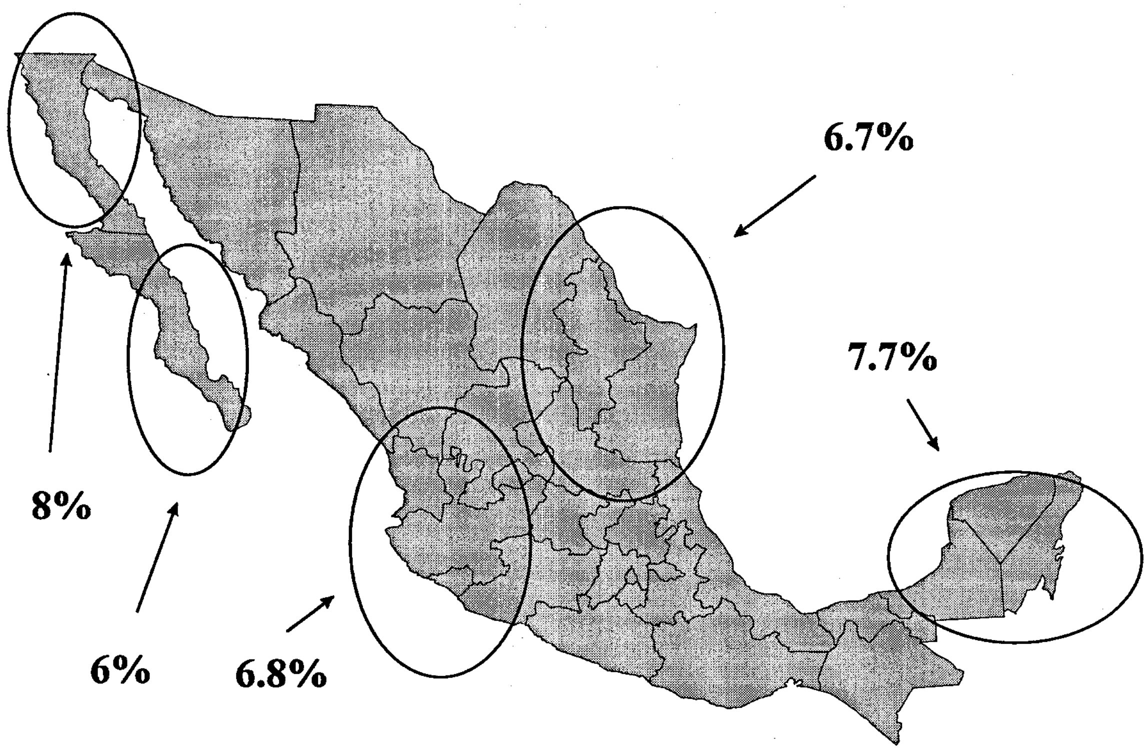
Energy Saving Central (Mexico City)	Associated with Empresas ESM. Has numerous audits to its credit, and is pursuing outsourcing type projects.
Compañía de Energía de México (Tijuana)	

Table 5: Research and Academic Institutions in the EE Sector

Company	*Observation*
Instituto de Investigaciones Electricas	Has a division dedicated to non-conventional sources of energy. Extensive research and development expertise. Has executed numerous projects.
Instituto de Ingeniería de la UNAM	Extensive research and development expertise. Has executed numerous projects.
Universidad Autónoma de Mexico – Iztapalapa	Extensive research and development expertise. Has executed numerous projects, especially in solar thermal energy.
CONAE	Extensive experience in promoting cogeneration and RE applications. Has prepared various surveys of potential and has organized the COFER, a public-private committee charged with promoting RE.

ANNEX 2: ELECTRICITY SALES GROWTH IN MEXICO

Regions of Highest Electricity Sales Growth in Mexico, 1988-1997



Source: SE and CFE. Does not include export sales. The areas indicated show the approximate region covered by the relevant CFE control area.

ANNEX 3: RE RESOURCES IN MEXICO

Summary of RE Resources in Mexico

Resource	*Key Geographic Regions*	*Technology Applications*	*Project Examples*	
Solar radiation	National average: 5 kWH/m2/day. Highest readings in the northwest and Baja California peninsula; significant readings throughout much of the rest of the country.	Solar thermal	Tonatiuh (1975), Guanajuato. ISSSTE (1993), Mexico City. Cancún Palace (1994), QR. Club UNAM, Mexico City. Centro Asturiano, Morelos.	
		Solar photovoltaic	UAM (1989), Mexico City. School buildings (1993), QR. SHS installations (ongoing) various locations.	
Wind	Several regions with densities over 100 W/m2: Tehuantepec Isthmus (Oaxaca); northeast Quintana Roo; central-south Zacatecas; northeastern Valley of Mexico; Saltillo-Monterrey corridor, Coahuila.	Wind turbines	Ehacatl SA (1991), Toluca. IIE (1987), Hidalgo. Exportadora de la Sal/ Mitsubishi (1985), BCS. CFE (1994), Oaxaca.	Cementera Apasco (1995), Coahuila.
		Hybrid systems (with solar)	X-Calak minigrid (1992), QR. S.M. Magdalena (1991), Hidalgo.	El Junco (1992), Zacatecas. La Gruñidora, Zacatecas. Ignacio Allende/Mazapil, Zacatecas. S.A. Agua Bendita (1993), Mexico State.
Hydro	Total hydro potential: 19,600 MW; of which 3,250 MW would be in plants of less than 10 MW. Geographic distribution: central highlands, Gulf Coast escarpment, Pacific Coast escarpment, southern highlands (Chiapas).	Low head and run of river minihydro plants	There are numerous small plants (<5 MW) in operation: 77 independently owned plants, from 1905 onward, with effective capacity of 43.5 MW; 30 owned by CFE (from 1901), effective capacity of 21.7 MW; and 14 from LFC (from 1905), effective capacity 11 MW.	
Biomass	Biomass accounts for 6 percent of total energy production in the country. The sugar industry already accounts for about 204 MW of generation capacity.	Cogeneration		
		Thermal energy	Various sugar mills.	
		Straight generation	Various sugar mills.	

Sources: CONAE, homepage; SE, *Balance Nacional de Energía, 1996* , (Mexico City: SE, 1997): 14; CONAE, Estudio de la Situación Actual de la Minihidráulica Nacional, (Mexico City: SE, 1997): 16, 23.

ANNEX 4: ESTIMATE OF RE AND EE POTENTIAL

ENERGY EFFICIENCY

REGION/SECTOR	INDUSTRIAL	COMMERCIAL	HOTELS	STATE/MUNICIPAL	FEDERAL
Baja California	High	High	High	High	High
S. Baja California	Low	Moderate	High	High	High
Northeast	High	High	High	High	High
Northwest	High	High	High	High	High
North	High	High	High	High	High
Central	Moderate	Moderate	Moderate	Low	Low
Western	High	High	High	Moderate	Moderate
Eastern	High	High	High	Moderate	Moderate
Peninsular	High	High	High	High	High
RENEWABLE ENERGY	INDUSTRIAL	COMMERCIAL	HOTELS	STATE/MUNICIPAL	FEDERAL
Baja California	High	High	High	High	High
S.Baja California	Moderate	Moderate	High	High	High
Northeast	Moderate	Moderate	Moderate	Low	Low
Northwest	High	Moderate	High	Moderate	High
North	Low	Moderate	Moderate	Moderate	High
Central	Moderate	Low	Low	Low	Low
Western	High	Moderate	Moderate	Moderate	Moderate
Eastern	Moderate	Moderate	Moderate	Moderate	Moderate
Peninsular	High	High	High	High	High

* The regions used are the CFE's administrative divisions

Source:EIC

ANNEX 5: POTENTIAL EXPORT OF U.S. SERVICES AND EQUIPMENT

Macroeconomic Factors

Mexico's macroeconomic situation has recovered dramatically from the 1994 -1995 peso crisis and the ensuing 6% economic contraction in 1995. The Zedillo Administration's handling of the crisis, which combined tight monetary policy and relative fiscal austerity (which was relaxed starting in 1998), succeeded in gaining the confidence of international markets and investors. Inflation has receded from levels in excess of 50% in 1995, with a corresponding decline in average commercial lending rates. Government spending had been restrained by the fiscal controls, as well as a contraction in oil prices and oil export revenues, which provide roughly one-third of government resources. The recent rebound in prices will yield additional resources and diminish the budget deficit. Higher oil and gas prices will also have a positive effect on the market for RE and EE technology and services where they can be substituted for power generated by fossil fuels.

The Secretariat of Finance and Public Credit (*Secretaría de Hacienda y Crédito Público*, SHCP) expects GDP growth to reach 4.5% for the year 2000. The chances of this figure being achieved, in fact exceeded, are bolstered by the figures announced by Banco de México, demonstrating a year-on-year growth of 7.9% for the first quarter and recent estimates by Government officials of 7.5% for the second quarter.[15]

Foreign direct investment and cross-border trade, meanwhile, have been spurred by the regulatory and trade advantages provided by the North American Free Trade Agreement (NAFTA) that took effect in 1994, and have remained strong. Foreign portfolio investment remains strong. Tariffs on most renewable energy and energy efficiency equipment began phasing out upon the implementation of NAFTA; remaining tariffs will be completely eliminated by 2004. President-elect Vincente Fox has publicly stated that he wishes to maintain the positive economic outlook by fostering exports, ecnouraging foreign direct investment and pursuing privatization. Overall, both short- and long-term economic fundamentals for the RE and EE markets are positive.

Renewable Energy Export Estimates

Renewables generally to fall into two market categories: utility-scale and off-grid/mini-grid. Mexico has great potential for renewable energy development especially in solar, wind and geothermal. The resources tend to be area-specific: biomass resources are most abundant in the sourth, wind resources are scattered in pockets around the country, geothermal resources only surface in certain areas and solar radiation is strongest in the north. These are all promising resources for utility-scale applications.

For off-grid and mini-grid applications, the potential market segment is also noteworthy. A significant portion of Mexico's populace remain unserved by electricity, about 8%. Photovoltaic systems, micro-hydro units and wind turbines could all serve this market. Additional applications include irrigation and pumping, remote telecommunications relays and other off-grid lighting and small power needs.
The principal markets for RE in Mexico will be for geothermal plants, large-scale hydroelectric plants and large windfarms. Geothermal expansion will follow CFE's plans of approximately 200 MW over the next five years. About 2225 MW of large-scale hydro are planned during the same period. Wind is still

[15] "Mexico's Growth Could Put Fox on the Spot," *The Wall Street Journal*, (August 15, 2000): A21.

considered a new and risky technology, but the government has announced plans to further exploit this resource. For smaller scale applications, sales of photovoltaic modules continue to grow and have hover around 1 MW per year in annual sales. Total national mini-hydro potential is estimated at 3, 250 MW by CONAE, and should begin to see some growth in Mexico, especially for rural applications. Overall, the market for RE in Mexico is estimated at just over $700 million, of which over $600 million will most likely be spent on large-scale hydroelectric plants and geothermal plants. These types of projects are still under the auspices of CFE and are considered civil works. Therefore, potential for export of RE services and equipment in which U.S. companies can compete is projected at $150 million.

Energy Efficiency Export Estimates

Energy efficiency typically falls into three market categories: end-use technologies, supply-side technologies and energy services. By 1998, CFE reported a savings of 5,200 GWh (4% of national consumption) and hopes to achieve savings of 24,680 GWh by 2007, equivalent to 11% of national consumption. Programs designed to target industrial, commercial and residential endu uses have been extremely successful. Actions have ranged from implementing Daylight Savings Time to substituting of incandescent bulbs for compact fluorescent bulbs to offering consumers rebates on highly efficient appliances.

The principal supply-side technology is cogeneration. Mexico's national energy conservation agency, CONAE, estimated that from 3,507 MW to 6,578 MW of cogeneration capacity would be developed from 1996 to 2006, requiring an investment during this period of $2.8 billion to $7.9 billion.[16] This is a fairly large sum of money for which U.S. equipment and services could compete. CONAE has estimated that large companies with projects greater than 50 MW represent 32% of this potential, and that the national oil company, PEMEX, represents around 20.5% of the total potential. However, the largest market segment for cogeneration is for plants of less than 50W capacity.

Energy services companies are beginning to make headway and perform projects in Mexico. U.S. equipment for use in implementing these services has a good reputation, and low tariffs under NAFTA provide U.S. companies with an advantage over competitors from other foreign countries.

Overall, the market for RE in Mexico is estimated at around $450 million, of which over $400 million will most likely be spent on cogeneration projects. U.S. cogeneration technology and is among the most advanced in the world and competes extremely well against technology from other countries. NAFTA also provides an edge to U.S. companies exporting EE equipment. Therefore, potential for export of RE services and equipment in which U.S. companies can compete is projected at $100 million.

[16] *Prospectiva del Sector Electrico 1998 – 2007*, Secretaria de Energia, México, 1998.

ATTACHMENT A: RENEWABLE ENERGY AND ENERGY EFFICIENCY PROJECT BRIEFS

Project 1: Masterpak S.A. de C.V.

PROJECT DESCRIPTION

This project will generate energy consumption reductions and enhanced production efficiencies within the compressed air and variable frequency systems in a plant owned by the Packaging Division of CYDSA, S.A. de C.V., a Mexican chemical conglomerate. These energy consumption reductions and enhanced production efficiencies will then be used to repay the investment required. The project is developed by Mexican energy services company Empresas ESM, S.A. de C.V.

LOCATION

Mexico

SPONSORS

Masterpak is part of the **Packaging Division of CYDSA**, one of the leading chemical groups in Mexico. Masterpak manufactures Cellophane, utilizing wood pulp as its base material. Through the development of a new line of thinner cellophane, Celorey expanded its North American markets. Process improvements using new technology have significantly improved dimensional control allowing the firm to met specific customer requirements.

Empresas ESM, S.A. de C.V. ("Empresas ESM") is a Monterrey-based firm specialized in the execution of energy efficiency and water treatment projects in the productive processes of industrial, manufacturing, commercial and tourism companies. Typically, Empresas ESM executes its projects on a performance contracting (or outsourcing) basis, as is the case with the Masterpak project.

STATUS

The project has received funding and is underway.

TECHNICAL ASSISTANCE

At present Empresas ESM is providing all the technical assistance necessary for this project. There should be no need for any other outside assistance on this project.

FINANCING

Masterpak and Empresas ESM have signed a contract (with performance contracting provisions) whereby Empresas ESM will receive $3,500 per month if 100% of the projected savings are obtained. This contract has a duration of 5 years and 4 months. During this period, the equipment installed to achieve the savings will be considered a lease to Masterpak, with an equipment purchase option for $24,125.70 (twenty four thousand one hundred twenty five dollars 70/100) once the contract has terminated.

The investment requirements for the project total **$241,000**. This amount may be broken down as follows: Compressed air system equipment, $146,900.00 and Frequency variation equipment, US$94,100.00. Empresas ESM can finance the labor costs for the project itself. However, it cannot begin work on the project without first having covered the capital requirements for the project.

The overall project generates an IRR of 22.8% when considered as an all-equity investment for a ten year period. However, considering a financial structure with $120,000 in debt and US$121,000 in equity. The debt is paid in five years through semi-annual installments and considers a 11% interest rate. The IRR for Empresas ESM is 13.7% for the 5 years and 4 months life of the contract.

NEXT STEPS

This project is currently underway. The plant was recently sold which may mean that the project size will have to be reevaluated. The new owners have expressed their interest in the continuation of the project.

Project 2: Pinturas Osel Energy Efficiency Project

PROJECT DESCRIPTION

This project involves the automation of paint-filling equipment and enhancements in the compressed air system of Pinturas Osel, a Mexican paint manufacturer. These upgrades will generate energy consumption reductions and enhanced production efficiencies that will cover the cost of the investment required. This project was developed by a Mexican energy services company Empresas ESM, S.A. de C.V.

LOCATION

Monterrey, Mexico

SPONSORS

The paint manufacturer **Pinturas Osel SA de CV**, formerly Pinturas Monterrey, was founded by the Elizondo family in 1950. From the beginning, the company has registered steady growth. Osel's home offices are located in Monterrey, Nuevo León state, Mexico, 160 miles south of Laredo Texas. In addition, Osel has warehouses in Mexico City, Guadalajara and Hermosillo, through which Osel markets its product in the major markets in Mexico outside of Monterrey.

Empresas ESM, S.A. de C.V. is a Monterrey-based firm specialized in the execution of energy efficiency and water treatment improvements in the productive processees of industrial, manufacturing, commercial and tourism companies.

FINANCING

Osel and Empresas ESM have signed a contract with performance contracting provisions whereby Empresas ESM will receive 58.5% of the savings generated by the project over seven years, with Osel obtaining the remaining 41.5% of the benefits generated. From year 8 onwards, Osel will receive 100% of the benefits generated.

STATUS

The project has received funding and is underway.

TECHNICAL ASSISTANCE

At present Empresas ESM is providing all the technical assistance necessary for this project. There should be no need for any other outside assistance on this project.

FINANCING

The investment requirements for the project total **US$75,000**. This amount is allocated as follows: Paint filling equipment automation, $49,000 and Compressed air system equipment, $26,000.00. Empresas ESM will finance the labor costs for the project itself.

The overall project generates an IRR of 35.8% when considered as an all-equity investment for a ten year period. This return is very attractive in comparison to other investments. This project is all equity financed.

NEXT STEPS

This project is currently underway.

Project 3: OXXO

PROJECT DESCRIPTION

This project calls for the upgrading of equipment in 1200 convenience stores across Mexico to more energy efficient technology. This will include, switching to high efficiency lighting fixtures, improving air-conditioning control, and the upgrading to more efficient refrigeration units then presently utilized. Oxxo has plans to initially make these changes in 10 stores to estimate the energy and cost savings per store. If substantial savings are achieved, they will implement the changes across all 1200 stores.

LOCATION

OXXO convenience stores are located all across Mexico, usually concentrated in urban areas.

SPONSORS

The **OXXO** convenience store chain, a subsidiary of **Fomento Economico Mexicano S.A. de C.V.** (FEMSA Retail), is the largest in Mexico. Internationally, it is among the top 20. The company has 1261 stores in 24 of Mexico's principal metropolitan areas. In an effort to provide better service, OXXO has implemented a policy of seeking out the latest technological equipment in order to be the best convenience store chain worldwide.

Promoción Control Professional (PCP) is a Monterrey-based firm specialized in the execution of energy efficiency. PCP will be handling all the technical implementation of this project.

STATUS

This project is still in the early phase of development. No contracts have been signed. OXXO and PCP are working together to assess the feasibility of these proposed improvements.

TECHNICAL ASSISTANCE

If the decision is made to go ahead with implementing these changes in all 1200 locations, additional technical assistance may be needed. If this occurs, it would be necessary to contract with additional engineering firms.

FINANCING

The estimated per store cost is $3,000 with a total estimated cost of $3,500,000 for all 1200 locations. The estimated payback period from these energy efficiency improvements is 2.8 years. At present, OXXO has not made a decision concerning whether to internally cover the cost of these improvements or look for external sources of debt funding.

NEXT STEPS

The major next steps are twofold, firstly, OXXO must decide whether it wants to proceed with implementing the changes in the first 10 stores, and secondly, they must decide how to finance the project. OXXO, and its parent Fomento Economico Mexicano have large equity holdings and could, if desired, go ahead with the project without external funding.

Project 4: Grupo Vitro

PROJECT DESCRIPTION

This project will generate energy consumption reductions and enhanced production efficiencies within the bit driver and variable frequency systems in a plant owned by the Grupo Vitro, Sociedad Anonima de C.V., a Mexican glass manufacturing company. These energy consumption reductions and enhanced production efficiencies will then be used to repay the investment required. The project is being developed by a Mexican engineering company **Promoción Control Professional (PCP).**

LOCATION

Monterrey, Mexico

SPONSORS

Grupo Vitro, Sociedad Anonima de C.V. is a Mexican manufacturer of glass and one of the two largest household products manufacturers in Mexico, with exports to 70 countries worldwide. The Company conducts all of its operations through subsidiaries and has investments in associated companies. The Company's main product lines include traditional glass products, flat glass for architectural and automotive use, and machinery and equipment for the glass industry. The company has joint ventures with 12 major manufacturers, which provide its subsidiaries with access to international markets, distribution channels and state-of-the-art technology. Grupo Vitro is also a member of the World Business Council for Sustainable Development.

Promoción Control Professional (PCP) is a Monterrey-based firm specialized in the execution of energy efficiency. PCP will be handling all the technical implementation of this project.

STATUS

This project is still in the early phase of development. No contracts have been signed. PCP is working with Grupo Vitro to come up with a plan to implement these production line improvements.

Technical Assistance

At present PCP is providing all the technical assistance necessary for this project. This will include all the retrofiting undertaken at the plant.

FINANCING

The necessary capital investment is presently estimated to be $1.1 million for this energy efficiency project. The estimated payback period is 2.7 years. Based on the relatively quick payback time period of such a large investment, this may become a very profitable venture. No decision has been made concerning whether to internally cover the cost of these improvements or look for external sources of funding.

NEXT STEPS

No decision concerning whether to proceed has been made. PCP is presently working with Grupo Vitro to help make this decision.

Project 5: Xcalack Wind

PROJECT DESCRIPTION

The small, remote village of Xcalack had historically depended on a diesel-powered system that lacked a reliable fuel supply and required frequent maintenance. In 1992, a 71 kW renewable energy system was commissioned by the state government to demonstrate the feasibility of hybrid systems in Mexico. The system consists of six 10 kW wind turbines, a photovoltaic array, a 400 kWh battery bank and a 40-kW inverter. CONDUMEX S.A. de C.V of Mexico designed, installed, and maintained the hybrid system and CFE upgraded the existing mini-grid.

This project encountered a number of political and technical problems soon after the system was installed. First, the Governor of Quintana Roo, who championed the project, was voted out of office in 1993 and the new Governor did not want to take responsibility for the system. The system was thus built without establishing either ownership or responsibility for it. The local committee established to manage the system had no funding, nor any clear authority, and local political divisions made operation and maintenance extremely uneven at best. Thus, technical problems that arose were left unresolved. To this date, a lack of system administration remains the major impediment to what could have been a successful project.

LOCATION

Xcalack, Mexico, is a remote fishing village located on the coast of the State of Quintana Roo on the Yucatan peninsula.

SPONSORS

The Mexican government originally sponsored this project. Under the PRONASOL program, approximately 50,000 solar PV systems were built to supply power to approximately 42,000 families. Private developers supplied an additional 25,000 solar PV systems and a number of communities were provided with about a dozen wind-hybrid systems.

STATUS

This project is currently suspended.

TECHNICAL ASSISTANCE

The local committee mandated to manage the system is at present not able to proceed due to a lack of technical aptitude and funding. By receiving outside assistance, this project could be completed and become self-sufficient.

NEXT STEPS

Procure outside assistance from a foundation, multi-lateral bank or angel investor.

ATTACHMENT B: MULTIPLE-POLLUTANT REDUCTION BENEFITS OF THE CCM BREWERY ENERGY EFFICIENCY PROJECTS

-- A Supplemental Analysis to the Mexico Carbon Portfolio Project

September 2000

Prepared by:

Center for Clean Air Policy
750 First St., NE, Suite 940
Washington, D.C. 20002
www.ccap.org

I. Introduction

The Mexico Carbon Portfolio Project is an effort to capture the benefits of carbon reductions from small-scale energy efficiency projects at industrial enterprises[17]. The background and the details of the Project are illustrated in "Small-Scale Energy Efficiency in Mexico, A Portfolio Approach", prepared by Econergy International Corporation and Empresas ESM. The pilot projects at the two brewery facilities operated by Cerveceria Cuauhtemoc Moctezuma (CCM) implement measures to improve energy efficiency in the brewing processes and to optimize load distribution. These measures reduce the total electricity demand from the power grid. As the carbon reduction analysis indicates, the annual energy consumption at the CCM brewery facilities decreases by 7% relative to the baseline, which corresponds to a 986-ton reduction in carbon emissions at the power generating plants each year.

The energy savings not only mitigate the global climate change impacts of carbon emissions, but also reduce other pollutants that may cause adverse human health effects and local air quality degradation, such as particulate matter, sulfur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs) and toxic substances. Reducing air pollutant emissions may contribute to the host country's sustainable development goals by providing local environmental and economic benefits. These co-benefits will make the project more attractive from the perspective of the host country, and thereby increase the project's chances for host country approval.

A study conducted in Mexico City, one of the most polluted cities in the world, shows that air pollution-related health costs amount to US$1.1 billion each year (World Bank, 2000). Particulate matter is the main culprit, although ozone, carbon monoxide and lead also contribute to health problems among city residents. The pollution levels in the regions where the two brewery projects are located are not as severe as Mexico City. Nevertheless, reductions in multiple-pollutant emissions will reduce the associated harmful impacts and improve the environmental quality in both of these regions.

The Navojoa region, where the Northwest System is located, is a coastal area in the western Mexico. It is a mostly rural area and thus the level of population exposure may be relatively low. The Tecate region where the Baja California System is located has a few urban centers with higher population densities. Therefore, power plant emissions reductions are more likely to induce more significant human health benefits. In addition, some of the power plants in Tecate are close to the U.S. border (Texas being the neighboring state), and emissions reductions in this region would reduce the potential transboundary migration of pollution to the U.S.

The objective of this report is to demonstrate and quantify the multiple-pollutant reduction benefits of the energy efficiency projects. Section 2 below discusses the human health and environmental impacts of multiple pollutants (particulate matter, SO_2, NO_x,

[17] Econergy International Corporation and Empresas ESM, S.A. de C.V, "Small-Scale Energy Efficiency in Mexico, A Portfolio Approach", March 13, 2000.

CO, VOCs and air toxics), as well as the potential global climate change impacts of carbon dioxide; Section 3 quantifies the emission reductions of the multiple pollutants as a result of the efficiency projects; and Section 4 summarizes the study results and findings.

II. Environmental and Human Health Impacts of Multiple Pollutants

1. Human Health and Environmental Impacts of Local Air Pollutants

A number of pollutants emitted from fossil fuel combustion processes at the power plants can cause adverse human health and environmental effects. The following information describes the most pertinent issues related to these pollutants. We divide the pollutants discussed in this document into two categories: criteria air pollutants and hazardous air pollutants, based on the classification generally accepted by regulatory and international agencies such as the US Environmental Protection Agency (USEPA) and World Health Organization (WHO). The criteria air pollutants are those that are prevalent in the ambient air with proven significant adverse effects on human health (especially among children, the elderly, and those with pre-existing respiratory illnesses) and the environment. Criteria air pollutants include particulate matter of small size (PM10), nitrogen oxides (NO_x), sulfur dioxide (SO_2), ozone (O_3) and carbon monoxide (CO). Hazardous air pollutants (HAPs) are pollutants that, in sufficient concentrations and exposure, are known or suspected to cause cancer or other serious health effects. In this study, we select five hazardous air pollutants of carcinogenic risk that are typically associated with combustion-related processes at power plants: benzene, formaldehyde, toluene, and inorganic arsenic and chromium (VI). Information on these pollutants is largely derived from scientific studies and observations in the U.S. and elsewhere in the world. However, the study findings can be applied to specific areas to evaluate the potential human health and environmental impacts, such as the regions in Mexico where the projects are located.

Criteria Air Pollutants

Particulate Matter (PM10)

Particulate matter (PM) is a term used to describe the mixture of solid particles and liquid droplets in the air, which originate from different stationary and mobile anthropogenic and natural sources. Particulate matter consists of particles of a wide range of sizes. Two categories of PM are often used to refer to the different range of particles. Fine particles (PM2.5) are those particles that are 2.5 micrometers (μm) in diameter or smaller. Coarse particles (PM10) are those particles that are larger than 2.5 μm. Fine particles are primarily emitted during fuel combustion by power plants, industrial facilities, mobile sources, and residential heating and cooking systems. Coarse particles come from both fuel combustion and natural sources such as dust, wind, and volcanic eruptions. When breathed into the pulmonary system, the particles can lead to a wide range of respiratory illnesses. Exposure to PM10 and PM2.5 has been linked with increased premature mortality risks, decreased lung function, aggravated respiratory symptoms, and increases in hospital admissions and emergency room visits. Fine particles are of the most significant health concern since they can penetrate deeper into the lung and tend to be more reactive.

In addition to the adverse impacts on human health, particulate matter can also cause visibility impairment and damage to paints and building materials.

Sulfur Dioxide (SO_2) and Acid Rain

Short-term exposures to elevated SO_2 levels may reduce lung function that may be accompanied by such symptoms as wheezing, chest tightness, or shortness of breath. Long-term exposures to high concentration of SO_2, in conjunction with high levels of PM, degrade the respiratory system, alter lung function, and aggravate existing cardiovascular disease. More significantly, SO_2 emitted into the atmosphere would react to form sulfate, a component of fine particles causing major adverse effects to the respiratory system. SO_2 can also combine with water vapor to form acidic aerosols which further enhances its ability to attack the respiratory system. Asthmatics, children, elderly, and individuals with cardiovascular disease or chronic lung disease are particularly susceptible to SO_2 exposures.

SO_2 is also a major precursor to the formation of acid rain, which causes acidification of soils, lakes, and streams, vegetation and crop damage, visibility impairment and corrosion to buildings and monuments.

Nitrogen Oxides (NO_x) and Ozone (O_3)

Inhalation exposure to NO_x can aggravate pulmonary diseases and increase susceptibility to respiratory infection. More importantly, NO_x is a major precursor to ground-level ozone, a secondary pollutant causing a number of adverse health and environmental effects. Exposures to ozone, even at very low levels, can trigger impairment in lung capacity and increased respiratory illness incidence.

NO_x leads to acidification of freshwater bodies and eutrophication of estuarine and coastal waters, which increase levels of toxins harmful to fish and other aquatic life. It also has the potential to effect changes in the composition of some species of vegetation in wetland and terrestrial systems. Together with SO_2, NO_x contributes to the formation of acid rain.

Ground-level ozone can also adversely affect the overall health of plants and natural ecosystems. Exposure to ozone can cause loss in agricultural and commercial forest yields, reduce growth and survivability of tree seedlings, and increase plant susceptibility to diseases, pests, and environmental stresses.

Another category of pollutant that contributes to the formation of ground-level ozone is volatile organic compounds (VOCs). VOCs also come from fossil fuel combustion processes. Usually, in the regulatory context, the emissions of NO_x and VOCs are restricted to limit the ozone concentrations.

Carbon Monoxide (CO)

CO is a colorless and odorless gas formed during the incomplete combustion of fossil fuels. CO enters the bloodstream through the lungs and reduces oxygen delivery to the body's organs and tissues. Low levels of CO can pose serious threat to those who suffer from cardiovascular disease. Long-term exposure to CO can cause damage to the brain and the nervous system, and reduce work capacity and cognitive performance. High levels of CO can lead to lethal or permanent damage to the body.

Hazardous Air Pollutants

Hazardous air pollutants (HAPs) are pollutants known or suspected to cause cancer or other serious health effects or adverse environmental impacts. HAPs are less prevalent in the air than the criteria air pollutants. However, human exposure to these pollutants at sufficient concentrations and duration can result in cancer, poisoning, or rapid onset of sickness. Other effects include damage to the immunological, neurological, reproductive, and respiratory systems. HAPs are deposited onto the soil and enter the groundwater, and are later delivered to humans via food and water intake. In this study, we discuss five HAPs associated with power plants and those that cause cancer and other adverse health effects.

Benzene is a known medium-hazard carcinogen, which is linked with increased incidence of leukemia, a cancer of the tissues that form white blood cells. Acute exposure to benzene via inhalation may cause drowsiness, dizziness, headaches, and unconsciousness.

Formaldehyde is a probable medium-hazard carcinogen and is linked with lung and nasopharyngeal cancer. Acute and chronic exposure to formaldehyde via inhalation can result in eye, nose, and throat irritation, as well as respiratory illness. Repeated exposure to formaldehyde is reported to cause reproductive damage among women workers, including menstrual disorders and pregnancy problems.

Toluene is a toxin that attacks the central nervous system (CNS). Exposure to toluene at low to moderate levels can cause CNS dysfunction, developmental effects in children, and narcosis. Acute and chronic exposures to toluene can also cause irritation of the eyes and upper respiratory tract, as well as sore throats, nausea, skin conditions, dizziness, headaches, and difficulty with sleep.

Inorganic arsenic is a high-hazard human carcinogen. Exposures to inorganic arsenic through inhalation and ingestion have been strongly associated with lung and skin cancer. Short-term inhalation exposure to inorganic arsenic may result in gastrointestinal effects (e.g. nausea, diarrhea, and abdominal pain), hemolysis, central and peripheral nervous system disorders, and may induce miscarriages among pregnant women. Arsine gas, a derivative of inorganic arsenic, is extremely toxic. Acute inhalation exposure to arsine (a half-hour exposure to 25 to 50 ppm) can be lethal.

Chromium (VI) is another known human carcinogen. Exposure to chromium (VI) increases the risk of lung cancer and can result in respiratory tract degradation with perforations and ulcerations of the septum. Bronchitis, decreased pulmonary function, pneumonia, asthma, and nasal itching and soreness are also connected with Chromium (VI) exposure.

2. Global Climate Change Impacts of CO_2

Human activities are increasing the atmospheric concentrations of greenhouse gases, particularly CO_2, which are linked with changes in regional and global climate patterns. The Intergovernmental Panel on Climate Change (IPCC) projected that the global mean surface temperatures would increase by between 1 and 3.5°C by 2100 and the global mean sea levels are expected to rise by about 15 to 95 cm, flooding many low-lying coastal areas.

Despite the uncertainties surrounding the scientific understanding of the impacts of climate change, significant adverse changes in the terrestrial and aquatic ecosystems have been identified. These include an increase in the incidence of floods, droughts, and extreme high-temperature events, resulting in fires, pest outbreaks, and changes in ecosystem composition, structure and functioning, including primary productivity. Such changes could have dramatic impacts on the human health, food security, economic activity, water resources, and the physical infrastructure. Warmer temperatures will also increase the incidence of warm weather systems which are more conducive to air pollution, heat waves, and the spread of vector-borne diseases.

III. Multiple-Pollutant Emissions Reductions of the Energy Efficiency Projects

In this section we quantify the emissions reductions of the criteria pollutants (PM10, NO_x, SO_2, CO, and VOCs) and the five hazardous air pollutants (benzene, formaldehyde, toluene, arsenic, and chromium) at the power plants serving the two regions where the brewery projects are located, resulting from the energy efficiency projects at the CCM brewery facilities.

1. The Power Systems

Both the brewery plants receive power supplied by the Federal Electricity Commission (CFE), a Mexican state utility. CFE's Northwest System serves power in the region where the Navojoa Plant is located, and the Baja California System serves power to the area of the Tecate Plant. The two systems are composed of a range of power plants employing different fuels and technologies. The power plants and their characteristics of the Northwest System and Baja California System are shown in Table 1 and Table 2 below.

Table 1. Northwest System Serving Power to the Navojoa Plant

	Year	Fuel	Type	Capacity (MW)	Operation	Capacity Factor
Caborca	1981	Diesel	TG	72	Peak	5%
Ciudad Obregon	1972	Diesel	TG	28	Peak	5%
Culiacan	1980	Diesel	TG	30	Peak	5%
Topolobampo	1995	Gas	TG	25	Semi-Peak	15%
Guaymas I	1970	FO/gas	Steam	70	Semi-Peak	20%
J. Aceves Pozos	1980	FO/gas	Steam	616	Interm.	50%
Juan de Dios Batiz	1968	FO/gas	Steam	360	Base	90%
Puerto Libertad	1989	FO/gas	Steam	632	Base	90%
C. Rodriguez Rivero	1980	FO/gas	Steam	484	Base	90%

* FO = FUEL OIL; TG = GAS TURBINE

Table 2. Baja California System Serving Power to the Tecate Plant

	Year	Fuel	Type	Capacity (MW)	Operation	Capacity Factor
Cipres	1982	Diesel	TG	55	Peak	10%
Mexicali	1977	Diesel	TG	62	Peak	10%
Tijuana	1982	Diesel	TG	60	Peak	10%
Presidente Juarez 1-4	1968	FO/gas	Steam	300	Base	90%
Presidente Juarez 5-6	1989	FO/gas	Steam	320	Base	90%

* FO = FUEL OIL; TG = GAS TURBINE

As shown in the tables, both systems are composed of plants of three major types:

1) Diesel-fired gas turbines
2) Natural Gas-fired gas turbines
3) Steam Turbines: Rankine cycle steam boilers fired by natural gas and heavy fuel oil (#6 fuel oil).

The column labeled "operation" describes whether the plant is used to meet base, peak, or intermediate loads. This information is important in determining which plants are operating on the margin at different seasons; so as to derive the emission factors used for calculating the emissions reductions.

2. Emission factors

We take two steps to identify the emission factors of each power systems. First we identify the emission factors of a specific type of plant based on the generation technology and fuel used, which we call *plant specific* emission factors. The plant specific emission factors are derived from "The Compilation of Air Pollutant Emission Factors" (or "AP-42"), a documentation of emission factors compiled by the United States Environmental Protection Agency (USEPA). AP-42 provides emission factors of multiple pollutants from different types of combustion sources and fuels based on monitoring and other calculation methods. In this study, we assume that the fuels used in Mexico have comparable features as fuels used in the U.S. Table 3 presents the emission factors of the various pollutants of the three types of generators at the CFE plants.

Table 3. Plant Specific Emission Factors (unit: kg/kWh)

	Diesel-Fired Gas Turbine	NG-Fired Gas Turbine	FO/Gas Steam Turbine*
Criteria Air Pollutants			
NO_x	3.75E-03	1.44E-03	1.25E-03
PM10	5.11E-05	2.97E-05	5.66E-05
CO	1.40E-05	3.69E-04	3.49E-04
SO_2	1.72E-03	1.53E-05	4.91E-04
VOCs	1.75E-06	9.46E-06	2.41E-05
Hazardous Air Pollutants			
Benzene	2.34E-07	5.40E-08	8.99E-09
Formaldehyde	1.19E-06	3.20E-06	3.97E-07
Toluene	5.54E-07	5.85E-07	3.21E-08
Arsenic	4.26E-08	1.04E-08	4.76E-09
Chromium	4.68E-08	6.18E-09	8.10E-09

* It is assumed that the FO/Gas steam turbine burns 90% natural gas and 10% heavy fuel oil (#6). The assumption is derived from available information of the power plants in Monterrey Region (Source: EIC).

Our second step is to determine the *system specific* emission factors. The power system is complex since the electricity comes from a group of contributing plants, each with its own generation efficiency, capacity factor, and emission factors. Ideally we would use daily electricity supply distribution information, along with specific plant operating hours to determine when and at what plants demand reductions are manifested to determine the emissions reductions at a given time. However, this information is limited to monthly load distributions. Therefore, we made the following assumptions on the operational characteristics of the systems to determine the composition of marginal plants and the emission factors during different seasons.

For the Northwest System, we assume that the peaking and semi-peaking units (as in Table 1) are the marginal plants during the peak season (May-October), and J. Aceves Pozos of intermediate load is the marginal plant during the off-peak season (November-April). During peak season, the peaking plants are comprised of three diesel-fired gas turbines, one natural gas-fired gas turbine, and one FO/NG steam turbine. We calculated the emission factors using a weighted average approach based on the rated capacity and capacity factors of the five plants. The emission factor of the marginal plant during off-peak season is much simpler to calculate since there is only one FO/NG steam turbine unit. Table 4 summarizes the emission factors of the marginal plant(s) of the Northwest System during the peak and off-peak season.

Table 4. Emission factors of Marginal Plants in the Northwest System (unit: kg/kWh)

Criteria Pollutants	Peak	Off-Peak
NOx	1.95E-03	1.25E-03
PM10	5.10E-05	5.66E-05
CO	2.62E-04	3.49E-04
SO_2	7.47E-04	4.91E-04
VOCs	1.59E-05	2.41E-05

HAPs	Peak	Off-Peak
Benzene	7.63E-08	8.99E-09
Formaldehyde	1.04E-06	3.97E-07
Toluene	2.57E-07	3.21E-08
Arsenic	1.58E-08	4.76E-09
Chromium	1.82E-08	8.10E-09

For the Baja California System serving Power to the Tecate Plant (Table 2), we assume that the three diesel gas turbine peaking units are the marginal plants during the peak season and the base-load FO/NG steam turbine units serve the marginal electricity demand during the off-peak season. Due to the homogenous composition of the marginal plants for the Baja California System, we derive the emission factors for peak and off-peak season directly from the diesel gas turbines and FO/NG steam turbines. The emission factors for the Baja California System are shown in Table 5 below.

Table 5. Emission factors of Marginal Plants in the Baja California System (unit: kg/kWh)

Criteria Pollutants	Peak	Off-Peak
NOx	3.75E-03	1.25E-03
PM10	5.11E-05	5.66E-05
CO	1.40E-05	3.49E-04
SO_2	1.72E-03	4.91E-04
VOCs	1.75E-06	2.41E-05

HAPs	Peak	Off-Peak
Benzene	2.34E-07	8.99E-09
Formaldehyde	1.19E-06	3.97E-07
Toluene	5.54E-07	3.21E-08
Arsenic	4.26E-08	4.76E-09
Chromium	4.68E-08	8.10E-09

3. Emissions Reductions

Once the emission factors are determined, we can estimate the total emissions reductions of the various pollutants over a given period of time by multiplying the emission factors by the corresponding energy savings. Tables 6 and 7 below summarize the total emissions reductions over a one and five-year project period in the two regions. The calculations are attached in Appendix I.

Table 6. Total Emissions Reductions from the Northwest System Serving the Navojoa Brewery (kg)

Criteria Air Pollutants	Annual	Five-Year
NO_x	3,114	15,572
PM10	107	533
CO	610	3,050
SO_2	1,204	6,020
VOCs	40	200

Hazardous Air Pollutants	Annual	Five-Year
Benzene	0.08	0.40
Formaldehyde	1.37	6.88
Toluene	0.27	1.35
Arsenic	0.02	0.10
Chromium	0.03	0.13

Table 7. Total Emissions Reductions from Power Plants in the Baja California System Serving the Tecate Brewery (kg)

Criteria Air Pollutants	Annual	Five-Year
NOx	4,500	22,500
PM10	97	485
CO	327	1,633
SO_2	1,990	9,950
VOCs	23	116

Hazardous Air Pollutants	Annual	Five-Year
Benzene	0.22	1.09
Formaldehyde	1.43	7.15
Toluene	0.53	2.64
Arsenic	0.04	0.21
Chromium	0.05	0.25

IV. Conclusions

The primary justification for the energy efficiency projects at the two breweries in Mexico is to reduce energy consumption and the emission of CO_2, in an effort to address the global issue of climate change. However, the benefits of these projects extend well beyond the incremental reduction in global atmospheric CO_2 levels. When energy consumption is reduced, there is a corresponding reduction in a host of other pollutants, which may have more immediate and severe local impacts. These impacts include human health complications, ecosystem and air quality degradation, and social and economic instability. The severity of these impacts depends on a range of factors that will be unique and specific to the region in question. Each impact has an associated cost, and each reduction has the potential to provide economic, environmental, and social benefits. These benefits are often overlooked, and may be significant factors when evaluating the economic viability of a mitigation option.

Reducing local and regional air pollutant emissions may be a key element of the sustainable development goals in the host country. Mexico and other host countries have well established national sustainable development priorities, and the ability of a project to contribute to these priorities will be considered during the host country approval process. The greater the air quality benefits of the project, the more likely the project will gain host country approval.

In this paper we have examined the power grids supplying electricity to the two CCM breweries, and illustrated that the multi-pollutant reductions that would ensue from energy efficiency mitigation projects are real and significant. We first outlined some of the key pollutants associated with the combustion of fossil fuels, and the associated problems they cause, and then presented a method for quantifying the multi-pollutant emissions reductions.

The actual benefits of these reductions remain unquantified, since the relative impacts of the pollutants in question heavily depend on the natural environmental situation, the baseline air quality and the demographic features of the locality of concern. But the ability to calculate the specific reductions provides a key first step in determining the overall social, environmental, and economic benefits of a project to reduce fossil fuel-derived energy consumption.

REFERENCES

The UN Framework Convention on Climate Change Activities Implemented Jointly (AIJ) Pilot: Experiences and Lessons Learned; Edited by Robert K. Dixon, Chapter 8: "Do AIJ Projects Support Sustainable Development Goals of the Host Country?" A. Hambleton, C. Figueres and K. Chatterjee. Kluwer Academic Publishers, 1999, Pgs 167-181

U. S. Environmental Protection Agency (USEPA), "The Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources", Section 1.3 "*Fuel Oil Combustion*", Section 1.4 "*Natural Gas Combustion*", Section 3.1 "*Stationary Gas Turbines*", http://www.epa.gov/ttn/chief/ap42.html

USEPA, "The Benefits and Costs of the Clean Air Act 1990 to 2010", Appendix D: "Human Health Effects of Criteria Pollutants", 1999.

USEPA, Health Effects of Toxic Air Pollutants, http://www.epa.gov/ttn/uatw/hlthef

World Bank, "Health Cost of Air Pollution (Mexico City, 1990)", 2000 http://www.worldbank.org/wbi/clean...ng/agenda/opening/faiz/tsld021.htm

World Bank, "Air Pollution and the Social Costs of Fuels: A Methodology with Application to Eight Cities", 1997.

World Health Organization (WHO), "Guidelines for Air Quality", WHO, Geneva, 1990

Appendix

Table I-a. Emissions Reductions from Northwest System Serving Power to Navojoa Brewery Plant

Month	Load	1997	1998 exp.	Savings	NOx	CO	PM-10	SO_2	VOC	Benzene	Formaldehyde	Toluene	Arsenic	Chromium
		KWh	kWh	kWh	kg	kg	kg	kg	kg	Kg	kg	Kg	kg	kg
Jan	Interm.	1944000	1566000	378000	473.910	131.846	19.450	185.545	9.124	0.0034	0.1501	0.0121	0.0018	0.0031
Feb	Interm.	2205000	1944000	261000	327.224	91.036	13.430	128.115	6.300	0.0023	0.1036	0.0084	0.0012	0.0021
Mar	Interm.	2754000	2718000	36000	45.134	12.557	1.852	17.671	0.869	0.0003	0.0143	0.0012	0.0002	0.0003
Apr	Interm.	2502000	2381904	120096	150.568	41.889	6.180	58.950	2.899	0.0011	0.0477	0.0039	0.0006	0.0010
May	Peak	2709000	2578968	130032	253.692	34.100	6.241	97.113	2.063	0.0099	0.1357	0.0335	0.0020	0.0024
June	Peak	3168000	3015936	152064	296.676	39.877	7.299	113.567	2.413	0.0116	0.1586	0.0391	0.0024	0.0028
July	Peak	3420000	3255840	164160	320.276	43.049	7.879	122.601	2.604	0.0125	0.1713	0.0423	0.0026	0.0030
Aug	Peak	3447000	3281544	165456	322.804	43.389	7.942	123.568	2.625	0.0126	0.1726	0.0426	0.0026	0.0030
Sept	Peak	3141000	2990232	150768	294.148	39.537	7.237	112.599	2.392	0.0115	0.1573	0.0388	0.0024	0.0027
Oct	Peak	3159000	3007368	151632	295.834	39.764	7.278	113.244	2.406	0.0116	0.1582	0.0390	0.0024	0.0028
Nov	Interm.	2862000	2724624	137376	172.232	47.916	7.069	67.432	3.316	0.0012	0.0546	0.0044	0.0007	0.0011
Dec	Interm.	2691000	2561832	129168	161.942	45.054	6.646	63.403	3.118	0.0012	0.0513	0.0041	0.0006	0.0010
Total				1975752	3114.440	610.015	98.504	1203.808	40.127	0.0793	1.3752	0.2694	0.0195	0.0252
Five-Year Total				*9878760*	*15,572*	*3,050*	*492*	*6,019*	*200*	*0.40*	*6.88*	*1.35*	*0.10*	*0.13*

Table I-b Emissions Reductions from Baja California System Serving Power to Tecate Plant

Month	Load	1997	1998 exp.	Savings	NOx	CO	PM-10	SO_2	VOC	Benzene	Formaldehyde	Toluene	Arsenic	Chromium
		kWh	kWh	kWh	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
Jan	Base	1606000	1456000	150000	188.06	52.32	7.72	73.63	3.62	0.0013	0.0596	0.0048	0.0007	0.0012
Feb	Base	1434400	1284400	150000	188.06	52.32	7.72	73.63	3.62	0.0013	0.0596	0.0048	0.0007	0.0012
Mar	Base	1579600	1429600	150000	188.06	52.32	7.72	73.63	3.62	0.0013	0.0596	0.0048	0.0007	0.0012
Apr	Base	1680800	1530800	150000	188.06	52.32	7.72	73.63	3.62	0.0013	0.0596	0.0048	0.0007	0.0012
May	Peak	1852400	1702400	150000	562.05	2.11	7.66	258.03	0.26	0.0351	0.1788	0.0830	0.0064	0.0070
June	Peak	1896400	1746400	150000	562.05	2.11	7.66	258.03	0.26	0.0351	0.1788	0.0830	0.0064	0.0070
July	Peak	1746800	1596800	150000	562.05	2.11	7.66	258.03	0.26	0.0351	0.1788	0.0830	0.0064	0.0070
Aug	Peak	1755600	1605600	150000	562.05	2.11	7.66	258.03	0.26	0.0351	0.1788	0.0830	0.0064	0.0070
Sept	Peak	1808400	1658400	150000	562.05	2.11	7.66	258.03	0.26	0.0351	0.1788	0.0830	0.0064	0.0070
Oct	Peak	1830400	1680400	150000	562.05	2.11	7.66	258.03	0.26	0.0351	0.1788	0.0830	0.0064	0.0070
Nov	Base	1760000	1610000	150000	188.06	52.32	7.72	73.63	3.62	0.0013	0.0596	0.0048	0.0007	0.0012
Dec	Base	1468720	1318720	150000	188.06	52.32	7.72	73.63	3.62	0.0013	0.0596	0.0048	0.0007	0.0012
Total				1800000	4500.63	326.56	92.30	1989.95	23.29	0.2189	1.4304	0.5271	0.0426	0.0494
Five-Year Total				*9,000,000*	*22,503*	*1,632*	*461*	*9,949*	*116*	*1.09*	*7.15*	*2.64*	*0.21*	*0.25*