I-5

Energy Issues in the U.S.-Mexican Binational Region: Focus on California-Baja California

Alan Sweedler, Margarito Quintero Núñez, and Kimberly Collins

Abstract

Energy is an indispensable lifeblood of the U.S.-Mexican border region and it is a key issue in the binational region's future. The energy sectors in the United States, Mexico, and Canada are undergoing changes that will affect how energy is produced, transmitted, distributed, and sold throughout North America. These changes will directly influence energy use and energy-related infrastructure in the U.S.-Mexican border region. This chapter focuses on national energy issues in the United States and Mexico, border-wide topics of concern, and the California-Baja California section on the border.

Population growth is the main force behind the increasing demand for energy services in the binational region. The expanding economy is another important factor. These factors have led to a greater demand for energy services in the border region than is expected for other areas of North America. To meet the expected demand in northern Mexico, new and upgraded interconnections of the transmission system with the United States will be needed. The

North American Free Trade Agreement (NAFTA) does provide new opportunities for private energy companies, particularly those in the electric power industry.

In addition to the increased need for power, there will be significant pressure on supplies of natural gas and associated infrastructure, such as high-pressure gas pipelines, distribution systems, and pumping stations. As prices for fossil fuels and electricity continue to rise, it is expected that solar energy (both thermal and electric) will also become more important in the border region than in the past.

A secure supply of reasonably priced energy with a minimal environmental impact will be needed for the U.S.-Mexican border region if it is to remain competitive in the global economy. Given the expected increase in population and living standards on the Mexican side of the border, it is difficult to see how power demand can be met without the construction of new generating facilities in the border region. However, if environmental degradation is to be avoided and quality of life standards improved, the type of generation will be important. Heavy reliance of fossil fuels, even natural gas, will inevitably degrade air quality, contribute to global climate change, and stress limited water supplies.

There are several ways to enhance crossborder cooperation in the energy field and provide the energy services needed for border residents in the future. But doing so will require effective cooperation and coordination between the privatized energy market players and the local and state agencies still responsible for regulating the energy sector in both the United States and Mexico.

Temas de Energía en la Región Binacional México-Estados Unidos: Enfoque en Baja California-California

Alan Sweedler, Margarito Quintero Núñez, y Kimberly Collins

Resumen

La energía es un sustento indispensable de la región fronteriza México-Estados Unidos y es un factor calve en el futuro de la región binacional. Los sectores de energía en los Estados Unidos, México y Canadá se encuentran sufriendo cambios continuos que afectarán la producción, transmisión, distribución y venta de energía en Norteamérica. Estos cambios influenciarán directamente el uso de la energía y la infraestructura relacionada con la energía en la región fronteriza México-Estados Unidos. Este capítulo se enfoca en temas nacionales de energía en México y los Estados Unidos, en temas fronterizos de preocupación, y en la sección fronteriza de Baja California-California.

El crecimiento de la población es la fuerza principal detrás de la creciente demanda de energía en la región binacional. La expansión de la economía es otro factor importante. Estos factores han llevado a una gran demanda de servicios de energía en la región fronteriza que no se esperan en otras áreas de Norteamérica. Para poder satisfacer la demanda esperada en el norte de México, se requerirán interconexiones nuevas y actualizadas de los sistemas de transmisión con los Estados Unidos. El Tratado de Libre Comercio para América del Norte (TLCAN) proporciona oportunidades nuevas para compañías privadas de energía, particularmente aquéllas pertenecientes al sector industrial de energía.

Adicionalmente a la demanda incrementada de energía, habrá una presión significativa de recursos de gas natural e infraestructura relacionada, tales como conductos de gas de alta presión, sistemas de distribución y estaciones de bombeo. Mientras los precios altos de

combustible fósil y de electricidad siguen incrementándose, se espera que la energía solar (termal y eléctrica) se convierta más importante en la región fronteriza que en el pasado.

Si se pretende permanecer competitivo en la economía global será necesario un suministro seguro de energía a un precio razonable con un impacto ambiental mínimo para la región fronteriza de México-Estados Unidos. Debido al incremento esperado de la población así como a los estándares de vida en el lado mexicano de la frontera, es difícil ver como la demanda de energía se puede satisfacer sin la construcción de nuevas instalaciones generadoras en la región fronteriza. Sin embargo, si se desea evadir la degradación ambiental y beneficiar los estándares de la calidad de vida, el tipo de generación será importante. Una dependencia fuerte de combustible fósil, inclusive de gas natural, degradará indudablemente la calidad del aire, contribuirá al cambio climático global, y tensionará los suministros limitados de agua.

Existen diversas maneras de acrecentar la cooperación transfronteriza en el ámbito de la energía y proveer los servicios de energía necesitados en un futuro para los residentes de la frontera.

Para lograr esto se requerirá una cooperación y coordinación efectiva entre agencias locales y estatales aún responsables de regular el sector de energía en México y los Estados Unidos.

Introduction

Energy is an indispensable lifeblood of the U.S.-Mexican border region. It makes homes and businesses comfortable, moves people and goods, operates the machinery of industry, and powers the infrastructure that underpins the region's communities. This pervasive role makes energy a key issue in the border region's future. Energy choices made today will have significant effects on tomorrow's economy, environment, and quality of life. Without secure, reliable, and reasonably priced sources of energy, the border region cannot develop to its full potential.

The energy sectors in the United States, the four U.S. border states, Mexico, and Canada are undergoing major changes that will affect how energy is produced, transmitted, distributed, and sold

throughout North America. These changes will directly influence energy use and energy-related infrastructure in the U.S.-Mexican border region.

Some of the important energy challenges confronting the binational region are:

- Meeting demand for electric services, which is expected to grow significantly over the next 10 years, in northern Mexico and the southwestern United States
- Meeting the rapidly increasing need for natural gas in the border region
- Understanding the complex array of different regulatory structures in the United States and those evolving in Mexico
- Developing crossborder infrastructure associated with natural gas and power transfers
- Creating the necessary administrative and regulatory mechanisms to plan and coordinate issues related to the energy sector in the binational region
- Developing environmentally sensitive and sustainable sources of energy for the region

This chapter discusses these issues and makes recommendations for improving crossborder collaboration to meet the future energy needs of the region. It will first focus on national energy issues in the United States and Mexico, then move on to border-wide topics of concern, and finally focus on the California-Baja California section on the border, where approximately 42% of the border population is currently located (Sweedler 2003). While many of the problems and opportunities facing the energy sector of this region are similar to other portions of the border, there are unique characteristics as well, which will be discussed.

Overview of the Region

To understand the energy sector in the border region it is important to examine the context within which energy services are used. The most important elements are the region's population and its expected growth, its economic activities, and the environmental impacts of energy production, transmission, and end use. Although

this chapter is focused on the U.S.-Mexican border region, energy systems are integrated over much larger areas than just the border zone. In fact, today's energy markets are truly global, and a comprehensive analysis must recognize the global context of energy.

Although widely used, the term "border region" is not precisely defined. The La Paz Agreement between the United States and Mexico in 1983 defined the U.S.-Mexican border region as a zone stretching 100 kilometers (km) on either side of the international boundary. However, for the purpose of analyzing energy flows and related environmental issues such as air pollution, this definition is not particularly meaningful. Energy and transportation systems are not localized within a narrow region, and the cities in the border area all have important links to other regions throughout the United States, Mexico, and Canada.

Population growth is the main force behind the increasing demand for energy services in the border region. The region's population in 2000 was 11.9 million, and by the year 2020 it is projected to range between 15.9 million and 18.7 million (Peach and Williams 2004). Just in the California-Baja California region alone the projected population range for 2020 is between 5.9 million and 7.5 million.

In addition to population growth, the expanding economy—especially industrialization and the expected increase in the number of cars and trucks associated with increased U.S.-Mexican trade—is an important factor influencing the region's energy needs. Maquiladoras and other types of industrial facilities are major users of electricity and water, while the transportation sector depends on liquid fuels mostly in the form of gasoline and diesel fuel. Since natural gas is likely to be the fuel of choice for new power generation in the region, significant shortfalls of this versatile fuel can be expected unless measures are taken in the near future to meet projected demand. Details of population growth and economic trends are covered in other chapters in this volume and thus will not be covered here.

The United States and Mexican Energy Sectors

As noted above, the production, transmission, distribution, and use of energy in the U.S.-Mexican border region takes place within the framework of the larger energy markets of the southwestern United States, Mexico, and to some extent Canada. Power transmission grids and natural gas pipelines cross the North American continent and link the energy systems of the three North American countries. High-power transmission lines routinely transmit electricity generated in Canada or Mexico for use in the United States, and vice versa. Natural gas produced in Canada is transported to U.S. markets by transborder pipelines, and trade in natural gas has begun to take place between the United States and Mexico. To analyze the energy sector in the border region, it is therefore necessary to briefly discuss the larger North American energy context, focusing on the United States and Mexico.

Energy Sources and Uses in the United States and Mexico

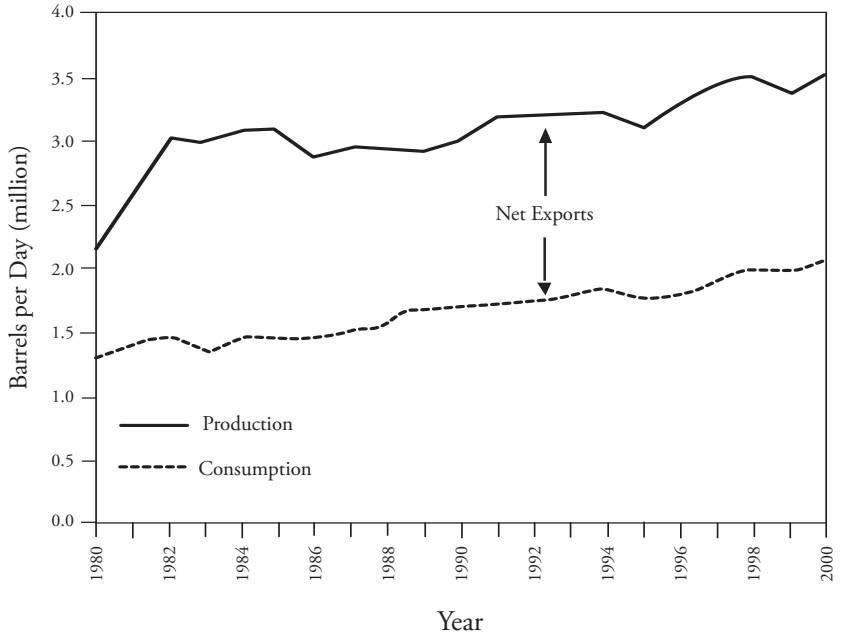
The structure of the energy sector and how energy is used in the United States and Mexico differ significantly. The United States uses a more broad spectrum of energy resources than Mexico, drawing on coal, oil, natural gas, nuclear, and hydropower, as well as a small amount of renewable resources. Mexico, by contrast, is heavily dependent on oil and natural gas, with the notable exception of geothermal resources in the state of Baja California.

Petroleum

The United States is the world's largest oil consumer, using 19.9 million barrels per day (bbl/d) in 1999 or 6.9 billion barrels per year (EIA 2001a). This is approximately one-quarter of oil consumption globally. In 2002, 11.4 million bbl/d were imported (57% of consumption), including 1.5 million bbl/d from Mexico (EIA 2004a). Mexico, by contrast, is self-sufficient in petroleum. It has the fourth largest proven crude oil reserves in the western hemisphere, totaling 20.7 billion barrels (Shields 2003). This estimate,

lower than in previous years, was revised downward in September 2002 to meet new U.S. Securities and Exchange Commission (SEC) filing guidelines, which require "proven reserves" to be under commitment for exploration in the short term. In 2003, Mexico produced about 3.18 million bbl/d of oil (*Oil and Gas Journal* 2002), with net oil exports of roughly 1.664 million bbl/d (Pemex 2002). Mexico ranked as the world's fourth largest oil producer and ninth largest oil exporter in 2002, with nearly 1.5 million bbl/d bound for the United States. The value of Mexican oil exports increased from $10.4 billion in 2000 to an estimated $21.3 billion in 2003. Oil exports account for approximately one-third of government revenues (EIA 2004b; Pemex 2003). Mexico's petroleum production and consumption from 1980 to 2003 are shown in Figure 1.

Figure 1. Mexican Petroleum Production and Consumption from 1980 to 2003



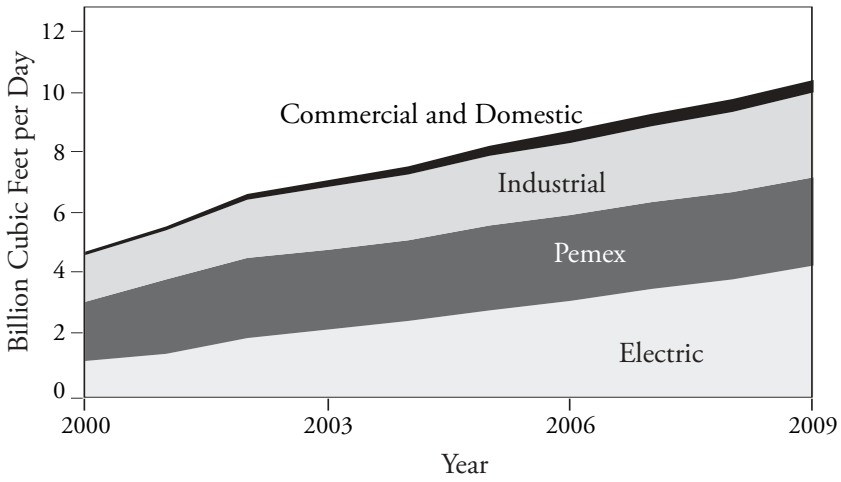
Source: U.S. Energy Information Agency 2003

Natural Gas

Mexico has proven natural gas reserves of 15.0 trillion cubic feet (Tcf), a figure that was also revised downward to meet SEC guidelines; 2002 production totaled nearly 1.33 Tcf (Secretaría de Energía 2004) and consumption nearly 1.51 Tcf (Pemex 2002). Mexico has not emphasized natural gas development and exploration until recently. Most of the gas now produced is "associated" gas that occurs as a co-product of oil production. Mexico is a small net importer of U.S. gas, a trend that is expected to continue in the coming decades. The tariff on Mexican imports of U.S. gas was eliminated in mid-1999, a move that will encourage continued and growing volumes of imports in the future.

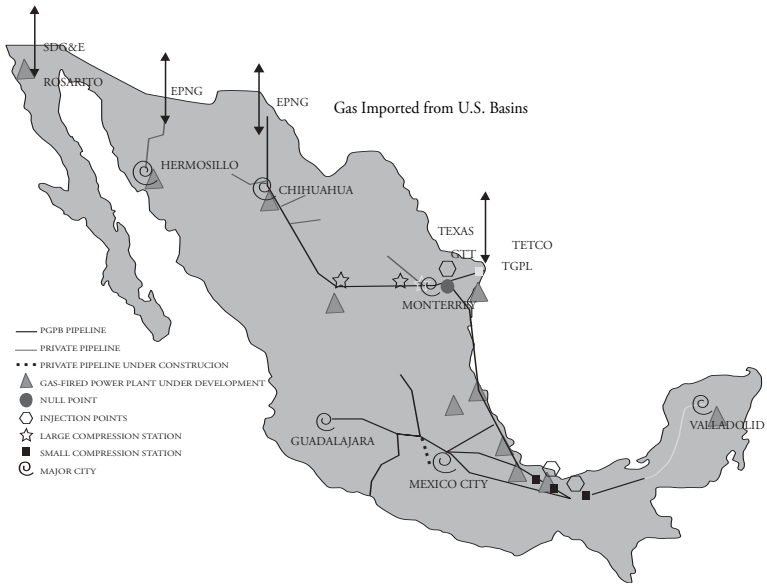
Natural gas is slated to play a more important role in the future as demand rises quickly, especially in the power sector and in the northern Mexican states. In response to anticipated demand growth, the state-run oil and gas monopoly Petróleos Mexicanos (Pemex) plans to increase U.S.-Mexican border infrastructure and capacity and to focus more on gas exploration activities. The Burgos field, located in northeastern Mexico, is expected to contain massive volumes of largely non-associated, recoverable natural gas resources. The Cantarell fields hold significant gas reserves in association with oil deposits, most of which is flared (emitted to the atmosphere). Pemex predicts that gas production will increase more than 50% from current levels by 2008. Pemex will invest almost twice as much capital in gas exploration and development activities in 2001 as it did in 2000. Figures 2 and 3 give the projected natural gas demand for Mexico and the major crossborder corridors. One can see that demand for natural gas in Mexico is expected to double in the next nine years.

Figure 2. Mexican Natural Gas Demand by Sector 2000–2009



Source: Pemex

Figure 3. Major U.S.-Mexican Gas Corridors



Source: El Paso Natural Gas Company

Mexico's growing reliance on natural gas is coinciding with historically high price levels for the fuel and growing demand in North America. The Mexican gas price was fixed to the Houston Ship Channel price in Texas in the early 1990s. As U.S. natural gas prices spiked in early 2001, Mexican President Vicente Fox came under pressure from Mexican industry and labor unions, which claimed that high prices were causing irreversible damage to businesses. In the wake of industrial plant closures, an agreement was reached whereby Pemex would sell natural gas to businesses at a fixed price of $4 per million British thermal units (Btu) for the next three years (compared to the U.S. Houston Ship Channel price, which reached more than $9 per million Btu in January 2001). Pemex would cover the difference when gas prices rose above $4 per million Btu but companies would continue to pay that price even if international prices drop below the $4 mark. The $4 per million Btu rate was retroactive to January 1, 2001. However, this arrangement excluded Baja California because natural gas in that region is purchased from the United States, not Pemex. Baja California remains subject to the price fluctuations of the U.S. market (EIA 2001). This illustrates the important point that Baja California is considered apart from the national energy markets by the Mexican authorities themselves, owing to the relatively isolated geography of Baja California relative to the rest of Mexico, as well as the growing reliance on U.S. natural gas in the state.

Natural gas consumption for the United States was 22.3 Tcf in 2003, nearly 15 times greater than Mexico's (*Natural Gas Monthly* 2003). Of this amount, 4.0 Tcf, or 18%, was imported; nearly 94% came from Canada (EIA 2004a). The availability and price of natural gas will be one of the most important energy issues in the border region during the next 20 years.

Electricity

Mexico has installed electric capacity of 42,300 megawatts (MW) and in 2002 generated 198.6 billion kilowatt-hours of electrical energy (CFE-CRE 2003). Oil-fired plants make up the largest share of electricity generation. Thermal (oil, gas, and coal) electricity generation in 2002 accounted for 80.1% of total generation, hydropower accounted for 12.4%, nuclear power for 4.8%, and

geothermal and eolic for 2.7% (CFE 2003). By 2012, it is expected that natural gas will comprise a much larger portion of thermal production—approximately 63% (SE 2003). Mexico's industrial energy policy calls for conversion of many oil-fired power plants to natural gas by 2005. Most new power plants will be run on natural gas and all proposed plants in the northern Mexican border region are slated to use natural gas.

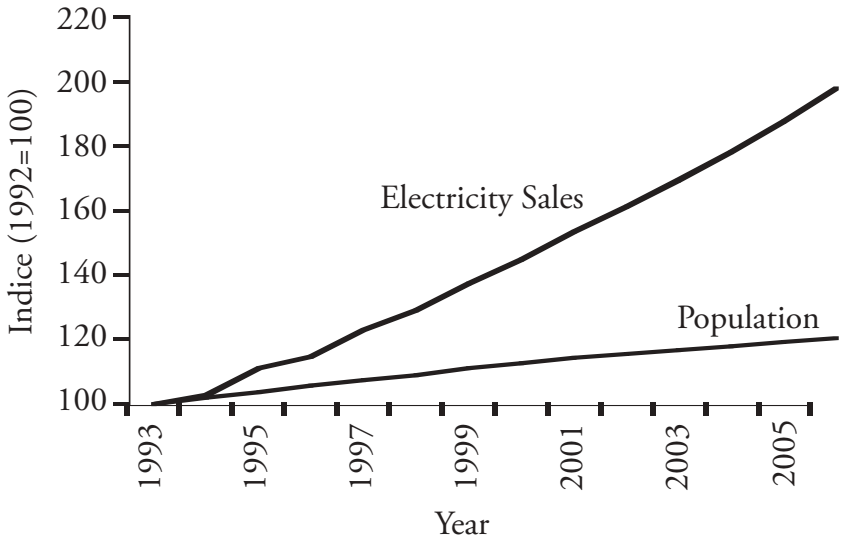
Mexico's electricity sector is at a crossroads. Although generation has increased rapidly over the past decade, supply is not expected to meet demand growth over the next two decades, especially in northern Mexico. Given current grid capacity constraints, shortages could result. It is expected that investments of approximately $50 billion will be needed over the next decade to meet projected electricity demand. Failure to make substantial investments in generation capacity and infrastructure could adversely affect the international competitiveness of key northern industrial regions. Although about 95% of Mexican households are electrified, there are still many thousands of rural towns without electricity (EIA 2001). Mexican electrical demand is plotted against population in Figure 4.

Structure of Energy Sectors in the United States and Mexico

The U.S. energy sector is, for the most part, owned and operated by private companies. Although in private hands, energy companies are regulated by state and federal agencies. The price of coal, oil, and natural gas is largely determined by market factors and relatively uniform prices exist across the United States. The price for electricity, however, has traditionally been established by state regulatory agencies and has not been determined directly by market forces until recently.

Some of the agencies responsible for regulating the energy industries in the United States are the Federal Energy Regulatory Commission (FERC), the U.S. Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and state public utilities commissions. In California, the California Public Utilities Commission (CPUC) and the California Energy Commission are the principal agencies that oversee the energy sector. At the local level,

Figure 4. Mexican Electricity Demand Versus Population Growth



Source: Authors

city and county jurisdictions may have to grant approval for energy-related construction such as gas pipelines and power transmission lines.

In contrast to the way energy is handled in the United States, the production, distribution, and management of energy supplies in Mexico are, by and large, under the control of the federal government. The federal government also sets energy prices. The Secretaría de Energía (SE) is the key government ministry responsible for formulating energy policies. SE has direct oversight of the national electric utility (the Comisión Federal de Electricidad [CFE]), Pemex, the national energy conservation commission (Comisión Nacional Para el Ahorro de Energía [CONAE]), and several energy-related research institutes. A relatively new agency, the Comisión Reguladora de Energía (CRE), was established in 1993.

The power sector in Mexico is dominated by the state-controlled CFE. Like Pemex in the oil and gas industry, CFE has enjoyed a monopoly in the electric power sector for decades, although reforms instituted in 1992 allow independent power producers (IPPs) and cogenerators to sell power to CFE.

Deregulation of the energy sector is a contentious issue in Mexico. Mexican President Fox has made privatization of the sector a top priority, as private investment will be needed to meet the country's rapidly increasing demand for electricity and gas. However, his reform efforts to date have met strong resistance. Fox had planned to submit a reform bill for electricity privatization before the end of 2002, but thus far he has failed to muster support within the opposition-controlled Congress. The bill is expected to call for a change in the constitution to allow private generators to sell electricity in a wholesale market, create increased incentives for foreign companies to participate in developing new oil and gas fields, and establish a separate electricity regulatory body. Currently, only the state's power companies can distribute and sell electricity to the general public. Fox has pledged not to privatize CFE during his presidency.

IPPs are allowed to build and own power generation facilities; the power can be used at related industrial companies or sold under long-term contracts to CFE. As of July 2004, 20 IPP permits had been issued for a total investment of $6.313 billion (CRE 2004). The projects are expected to add more than 11,478 MW of capacity by 2004. Of the 20 IPP projects in progress, eight are in northern Mexico; most of these are either totally or partially dependent on natural gas imports from the United States. An additional eight projects in northern Mexico are in the bidding process. However, natural gas and electricity shortages in the United States are having a negative effect on IPP development in Mexico; uncertainty about import sources could explain the low level of interest in new projects offered by CFE (CFE 2002).

Subsidies paid to agricultural and residential electricity consumers and the lack of an open power market are blamed for escalating industrial electricity costs, which are now more than average

international industrial electricity costs. Mexican industry warns that these costs will make Mexican industry internationally uncompetitive.

NAFTA and Energy

The treatment of the energy sector in the North American Free Trade Agreement (NAFTA) is perhaps most significant for what it lacks. Pursuant to the restriction in the Mexican Constitution that reserves for the Mexican federal government all ownership of Mexico's basic energy resources, NAFTA does not create significant new opportunities for private investment in oil, gas, refining, basic petrochemicals, or direct delivery of electricity. These activities remain controlled by Pemex and CFE. Nevertheless, NAFTA does provide new opportunities for private energy companies, particularly those in the electric power industry.

Under NAFTA, foreign companies can acquire, establish, and operate electric generation facilities in Mexico. Electricity generated at these facilities can be used at the site or sold to CFE. Moreover, the opening of the Mexican government procurement market will create opportunities for foreign companies to compete with Mexican entities for contracts to supply and service Pemex and CFE.

NAFTA reserves for the Mexican state goods, activities, and investments in the oil, gas, refining, basic petrochemicals, nuclear, and electricity sectors. Consistent with Mexico's move to greater privatization of industries and resources, however, NAFTA opens many downstream activities in the energy sector to greater private investment, both foreign and domestic. NAFTA also expands on Mexico's current Build-Lease-Transfer (BLT) program, which permits foreign companies to build an energy facility while leasing the site during construction, and then to transfer the plant back to the government shortly before commercial operation. With the full implementation of NAFTA, foreign companies will be able to own the plants and earn profits on sales of power back to CFE for the life of the facility. In addition, NAFTA's gas provisions potentially enable U.S. owners of gas-fired cogeneration facilities and other gas-fired facilities in Mexico to arrange for competitive gas supplies from U.S. gas companies.

NAFTA aims for more open markets in the energy sector, but it remains unclear whether those markets will provide sufficient returns to support increased investment. Remaining issues to be resolved are:

- The rates CFE will pay for electricity sold by the foreign-owned facilities
- The extent to which the Mexican government may regulate and modify the rates and terms of power sale agreements with CFE (deals will be limited or impossible if these arrangements fail to ensure a guaranteed payment stream to cover the debt service)
- The level of taxes that may be imposed on such operations in Mexico
- The role Pemex will play in importing gas for gas-fired electric power facilities

Genuinely open oil and gas markets are not created under NAFTA. The effect of the agreement's electricity provisions will depend greatly on how they are implemented. This will depend, in turn, on the extent to which the Mexican administration succeeds in bringing reform and a market-oriented spirit to Pemex and CFE.

The Energy Sector of the U.S.-Mexican Border Region

The four U.S. states and the six Mexican states that make up the border region confront some energy issues different from, but related to, the general energy situation in the whole of North America. Compared to other regions in the United States and Mexico, both the southwestern United States and northern Mexico are experiencing large population increases and high economic growth that are expected to continue for at least the next decade. These factors have led to a greater demand for energy services in the border region than is expected for other areas of North America. For example, demand for power in northern Mexico is expected to grow by 6.5% per year for the next 10 years, compared to 5.6% for the

rest of the country (CFE 2002). To meet the expected demand in northern Mexico, new and upgraded interconnections of the transmission system with the United States will be needed.

In addition to the increased need for power, there will be significant pressure on supplies of natural gas and associated infrastructure, such as high-pressure gas pipelines, distribution systems, and pumping stations. Now more than ever, there is a close relationship between natural gas and power generation, since all of the new power plants in the border region are expected to be the high efficiency, combined-cycle design that requires natural gas for their primary fuel.

Like the rest of North America, the energy sector of the border region is primarily dependent on fossil fuels. The three main fossil fuels—petroleum, natural gas, and coal—account for the main sources of energy in the border region. Gasoline and diesel (derived from petroleum) are used as the main transportation fuels, and liquid petroleum gas (LPG) is used extensively in place of natural gas on the Mexican side of the border for cooking, heating, and industrial processes. Where available, natural gas is used for heating and industrial process heat. Current power production is dependent on oil, coal, and some natural gas in Mexico, whereas in the U.S. portion of the border region natural gas and nuclear energy make up the bulk of fuels used for power generation. As mentioned previously, this fuel mix will change during the next decade as natural gas replaces oil, coal, and nuclear as the most preferred fuel for power generation on both sides of the border.

Besides fossil fuels, renewable resources also play a role in the border region, especially geothermal energy and wind power, with the latter growing rapidly in Texas. The use of renewable resources is expected to grow substantially in California over the next two decades because the CPUC has stipulated that 20% of the state's energy must be generated using renewable sources by 2020. As prices for fossil fuels and electricity continue to rise, it is expected that solar energy (both thermal and electric) will also play a larger role in the border region than in the past.

Electric Energy in the Border Region

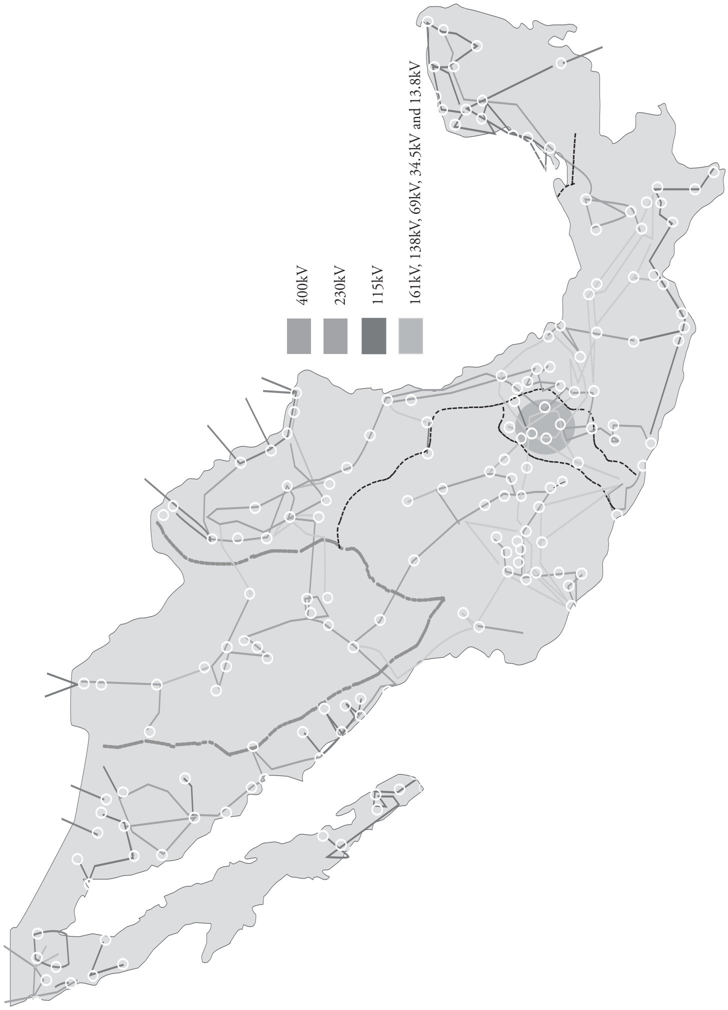
Figures 5 and 6 show the main electric transmission system of Mexico, as well as the crossborder connections. There are 12 transmission lines that cross the border—three in California, two in Arizona, and seven in Texas. Of these, only three are 230 kilovolts (kV); the others are 115 kV or less. The three high-voltage lines are located in the California-Baja California region. One important issue facing the border region is the need to increase the capacity of the crossborder transmission system by upgrading existing lines or developing new lines. Because this involves an international transfer of energy, FERC and DOE would have to be involved in addition to state and local agencies. In Mexico, CFE and SE would be the main entities involved, with possible input from the growing influence of state and municipal authorities.

Natural Gas

As previously noted, natural gas will become an important element in the fuel mix for the border region in years to come. The main reason is that natural gas is relatively clean-burning compared to coal or oil; it is also the best fuel for the new, efficient, gas turbine-steam generator (combined-cycle) power plants planned for construction in the border region. Because of this, creating, obtaining, and maintaining a secure and reasonably priced supply of natural gas will be one of the main challenges for the region.

The use of natural gas in the Mexican power sector will result in an unprecedented increase in the annual growth rate. It increased at 13.9% for the period 1993 to 2002 (SE 2003) and it is expected to remain at 12.1% for the period 2002 to 2011 (SE 2002), as shown in Figure 7. To increase domestic natural gas production, Mexico has introduced Multiple Service Contracts (MSCs). Under an MSC, foreign companies are paid for their services in developing natural gas reserves, but any gas produced remains the property of Pemex. To date, five of seven blocks have been awarded for a total estimated production increase of 440 million cubic feet per day (Mmcf/d).

Figure 5. Main Mexican Power Transmission Lines as of 1999



Source: CFE

Figure 6. Crossborder Power Transmission Lines in 1999

THE MOST IMPORTANT CROSS BORDER TRANSMISSION LINES EXIST IN BAJA CALIFORNIA AND IN CIUDAD JUAREZ, CHIH.

Source: CFE

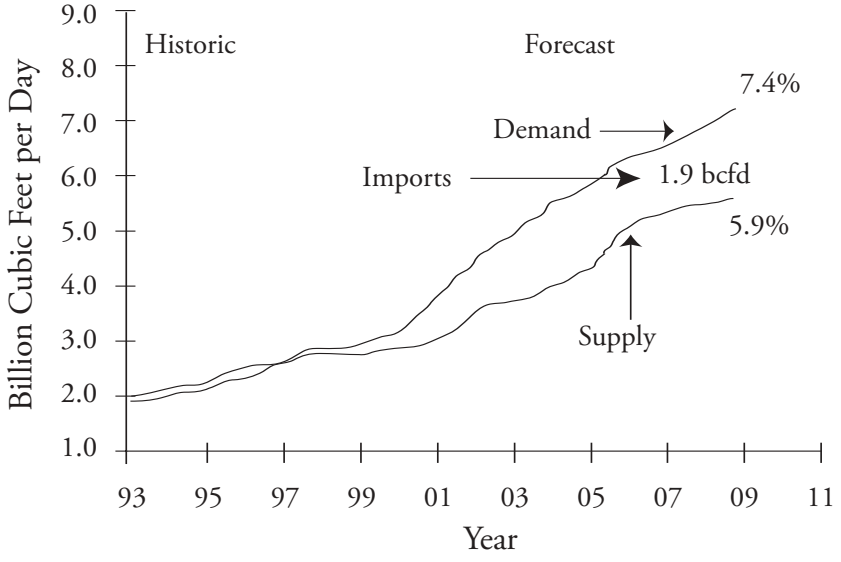
However, the two largest blocks did not receive any bids, demonstrating the lack of interest among large companies in the terms of the contracts.

In 1998, natural gas accounted for only 18% of total power generation in Mexico, but is expected to account for 58% by 2008 (CRE 2000), as seen in Figure 8. Much of that projected consumption for natural gas will take place in northern Mexico, as seen in Figure 9.

Geothermal Energy

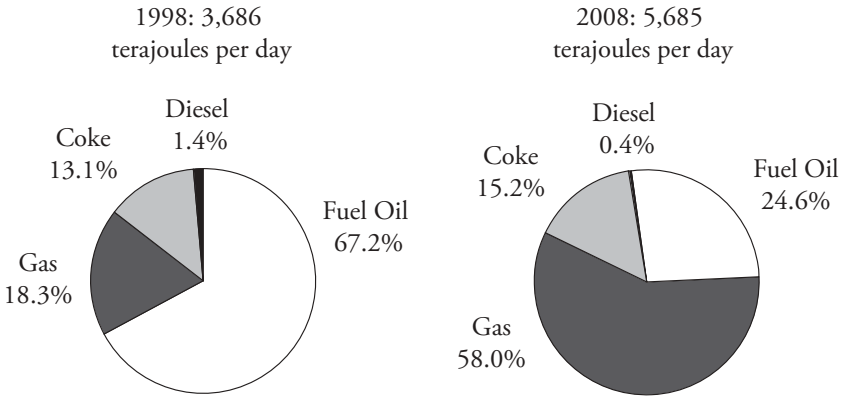
Geothermal sources of energy for power production are important in the border region, but only in the California-Baja California area, where there are significant geothermal resources in the Imperial-Mexicali Valley. These will be discussed later.

Figure 7. Historical and Projected Natural Gas Demand 1991–2008



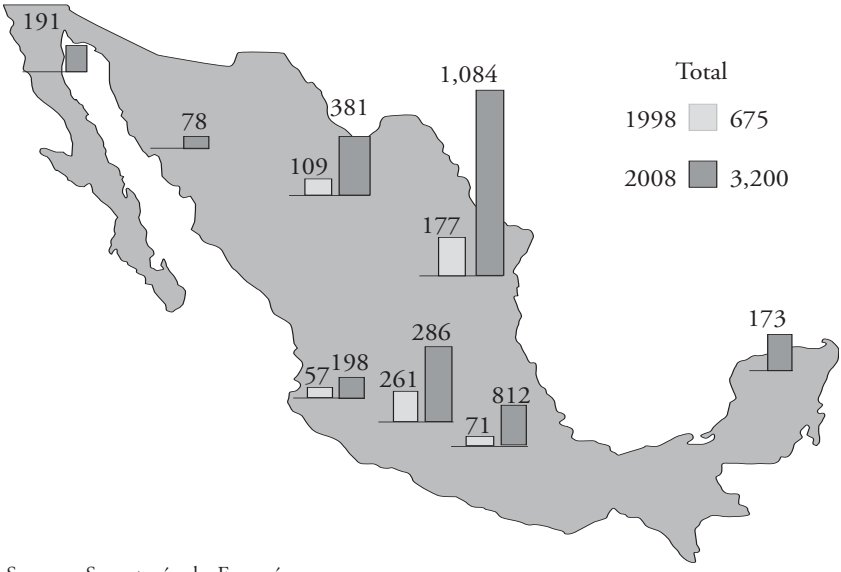
Source: Secretaría de Energía

Figure 8. Projected Evolution of Fossil Fuel Consumption in Electricity Generation



Source: CRE

Figure 9. Consumption of Natural Gas for the Generation of Electricity in Mexico



Source: Secretaría de Energía

California-Baja California Border Region

The California-Baja California portion of the U.S.-Mexican border region is an especially important section of the borderlands. In this western part of the border zone resides 42% of the total border population in the largest U.S. and Mexican twin cities—San Diego, Calif., and Tijuana, B.C. The energy issues here differ somewhat from other border regions because of the complex energy situation in California and the fact that Baja California is somewhat physically isolated from the rest of Mexico. Although the power grid of Baja California is not connected to the main Mexican transmission system, three of the largest crossborder connections are in this region (see Figure 6). The Mexican natural gas pipeline system also does not reach Baja California; any gas supplies will have to come across the border with California or Arizona, or possibly be imported in the form of liquefied natural gas (LNG).

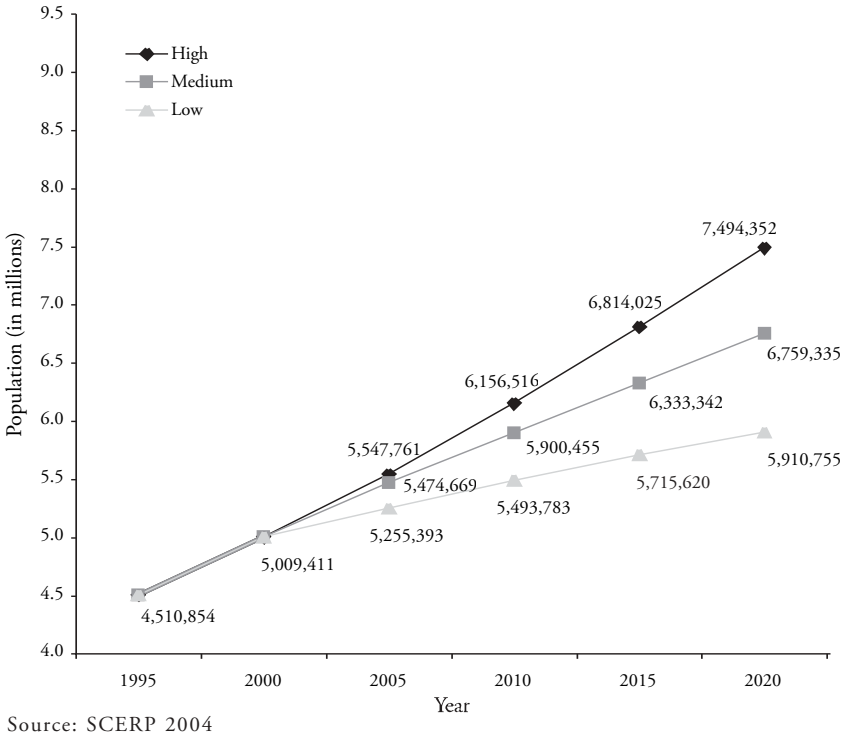
As is the case for the entire border region, population growth is the principal driving factor for projected increases in energy services. Figure 10 gives the expected population growth to 2020, at which time between 5.9 million and 7.5 million people are expected to reside in the region. Just the San Diego-Tijuana metropolitan region is expected to have 5.8 million people by 2020 (SCERP 2004).

In addition to population growth, the 867 maquiladora plants employing 215,186 people (SDE 2004) are major consumers of energy. Added to the growth of the industrial sector will be the large increase in cars and trucks as U.S.-Mexican trade increases. This, in turn, will lead to a greater demand for liquid fuels such as unleaded gasoline and diesel fuel.

Electric Power in Baja California

Demand for power in Baja California is expected to grow by 7.2% per year over the next decade, resulting in a doubling of demand by 2010 (CFE 2002). This translates into a need for more than 1,400 additional megawatts just to meet the needs of the Mexican population, leaving nothing for export to California. San Diego's power

Figure 10. California-Baja California Border Population, 1995–2020



Source: SCERP 2004

needs are also expected to grow, but by 2.11% per year through 2009 (SDG&E 2004). Although a lower growth rate, it is still considerable and begins from a higher base load.

Baja California's electrical energy infrastructure consists of power plant complexes near Tijuana and Mexicali. The current installed capacity is 4,000.5 MW. The location and fuels used are given in Table 1. The power grid is connected to San Diego via three 240 kV lines, one near Tijuana and the other two near Mexicali.

Table 1. Baja California Generating Facilities

Municipality	Site	Fuel	Capacity in MW
Tijuana	Turbogas	Diesel	210.0
Rosarito	Rosarito	Natural gas	1326.0
Mexicali	Cerro Prieto I-IV	Geothermal	720.0
	Termoeléctrica de Mexicali	Natural gas	600.0
	La Rosita	Natural gas	1060.0
	Turbogas	Diesel	62.0
Ensenada	Turbogas (Cipres)	Diesel	27.5
Total			4005.5

Source: Authors

Natural gas has become the main fuel used for power generation in Baja California and it powers the Rosarito and Mexicali facilities. From an air quality perspective, the main power plant supplying power to Tijuana—the 1,326-MW facility in Rosarito—is just 24 km from the border. It now uses natural gas as its primary fuel, although some generators still burn fuel oil. From an air quality perspective, it is important that the supply of natural gas, which is imported from the United States, be secure and reasonably priced. Although combustion of natural gas still results in significant atmospheric emissions of nitrogen oxides (NO_x), carbon monoxide (CO), and carbon dioxide (CO_2), they emit less than coal- or oil-based plants for an equivalent amount of energy produced.

The only indigenous energy source used on a large scale in Baja California is geothermally generated electricity, located south of Mexicali at Cerro Prieto. Until a few years ago, power from Cerro Prieto was exported to Southern California under a contract with Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E). These exports peaked in 1987 and 1992, and accounted for 12% and 10%, respectively, of San Diego's electricity supply in those years (CFE 1993). Electric imports from Mexico to San Diego ended in 1996, as supply in Baja California has barely kept up with growing internal demand. However, beginning in July 2003 electric-

ity exports totaling 1,130 MW from Intergen's recently completed La Rosita power plant and Sempra Energy's Termoelectrica de Mexicali plant began to flow into the United States (Cabrera 2003). These plants were built under the IPP scenario discussed earlier, mainly for the purpose of exporting power to California. For all of Mexico, the balance of trade in electricity is given in Table 2, where one can see the growing level of power imports from the United States beginning in 1995.

Table 2. Balance of Trade for Electricity (thousands of dollars)

Year	Exports	Imports
1980	104.0	615.0
1981	44.0	336.0
1982	8.0	9.0
1983	56.0	4.0
1984	90.0	5.0
1985	114.0	140.3
1986	1,461.0	100.7
1987	2,042.0	123.1
1988	1,996.0	170.9
1989	1,932.0	611.8
1990	1,946.0	575.1
1991	2,019.0	617.9
1992	2,041.0	989.5
1993	2,015.0	908.6
1994	1,970.0	1,140.2
1995	1,944.0	1,163.8
1996	1,288.4	1,387.5
1997	51.6	1,511.8
1998	77.0	1,510.0
1999	130.6	657.2
2000	202.7	1,080.8
2001	266.5	360.8
2002	343.5	475.8
2003	953.2	71.9

Source: Secretaría de Energía

Between 1996 and 1998, electric consumption increased 12.5% for the state of Baja California and 17.6% for Tijuana (CFE 2000). These large increases have put a significant strain on CFE's generating capacities in Baja California. By comparison, electric use in San Diego County increased by only 6.6% in the same two-year period (SDREO 2003). In Tijuana, the industrial and residential sectors are the major users of electricity. This is different from electric use patterns in San Diego, where the commercial and residential sectors consume more electricity than the industrial sector. The difference in electric energy use between Tijuana and San Diego reflects the fact that manufacturing and assembly activities form a larger part of the economy in Tijuana than they do in San Diego.

In Mexicali, residential electric consumption is more than twice Tijuana's, even though Mexicali's population is less than Tijuana's (CFE 2000). Mexicali has some of the highest temperatures in Mexico, with daily average outdoor temperatures well above 90°F in July and August. It also has an energy-inefficient housing infrastructure, mainly due to the poor shell characteristics of the housing stock and the low efficiency of the electric devices used for air conditioning. In fact, Mexicali has the highest per capita residential energy use in Mexico. The inefficient air conditioning sector in Mexicali is an obvious area where improvements could be made. Reduced air conditioning loads would result in a reduction in demand for electricity in Baja California. Several programs are under way to increase the energy efficiency of the housing stock and reduce air conditioning loads in Mexicali.

Although per capita electric use in Baja California is greater than the Mexican average, it is still much less than San Diego's. For Baja California as a whole, per capita electric use for 2000 was only 3,010 kilowatt-hours (kWh)—nearly half of San Diego's 6,333 kWh. For Tijuana, per capita electric use was only 2,362 kWh—nearly one-third of San Diego's. Mexicali, with 3,268 kWh per capita (CFE 2001), is the highest per capita consumer in Baja California.

Future Power Needs in Baja California

The process of estimating future energy needs and planning to meet those needs in Mexico is quite different from the process in California. There are no federal or state counterpart agencies in Mexico to the CPUC, the California Energy Commission, or the San Diego Association of Governments (SANDAG). Future electricity demand has traditionally been estimated by CFE, based more or less on historical growth patterns than on a detailed analysis of the different electricity-consuming sectors.

Estimates of future annual growth rates for power are in the range of 5% to 7% for Baja California for the next decade (CFE 2003). This means that between 910 MW and 1,400 MW of additional capacity will be needed by 2010. The completion of the two new power plants in Mexicali has added 1,560 MW of capacity. However, as most of this power is slated to be exported to California, it is unknown whether these new plants will be sufficient to meet Baja California's growing demand. Additional power plants proposed for the region are shown in Table 3. The total potential capacity of 430 MW will not be enough if actual demand follows CFE's projected demand.

Table 3. Proposed Power Plants in Baja California

Facility	Location	Output (MW)	Estimated Online Date	Technology	Fuel Type	Notes
La Jovita*	Costa Azul (15km North Ensenada)	280	2006	Combined cycle natural gas	Natural gas	CFE
El Carrizo	TKT	40-50	2007	Small hydro water	Water	CFE
El Retiro	Ensenada	60-100	2007	Small hydro water	Sea water	CFE

Source: Secretaría de Dessarrollo Económico, Estado de Baja California

Instead of increasing generating capacity within Baja California, expected demand might be met by purchasing more electricity from the North American power system and integrating Baja California more fully into the electric transmission system of the United States. As noted earlier, the Baja California power grid is isolated from the Mexican national system but connected to the California system at two points. This permits a limited amount of power transfers between the western North American system and Baja California. Whatever the ultimate fate of restructuring efforts in California and the west, there is little doubt that a regional market for power will develop in the western United States, and there is no reason why Baja California and northern Mexico will not be part of that power pool. Electric customers and energy brokers will be searching all over North America for the cheapest power available. It may prove cost-effective for CFE in Baja California to both buy and sell power within this large electric market. Large consumers of power in Baja California, such as industrial parks, may find it cheaper to purchase power from the United States rather than from CFE. Similarly, customers in San Diego may find it less costly to obtain power from CFE in Baja California or from independent power producers in Mexico instead of from local generators in the United States.

Baja California's Natural Gas Market

As noted above, Baja California has no direct access to the abundant natural gas resources of Mexico because of its location relative to those resources. There is, however, a growing recognition that natural gas would be an ideal fuel to meet the region's growing demand for industrial heat and electric generation and that the United States, and perhaps even Canada, can serve as sources of natural gas for Baja California if appropriate crossborder pipelines could be constructed.

Baja California's dependence on U.S. natural gas supplies can have drawbacks, however. The Mexican government is guaranteeing a price of $4 per therm, except for users in Baja California because that state's gas comes from the United States, not Pemex. Marcos Ramirez Silva, Pemex's director of gas and petrochemicals, has been quoted as saying, "We don't have any infrastructure there...

Nothing. Well, it's (Baja California) more like the United States. They should be burning fuel oil" (Lundquist 2001). Of course, if the price of U.S. natural gas falls below Mexico's price, Baja California could benefit.

The use of natural gas for power generation in Baja California is of particular importance to the San Diego-Tijuana region. Since the principal thermal power plant in the Baja California is just 24 km south of the border, supplying that plant and its planned additions with natural gas will improve air quality in the region while at the same time provide natural gas to industries and residents of Tijuana. Gas-fired electrical generation produces almost no sulfur oxides and is generally more efficient than an oil-fired plant because combined-cycle technology can be used.

For the first time in Baja California, natural gas is now available via pipelines crossing the border east of Calexico, Calif., and south of San Diego. As of May 1999, 70 industrial customers, 80 commercial businesses, and 10,308 residences had been connected to this distribution system. Contracts had already been signed for an additional 78 industrial customers, 127 commercial businesses, and 15,700 residences. In addition, a new pipeline is supplying natural gas to the new power plants at La Rosita, near Mexicali (Rivero 2002).

Plans to import LNG to the Baja California coast have run into significant opposition from local residents, state and local authorities, and even from some sections of the Mexican Congress. Out of six original proposals, there are currently only two projects in the advanced development stage. Shell International Gas Limited and Sempra Energy LNG Corp. have joined efforts to develop an onshore LNG terminal at Costa Azul between Rosarito and Ensenada. The $600 million project would provide 1 billion cubic feet per day (bcf/d) when completed in 2007 (Sempra Energy 2003). ChevronTexaco plans to construct an LNG regasification terminal eight miles off the coast of Baja California in the Coronado Islands. The $650 million project would deliver 1.4 bcf/d at full capacity, with operations projected to begin by the end of 2007 (ChevronTexaco 2003).

The experience of trying to site large LNG facilities on the Baja California coast highlights many of the energy-related issues of concern in the border region. On the one hand, most analyses of future natural gas demand in California and Baja California conclude that the region will experience shortfalls in this resource in the next 10 years. Because both San Diego and Baja California are located far from sources of natural gas in both countries and because pipeline transmission capacity is limited, importing LNG would appear to be an attractive source of supply.

On the other hand, critics have pointed out that these large facilities are inconsistent with the natural ecology of the peninsula's coast and near-shore environment. They also question the validity of demand forecasts that show large increases in natural gas needs, claiming that aggressive conservation and renewable energy resources can meet future demand. Critics also cite safety concerns in locating potentially dangerous plants near population centers.

An important argument, which has relevance for LNG plants and other large energy production facilities in Baja California, is that most of the gas will be used to satisfy the California market, with relatively little distribution in Baja California. Thus, in this view, Baja California assumes most of the negative environmental effects and potential safety risks with little benefit from increased supplies of natural gas.

Added to these issues is the question of national security, from both the U.S. and Mexican perspectives. From the U.S. perspective, becoming dependent on imported LNG from distant shores could result in a situation similar to what currently exists for imported petroleum. The United States now imports more than half of this vital resource (Department of Energy 2002), in many cases from unstable regions of the world, thus elevating oil supply to a question of national security. For those who advocate greater energy independence for the United States, importing LNG will only make matters worse.

For those in Mexico concerned about Mexican sovereignty, allowing the location of critical U.S. energy infrastructure facilities, such as LNG plants, in Mexico could raise questions about protecting those facilities from terrorist attacks. In this view, if the United States authorities do not believe that Mexico can provide adequate

protection, they may intervene to secure the relevant facilities, which would clearly be a violation of national sovereignty. Although considered unlikely by most observers, this argument has been given prominence in the Mexican national press and in the Mexican Congress. To some extent it is a reaction to what is considered an aggressive American foreign policy to secure U.S. interests, especially where energy is concerned.

Regardless of one's view, it is important to understand the different perspectives and to understand that energy-related issues take place in a political and social context. In most cases, the types of energy systems that are finally constructed are the result of a complex interaction between resources, economics, politics, and local environmental considerations. This is even more true in a region between two very different nations.

Renewable Sources of Energy in Baja California

It was noted earlier that both San Diego and Baja California are heavily dependent for energy supplies on fossil fuels (petroleum products and natural gas) that originate far from the region. Not only does this represent an outflow of regional capital, but the burning of fossil fuels is a major source of air pollution. Therefore, it is of interest to examine the potential for development of indigenous and renewable sources of energy in the border area as a long-term replacement for fossil fuels.

Although Baja California has an impressive array of renewable energy resources, very few of these resources have been developed to produce significant amounts of energy. The main reasons for the lack of renewable energy development in Baja California are the same that plague renewable energy development elsewhere: Until recently, relatively low costs for oil and natural gas were coupled with relatively high initial capital costs for most renewable energy projects. These factors present an even larger impediment for the development of most renewable projects in Mexico because of the plentiful supply of oil and gas and the lack of capital. However, with the current upsurge in natural gas prices, the high prices of oil, and the shortage of power in California and the west, incentives to develop renewable energy resources continue to grow.

Renewable energy resources in Baja California consist of geothermal, microhydroelectric, biomass, wind, solar, and tidal. With the exception of geothermally generated electricity, none of these renewable resources has been significantly exploited to date.

Geothermal

Baja California is home to some of the largest geothermal reserves in Mexico. These considerable resources are located at Cerro Prieto in the Valley of Mexicali, about 30 km from the international border. An intriguing potential source of even greater geothermal energy than the Valley of Mexicali might be in the form of geopressurized deposits (high-temperature, high-pressure water located beneath the sea bed) located in the northern part of the Gulf of California. This region displays characteristics found nowhere else in the world for the development of marine geothermal resources. The initial geothermal potential has been estimated to be tens of times greater than that of Cerro Prieto.

Geothermal Binary Cycle

There is the potential to use heat from the residual brine that results from the operation of the geothermal fields at Cerro Prieto. The fields have an installed capacity of 720 MW and, when in full operation, produce approximately 12,000 tons of residual water per hour with a temperature range of 120°C to 135°C (Quintero N. 1988). This represents an important amount of useful energy for a binary cycle operation. Estimates suggest that as much as 246 MW of additional power could be produced in this fashion.

Microhydroelectric Power

An interesting renewable technology that could prove practical in Baja California is microhydroelectric power generation in the Mexicali Valley. This is based on capturing the energy in the flow of water from the extensive irrigation system that exists in the agriculture-intensive region surrounding the city of Mexicali. Estimates as high as 80 MW have been suggested for microhydroelectric generation.

Solar, Wind, and Biomass

Table 4 lists an estimate of renewable and alternative energy resources for Baja California. One can see that these sources of energy could play a significant role in the region's energy portfolio. Although the potential contribution to the region's energy mix from solar (thermal and electric), wind power, and biomass could be substantial, there are no studies that examine in a comprehensive fashion the potential of these resources. The authors of this chapter are in the process of completing such a study.

Table 4. Estimated Renewable and Alternative Energy Resources for Baja California

Energy Source	Potential
Geothermal	1,000 MW proven reserves (Mexicali)
Solar	3.3 kWh/m^2 to 6.9 kWh/m^2
Wind	100 watts/m^2 to 250 watts/m^2
Biomass	
Agricultural waste	3,600m^3 (Mexicali)
Solid urban waste	25 MW to 30 MW + heat
Seaweed	~75,000 Barrels of oil equivalent per year
Fuel wood	Negligible
Mycrohydroelectric	~80 MW (Mexicali)
	~20 MW (Tecate)
Tidal Power	~1,200 MW (Gulf of Cortez)

Source: Huacuz 1995

San Diego's Energy Sector

Overview

A comprehensive analysis of the energy sector in San Diego was recently carried out by a consortium of agencies led by the San Diego Regional Energy Office (SDREO) called "Energy 2030: The San Diego Regional Energy Plan" (SDREO 2003). The Regional Energy Strategy was adopted by SANDAG in December 2003 to form the energy component of the Regional Comprehensive Plan.

The main features of the energy sector in San Diego are the dominance of the transportation sector in terms of energy consumption, the high proportion of electricity imported from outside the region, and relatively high electricity and gasoline prices. Transportation accounts for more than 60% of end-use energy consumption in San Diego, followed by the residential, commercial, and industrial sectors. This energy consumption pattern reflects the structure of the San Diego economy—most San Diego residents commute to work in private automobiles with one or two occupants. Moreover, most of the rapid population growth during the last 10 years has occurred in the northern sections of the county, resulting in longer commutes from home to work.

Power Sector

San Diego is dependent on power imports from outside the region, which supplied more than half of summer peak demand in 2002. The commercial sector uses more electricity proportionally than the rest of the state, reflecting San Diego's concentration of high-tech businesses, tourist activities, and retail trade. This is important because these sectors are rapidly growing not only in San Diego but in Tijuana, although at the present time industrial use of power is still greater than commercial activities in Tijuana and Mexicali, compared to San Diego.

The major power-related infrastructure elements in San Diego consist of two large thermal power plants located in Carlsbad (Encina) and Chula Vista (South Bay), plus the San Onofre Nuclear Generating Station (SONGS) located just south of San Clemente, 20% of which is owned by SDG&E. All thermal power plants operating in the county use natural gas, and there are only two high-

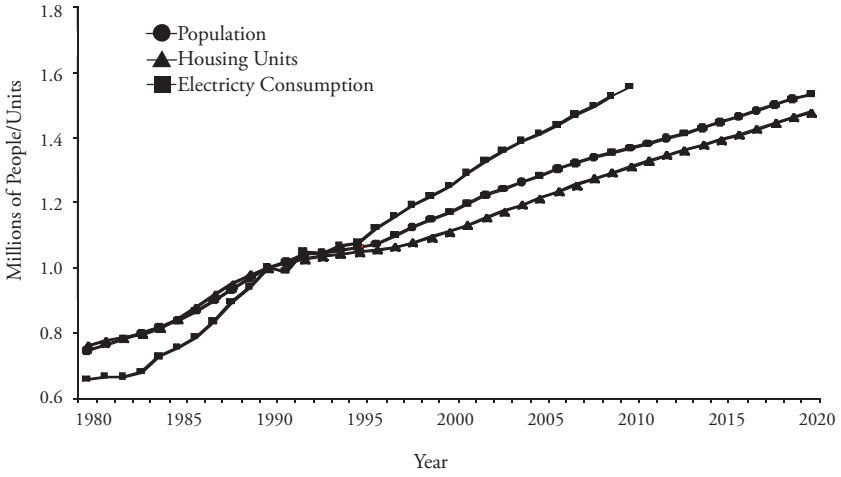
voltage (500 kV) transmission lines, one to the north and the other to the east, responsible for carrying all the imported power into the region.

Figure 11 gives historical and projected electricity demands compared to housing and population growth, indexed to 1990. The figure shows that demand for power has grown faster than population and housing since 1995, a trend that is expected to continue through 2020. The main reason for this is the large amounts of power consumed in office buildings, Web centers, and information-processing sectors, all of which play an important role in the San Diego economy.

To meet this projected demand for power, San Diego, indeed the entire binational region, has several choices:

- Increase in-region generation capability
- Increase electricity imports from outside the region
- Reduce demand
- Some combination of the above

Figure 11. Population, Housing, and Electric Use for San Diego County, 1980–2020



Source: California Energy Commission; SANDAG

For San Diego, new conventional power plants, distributed generation, and an increase in renewable energy generation offer three ways to increase in-region generation. In June 2004, two new large, combined-cycle power plants were approved by CPUC for San Diego. One, the Palomar Energy facility, which is to be constructed in Escondido, is slated to produce 546 MW when completed in late 2005. The other, a 550 MW facility owned by Calpine, is located on the border in Otay Mesa and is scheduled for completion in 2007. These two facilities and other smaller projects approved by the CPUC will add 1,236 MW of in-region generation by 2007.

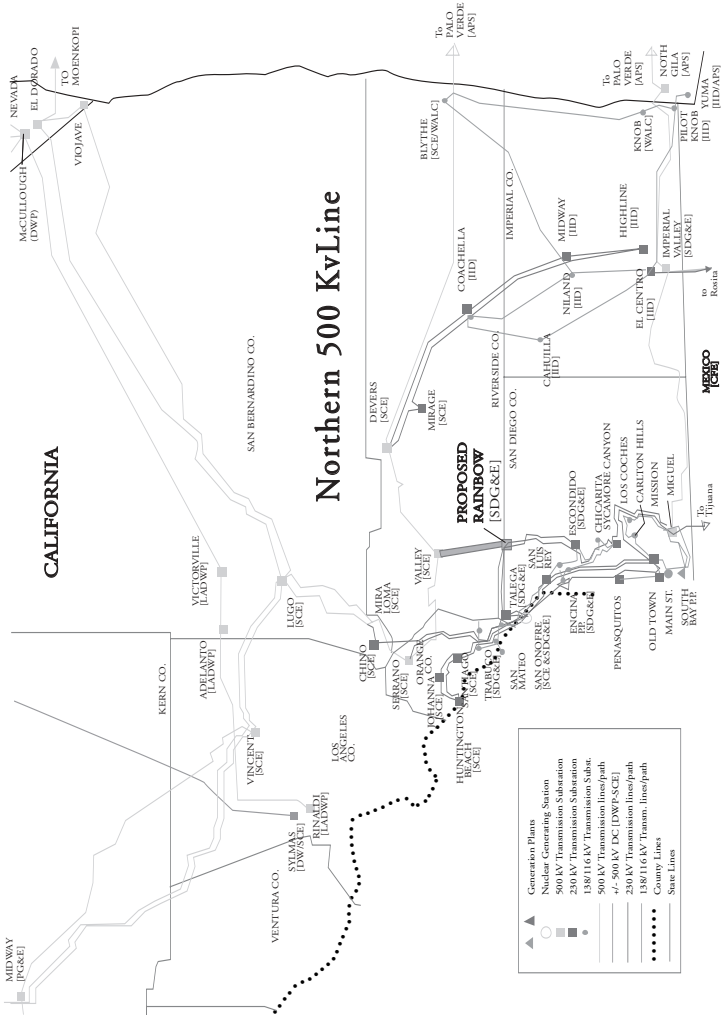
One of the interesting features of the Otay Mesa plant is the use of mobile offsets to comply with air emissions requirements. This means the plant owners will replace diesel buses with natural gas burning vehicles, thereby reducing mobile emissions in the region. This is the first time mobile offsets have been used to replace stationary emissions and it could represent a creative approach to reducing air pollution while increasing energy production. A natural extension of this concept would be to consider crossborder air emissions trading in regions such as San Diego-Tijuana, Imperial, Calif.-Mexicali, B.C., and El Paso, Tex.-Ciudad Juárez, Chih.

Importing more electricity into San Diego is currently difficult because of limited transmission capabilities into the region, as can be seen from Figure 12, which shows the grid system for San Diego.

There is a proposal to build a 500 kV connecting line that would allow more power to be brought into the region from the north. But, it has not yet been approved and there is considerable opposition to its construction.

Reducing energy demand is a tried and true approach that complements increasing energy supply. Any comprehensive energy plan for the binational region should have energy-reduction programs such as increasing energy efficiency in buildings, appliances, and lighting; economic incentives for installing energy-efficient devices; and tiered pricing structures that encourage lower energy consumption.

Figure 12. Electric Transmission for the San Diego Region



Source: Center for Energy Studies

Binational Energy Strategy Committee

Recognizing the need for better planning and coordination between California and Baja California in the energy sector, SANDAG, under its Borders Committee, established the Binational Energy Issues Group (BEIG) in 2000. BEIG serves as the only public forum that discusses energy issues of importance to the entire binational area. It serves as an information resource, a place where new projects can be vetted, and ensures better communication between and among stakeholders. Members of BEIG represent the major energy stakeholders from both sides of the border.

Challenges and Opportunities: Issues for Discussion

A secure supply of reasonably priced energy with a minimal environmental impact will be needed for the U.S.-Mexican border region if it is to remain competitive in the global economy. Given the high population growth expected over the next 10 years to 20 years, meeting increased demand for energy services will prove to be one of the most important challenges facing the binational region.

The large increase in energy demand projected over the next 20 years for the border region is not a forgone conclusion, however. It is clear that as a society develops and standards of living rise, per capita energy demand can actually decrease. This was the experience in many of the industrialized countries during the period from 1975 to 1998. Although total energy demand per capita may decrease as the economy becomes more efficient, there is also a trend that electric energy use appears to grow faster than the population. Therefore, unless vigorous and consistent power efficiency and conservation programs are put in place in the border region, residents are likely to realize the high growth rates discussed in this chapter.

Even with such a conservation program, given the expected increase in population and living standards on the Mexican side of the border, it is difficult to see how power demand can be met without the construction of new generating facilities in the region. However, if environmental degradation is to be avoided and quality of life standards improved, the type of generation will be important. Heavy reliance on fossil fuels, even natural gas, will inevitably

degrade air quality and stress limited water supplies. Because transportation pollutes more than other sectors, plans to use fuels other than gasoline and diesel will ultimately pave the way for a cleaner environment than currently exists or is projected to exist in the next 20 years.

Meeting this challenge will require effective cooperation and coordination between the privatized energy market players and the local and state agencies still responsible for regulating the energy sector in both the United States and Mexico. Complicating the development of new methods of planning for future energy-related infrastructure is the lack of formal crossborder energy planning, coordination, and cooperation. The impediments to creating a healthy energy supply system in the binational region are not mainly technical or financial, but grow out of the absence of planning, forecasting, and coordination at the binational and regional level.

Some suggestions follow that would enhance crossborder cooperation in the energy field and provide the energy services needed for border residents.

1. Create a binational collaborative effort to examine the future energy needs of the binational region and surrounding areas. This group should have representatives from all the major stakeholders in the region, including energy services companies, major energy consumers, relevant local and state agencies, environmental groups, appropriate non-governmental organizations (NGOs), ratepayer advocates, and the general public. It is critical that broad representation from both sides of the border be present. An effort of this sort could be structured like the aforementioned Binational Energy Issues Group for the California-Baja California region. Another model is the Air Alliance for the El Paso-Ciudad Juárez region and the Binational Air Quality Alliance in the San Diego-Tijuana area.
2. Develop the necessary infrastructure to handle the increased use of natural gas in the border region, especially the western sections. A secure supply of natural gas for industry and power generation will go a long way toward meeting the energy needs of the binational region in a manner less harmful to the environment than fuels currently in use, such as oil and coal. One possible way to assist the transition to natural gas

in the California-Baja California region is to consider a gas exchange program between Mexico and the United States. Mexican natural gas could be imported to the United States via Texas and an equivalent amount of U.S. gas exported to Baja California by extending San Diego pipelines into Tijuana. This could reduce the burden on Mexico of having to use its foreign currency reserves to purchase U.S. natural gas. Other issues that need to be addressed are safety and security of supply.

3. Prepare and maintain a comprehensive energy database for the crossborder region. The region has no central database related to energy, and no entity is collecting or distributing such information.
4. Invest in renewable sources of energy. Although the crossborder region will likely remain dependent on non-renewable energy sources imported from outside the region for some time, more could be done to encourage and use existing renewable energy resources found on both sides of the border. The region has yet to fully use a combination of energy resources including solar, wind, geothermal, and biomass. Greater use of renewable sources of energy not only will reduce air pollution but could form the basis of a new high tech research, development, and manufacturing sector in the field of advanced energy technology.

The underlying logic of electric restructuring in the United States, the opening of the energy sector in Mexico to private investment, and the growing economic interdependence of the United States and Mexico will inevitable lead to greater crossborder trade in energy services between the two countries. This trade is likely to take place in the purchase and sale of electricity by private industries and local and state agencies responsible for supplying power that are located on either side of the border. In the open market for energy services emerging on both sides of the border, the final price to consumers will be the most important element in deciding where to purchase energy; the location of the energy source will become

less relevant than it is today. Over time, the international border will become less of a barrier to energy flows—a consequence of the continued integration of the crossborder region.

References

Cabrera, E. 2003. "Exportan energia las dos plantas." *La Crónica.* 31 July (5/A).

ChevronTexaco. 2003. "ChevronTexaco Announces Plans for an Offshore LNG Terminal in Baja California." Press release, 30 October.

Comisión Federal de Electricidad. 1993. Personal communication with the authors. 27 September.

Comisión Federal de Electricidad. 2000. "Compañía Federal de Electricidad, División Baja California 1995-1999." http://www.cfe.gob.mx.

Comisión Federal de Electricidad. 2001. Personal communication with the authors.

Comisión Federal de Electricidad. 2002. Personal communication with the authors.

Comisión Federal de Electricidad. 2003. "Prospectiva del Sector Electrico 2003-2012." http://www.cfe.gob.mx.

Comisión Federal de Electricidad-Comisión Reguladora de Energía. 2003. "Prospectiva del Sector Eléctrico 2003-2012." http://www.cfe.gob.mx.

Comisión Reguladora de Energía. 2000. Presentation given at the 9th Annual Latin American Energy Conference, 15 May, La Jolla, Calif.

Comisión Reguladora de Energía. 2004. "Comisión Reguladora de Energía." Cited 25 August. http://www.cre.gob.mx.

Ganster, P., ed. 2000. *The U.S.-Mexican Border Environment: A Road Map to a Sustainable 2020* SCERP Monograph No. 1. San Diego, Calif.: SDSU Press.

Huacuz, J. 1995. "Non-Fossil Fuel Based Energy System." Page 135 in *Energy and Environment in the California-Baja California Border Region,* A. Sweedler, P. Ganster, and P. Bennett, eds. San Diego, Calif.: SDSU Press.

Lindquist, D. 2001. "Baja seeking Mexico price for natural gas." *San Diego Union-Tribune.* March 3 (C3).

Natural Gas Monthly. 2003. http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/natural_gas_monthly/ngm.html.

Oil and Gas Journal. 2002. http://www.ogjonline.com.

Peach, J., and J. Williams. 2004. *Population Dynamics of the U.S.-Mexican Border Region.* Unpublished, forthcoming SCERP Monograph. San Diego, Calif.: SDSU Press.

Petróleos Mexicanos. 2003. "Informe Estadístico de Labores 2002. Información de PEMEX Exploración y Producción [PEP]." http://www.pemex.com.

Petróleos Mexicanos. 2003. *Pemex 2003 Financial Results Report.* http://www.pemex.com/files/dcf/dcf_rr_0312_i.pdf.

Quintero N., M. 1988. "Binary Cycle, Potential Exploitation of the Residual Brine at Cerro Prieto." Paper presented at the Geothermal Resources Council Congress 1988 Annual Meeting, 12 October, San Diego, Calif.

Rivero, M. 2002. "Reactivan en la Rosita Segunda Expansión." *La Crónica.* 30 June (2F).

San Diego Gas & Electric. 2004. *SDG&E Long Term Resource Plan.* 9 July 2004. http://www.sdge.com.

San Diego Regional Energy Office. 2003. "Energy 2030: The San Diego Regional Energy Plan." http://www.sdenergy.org.

Secretaría de Dessarrollo Economico. 2004. "Estadísticas Basicas del Estado." Secretaría de Desarrollo Economico (SDE) Gobierno del Estado de Baja California, February.

Secretaría de Energía 2002. "Prospectiva del Sector Electrico 2002-2011." Primera Edición. Mexico City: SE.

Secretaría de Energía. 2003. "Prospectiva del mercado de gas natural 2003-2012." Primera Edición. Mexico City: SE.

Secretaría de Energía. 2004. "Mexico's Installed Capacity." Cited 12 July. http://www.energia.gob.mx/work/secciones/112/imágenes/capacidad_intalada.xls.

Sempra Energy. 2003. "Sempra Energy LNG Corp. and Shell propose to develop Mexican LNG receiving terminal." Press release, 22 December.

Shields, D. 2003. "PEMEX, un futuro incierto." *Editorial Planeta.*

Southwest Consortium for Environmental Research and Policy. 2004. "Border Population Projections." Cited 15 September 2004. http://www.scerp.org.

Sweedler. A., M. Quintero-Núñez, and K. Collins. 2003. "Energy Issues in the U.S.-Mexican Binational Region California-Baja California." *The U.S.-Mexican Border Environment: Trade, Energy and the Environment: Challenges and Opportunities for the Border Region, Now and in 2020* SCERP Monograph No. 7, D. Rohy, ed. San Diego, Calif.: SDSU Press.

U.S. Department of Energy. 2002. "Annual Energy Outlook 2003." http://tonto.eia.doe.gov/FTPROOT/forecasting/0383(2003).pdf.

U.S. Energy Information Agency. 2001. *Country Analyses, Mexico.* February http://www.eia.doe.gove/emeu/cabs/mexico.html.

U.S. Energy Information Agency. 2003. *Country Analysis, Mexico.* Cited 15 September 2004. http://www.eia.doe.gove/emeu/cabs/mexico.html.

U.S. Energy Information Agency. 2004a. *United States Country Analysis Brief.* April. http://www.eia.doe.gov/emeu/cabs/usa.html.

U.S. Energy Information Agency. 2004b. *Country Analyses, Mexico.* March http://www.eia.doe.gov/emeu/cabs/mexico.html.