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Issues Related to Air Quality and Health in the California-Baja California Border Region

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Abstract

A rapidly increasing population living in a diverse and dynamic region, stark differences in air quality, economic disparity, lack of harmonized data, insufficient resources or technology, and different perspectives on the quality of the environment—these are just a few of the challenges found in the California-Baja California border region. This chapter discusses a number of these challenges and proposes recommendations and solutions.

Air quality data indicate that the cities of San Diego, California, and Tijuana, Baja California, are either in attainment or close to attainment with respect to their respective national ambient standards for all regulated pollutants, despite some historical problems. In comparison, Imperial County, California, and the *municipio* of Mexicali, Baja California, experience high levels of particulate matter measuring 10 microns or less (PM_{10}) and certain toxic air

contaminants. They have seen improvements in ozone and carbon monoxide. Air pollution has health effects. Although the associations are not completely clear, a number of studies point to increased health impacts with additional contamination.

Despite the negative data in the Imperial-Mexicali area and pessimistic projections for selected pollutants, people do enjoy living in the region. People have choices about where they live and the residents of Calexico, California, and Mexicali, even though they notice the air quality is bad, place significant value on other positive local conditions. This is even more so in Calexico—comparatively, local conditions people notice every day are better in Calexico than Mexicali. This plays a significant role in the development of individuals' perspectives in the region. A corollary of that perception is that because environmental issues are not at the top of residents' concerns, it is difficult to convince governmental entities to focus the appropriate level of resources on the region's air issues.

Researchers within and outside the area have been conducting scientific and social studies to understand the complexities of the region. More such research is merited, and this chapter makes several additional recommendations, including the need for the harmonization of data, designation of binational airsheds, harmonization of vehicle inspection and maintenance programs, and coordination of policies regarding energy production. Also, to improve air quality in the California-Baja California region, resources are needed to build technological infrastructure as well as human capacity and understanding, and for programs in pollution reduction.

The principal sources of pollution in the California-Baja California border region are industry (carbon monoxide in Mexicali; sulfur dioxide in Tijuana); energy (fast food operations in Tijuana and geothermal and fossil fuel-fired power plants in Mexicali); and transportation (vehicles constitute the principal source of emissions in this region). As well, the largest contributors to particulate matter levels are unpaved roads, wind erosion of soils, burning of agricultural waste and trash, and open air grills.

Imperial County and Mexicali provide a good case study of border problems with air quality. These two communities—in violation of their respective national standards for particulate matter and ozone—have extremely high levels of respiratory problems among children.

The construction of natural gas-fired power plants in the Mexicali area exclusively to serve the California energy market has occurred and is likely to continue. These power plants are among the largest single sources of air pollution in the California-Baja California border region, and the power plants in Rosarito (natural gas) and Cerro Prieto (geothermal) are also noteworthy. In the case of the latter, the emission of hydrogen sulfide (and even carbon dioxide) is significant.

Aspectos Relacionados con la Calidad del Aire y la Salud en la Región Fronteriza de Baja California-California

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Resumen

Una población en rápido crecimiento que habita una región diversa y dinámica; diferencias austeras en la calidad del aire; disparidades económicas; falta de información homogeneizada; insuficiencia de recursos o tecnología y diferentes perspectivas sobre la calidad del medio ambiente —son sólo algunos de los retos que caracterizan a la

región fronteriza de Baja California-California—. En este apartado se discuten varios de estos retos y se proponen algunas recomendaciones y soluciones.

La información de la calidad del aire indica que las ciudades de Tijuana, Baja California y San Diego, California están en cumplimiento o casi en cumplimiento de sus respectivas normas ambientales nacionales de todos los contaminantes de regulados a pesar de algunos problemas históricos. En comparación, el Condado de Imperial, California, y el municipio de Mexicali, Baja California, padecen de altos niveles de materia particulada que mide 10 micrones o menos (PM_{10}) y de ciertos contaminantes tóxicos del aire. Se han observado mejoras en lo que respecta al ozono y al monóxido de carbono. Existen efectos a la salud debidos a la contaminación del aire. Aunque las correlaciones aún no son completamente claras, un número de estudios muestran mayores impactos a la salud debido a la contaminación del aire.

No obstante los datos negativos en el área de Mexicali e Imperial y las proyecciones pesimistas de contaminantes selectos, a los habitantes les gusta vivir en la región. La gente tiene opciones de donde vivir y aunque los residentes de Mexicali, Baja California y Caléxico, California, notan que la calidad del aire es mala, le dan un valor importante a otras condiciones locales positivas. Esto es más evidente en Caléxico: comparativamente, las condiciones que la gente nota todos lo días son mejor en Caléxico que en Mexicali. Esto tiene una influencia importante en el desarrollo de las perspectivas de las personas en la región. Un corolario de esa percepción es que debido a que los temas ambientales no se encuentran al principio de la lista de preocupaciones de los residentes, es difícil lograr que las entidades gubernamentales enfoquen el nivel apropiado de recursos en los temas del aire de la región.

Los investigadores dentro y fuera del área han estado realizando estudios científicos y sociales para entender las complejidades de la región. Se requiere más trabajo de tales investigaciones y este capítulo hace varias otras recomendaciones que incluyen la necesidad de homogeneizar la información, la designación de cuencas binacionales de aire, la armonización de los programas de inspección y mantenimiento de vehículos y una coordinación de políticas referentes a la producción de energía. Adicionalmente, para

mejorar la calidad del aire en la región de Baja California-California, se necesitan recursos para construir una infraestructura tecnológica, desarrollar capacidad humana y entendimiento y para programas relacionados a la reducción de la contaminación.

Las principales fuentes de contaminación en la región fronteriza Baja California-California son: la industria (monóxido de carbono en Mexicali, CO) (dióxido de azufre, SO_2 en Tijuana). La energía (las operaciones de comida rápida en Tijuana y las plantas de generación eléctrica geo-térmicas y de activación con combustible fósil en Mexicali) y el transporte de los vehículos constituye la fuente principal de emisiones en esta región. Asimismo, las fuentes mayores de contribución a los niveles de materia particulada, son las calles sin pavimentación, y generación por la erosión eólica de los suelos, la quema de residuos agrícolas y de basura y asaderos al aire libre.

El Condado Imperial y Mexicali proveen un buen estudio de caso de los problemas fronterizos con la calidad del aire. Ambas comunidades—las cuales están en violación de sus respectivas normas nacionales para la materia particulada y el ozono—tienen niveles sumamente elevados de problemas respiratorios en los niños.

Se ha construido en el área de Mexicali plantas de energía que usan gas natural y que son exclusivamente para atender al mercado de energía de California; es probable que esta tendencia continúe. Estas plantas se encuentran entre las fuentes individuales más grandes de contaminación del aire en la región fronteriza de Baja California-California. Las plantas de energía de Rosarito (gas natural) y de Cerro Prieto (geotermal) también tienen que ser mencionadas. En el caso de la planta de Cerro Prieto, la emisión de sulfuro de hidrógeno (e incluso de dióxido de carbono) es significativa.

Introduction

The California-Baja California border extends 220 kilometers. Two counties (Imperial in the east and San Diego in the west) are on the California side and three *municipios* (from east to west Mexicali,

Tecate, and Tijuana) are on the Baja side. It is a complex and diverse region offering its residents beaches, mountains, and a desert (much of which is below sea level).

The western part of the region is heavily populated on both the California and Baja California sides, with a population of more than 4 million in 2000. Population growth rates have slowed in San Diego, likely because of housing costs, but have been very high in Tijuana. The eastern portion of the region—the Imperial and Mexicali Valleys—is not as populated, with 1 million people in 2000, but is growing at a fairly high rate (Sweedler 2003). Table 1 shows the growth in the principal portions of the region during the 1990s.

The differences in climate, population, and economic activities contribute to dynamics within the two sub-regions that are reflected in very different air quality issues. This chapter reviews which air pollutants present problems in the sister cities of San Diego-Tijuana and Imperial-Mexicali, related health ramifications, residents' perceptions of these issues in each sub-region, and a few successes and failures that have occurred as a result of efforts to address the challenges. It is not meant to be a thorough analysis, but it does provide an overview of recent data for the region, as well as recommendations.

On the U.S. side, the U.S. Environmental Protection Agency (EPA) has delegated most responsibilities for air quality management to the states. In turn, California has established regional air pollution control districts. These districts are responsible for moni-

Table 1. Population in the California-Baja California Border Region

County/Municipio	1990	2000	Percent Change
San Diego	2,498,016	2,813,833	12.6
Tijuana	747,381	1,212,232	62.2
Imperial	109,303	142,361	30.2
Mexicali	601,938	764,902	27.1

Source: U.S. Census Bureau 1990 and 2000, and Instituto Nacional de Estadísticas, Geografía e Informática

toring and assessing air quality and for developing and implementing policies and programs to reduce air pollution pursuant to the federal Clean Air Act and the California Clean Air Act. The border region has two such districts—the San Diego County Air Pollution Control District (APCD) and the Imperial County APCD.

In Mexico, the federal Instituto Nacional de Ecología (in English National Ecology Institute), a unit within the Secretaría de Medio Ambiente y Recursos Naturales (in English Secretariat for Environment and Natural Resources) (SEMARNAT) oversees all these functions but delegates selected responsibilities to the states and *municipios*.

Standards and Monitoring

The two countries have established similar health-based ambient air quality standards for carbon monoxide, sulfur dioxide (SO_2), ozone, nitrogen dioxide, particulate matter measuring 10 microns or less in diameter (PM_{10}), PM measuring 2.5 microns or less in diameter ($PM_{2.5}$), and lead. Mexico also has standards for a broader definition of particulate matter called, in English, total suspended particulates. Table A in the front section of this monograph compares the Mexican and U.S. standards. The principal differences are that Mexico does not yet have an eight-hour ozone standard and the United States no longer has standards for total suspended particulates.

The San Diego APCD began monitoring air quality in the mid-1950s and expanded the monitoring significantly in the 1970s after the federal Clean Air Act was passed. Currently the district measures ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$), lead, and selected toxics. In Tijuana, Mexican authorities began monitoring in 1990 but started using new monitoring equipment in 1997 and currently measure ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter (PM_{10}), lead, and toxics.

The Imperial County APCD has been monitoring air quality since 1990 and currently measures ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$), lead, and toxics. In Mexicali, Mexican authorities began monitoring

in 1990 but (as in Tijuana) started using new monitoring equipment in 1997. They currently measure ozone, sulfur dioxide, nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$, the latter only at a monitor at the Universidad Autónoma de Baja California), lead, and toxics. Table 2 shows the number of sites at which the relevant jurisdictions measure the pollutants of principal concern, plus toxics.

Assessment of the Data—What and Where are the Air Quality Problems?

In addition to the U.S. standards listed in Table A, EPA has issued criteria for determining when the pattern of concentrations of a specific pollutant in a particular geographical area over a one- to three-year period (the number of times the standard is exceeded) constitutes a violation. See Table B (also near the front of this volume) for a list of these criteria. When a violation occurs, the area is designated nonattainment for that pollutant and various requirements aimed at reducing the offending pollutant or pollutants take effect.

Mexico currently does not have a similar system for official designation of areas with problems, but the EPA methodology can be applied unofficially to determine whether the concentrations of a pollutant in a Mexican municipio over a period of time would place the community in nonattainment. Data from monitors in some

Table 2. Air Quality Monitoring Stations in the California-Baja California Border Region

County/Municipio	Number of Monitoring Stations			
	Ozone	Carbon Monoxide	PM_{10}	Toxics
San Diego	9	5	6	2
Imperial	6	3	6	1
Tijuana	3	3	5	0
Rosarito	1	1	1	1
Tecate	1	1	1	0
Mexicali	3	3	5	1

Source: California Air Resources Board

Mexican *municipios*, when combined with data available about emissions from specific local sources, provide sufficient information to make such determinations.

Table 3 lists the California border cities in violation, or nonattainment, of U.S. ambient air quality standards and the border *municipios* in Baja California where available data indicate potential nonattainment.

The California Air Resources Board (CARB) recently analyzed the air quality data for several years (1997 through 2003) for California and Baja California border cities. The pollutants examined included ozone, carbon monoxide, and PM. The following subsections provide a summary of the findings (CARB 2005).

Ozone Trends

Because the U.S. eight-hour ozone standard was not in effect until after the study period, and because Mexico does not have an eight-hour standard, the CARB study looked only at the one-hour standard. Table 4 shows the number of days on which one or more monitors in the two California counties and two Baja California *municipios* registered exceedances of the one-hour standard annually from 1997 to 2003. To meet the EPA threshold for attainment, no single monitor can register more than three exceedances in any three-year period.

Table 3. Attainment Designations in California Border Counties, and Equivalent Unofficial Determinations for Baja California *Municipios*

County/ Municipio	Pollutant			
	Ozone		CO	PM_{10}
	One-hour	Eight-hour		
San Diego	Standards met	In violation	Standards met	Standards met
Tijuana	Standards met	In violation	Standards met	In violation
Imperial	In violation	In violation	In violation	In violation
Mexicali	In violation	In violation	In violation	In violation

Source: EPA 2001

Table 4. Days Exceeding the National One-hour Ozone Standard

County/ Municipio	Numbers of Days on Which the Standard was Exceeded[1]							
	1997	1998	1999	2000	2001	2002	2003	2004
Tijuana	3	0	0	1	0	0	0	1
San Diego	1	9	0	0	2	0	1	1
Mexicali	15	14	18	7	7	5	5	1
Imperial	10	5	24	5	10	3	3	0

[1] The number of days on which at least one monitor in the county or municipio measured a 1-hour average concentration greater than or equal to 125 ppm, which is the U.S. criterior.
Source: California Air Resources Board 2005

In the seven-year period covered by the analysis, 1998 was clearly a bad year for San Diego, with eight days of exceedances, but three of the other years saw no exceedances and the remaining three years saw two or three exceedances each. It is conceivable, therefore, that a continuing program of pollutant reductions could bring San Diego into attainment in relatively few years. Tijuana, meanwhile, exceeded the one-hour standard in 1997 on three different days, but in five of the six subsequent years registered no exceedances (insufficient data in 2000 precludes any statements about exceedances in that year). Using U.S. criteria, then, Tijuana would have been in attainment under the one-hour standard.

Monitors in Imperial County and Mexicali, on the other hand, have registered multiple exceedances of the U.S. one-hour ozone standard in each year shown. Looking on the bright side, the number of days of exceedances in Imperial County in 2002 and 2003 declined from previous years. The numbers of exceedances in Mexicali also declined, but in three of the last three years were higher than those in Imperial.

Carbon Monoxide Trends

Table 5 shows San Diego did not exceed the U.S. eight-hour standard for carbon monoxide during the selected time period. Tijuana has approximately three days per year that exceed the standard. Carbon monoxide levels decreased in Imperial County from 13 days of exceedances in 1999 to no days of exceedances in 2003. Mexicali, on the other hand, has had many days with exceedances each year since 1997.

PM_{10} Trends

As with the eight-hour carbon monoxide standard, San Diego did not exceed the national 24-hour standard for PM_{10} from 1997 to 2003 (Table 6). Tijuana averages three days per year with average concentrations exceeding the U.S. national standard (in the United States, an area is in nonattainment if a three-year average of the 99th percentile of concentration levels, based on 24-hour averages, exceeds the standard).

Calexico's levels of PM_{10} average approximately four exceedances per year. Monitors in Mexicali registered a peak number of exceedance days—nearly 50—in 2000 and since then have averaged well over 30 days of exceedance per year.

Table 5. Days Exceeding the National Eight-hour Carbon Monoxide Standard

County/ Municipio	Numbers of Days on Which the Standard was Exceeded[1]							
	1997	1998	1999	2000	2001	2002	2003	2004
Tijuana	2	1	2	3	1	1	0	0
San Diego	59	82	85	60	59	60	36	23
Mexicali	0	0	0	0	0	0	1	0
Imperial	10	8	11	6	6	3	0	1

[1] The number of days on which at least one monitor in the county or municipio measured a 8-hour average concentration greater than or equal to 9.5 ppm, which is the U.S. criterior.
Source: California Air Resources Board 2005

Table 6. Days Exceeding the National 24-hour PM_{10} Standard

County/ Municipio	Numbers of Days on Which the Standard was Exceeded[1]							
	1997	1998	1999	2000	2001	2002	2003	2004
Mexicali	21	23	30	49	40	34	35	46
Tijuana	3	3	5	1	2	3	1	4
San Diego County	0	0	0	0	0	0	1	0
Imperial County	4	2	5	6	3	3	4	2

[1] The number of days on which the monitor with the largest number of exceedances in that county or municipio for that year measured a 24-hour average concentration greater than 150 $\mu g/m^3$, which is the U.S criterion for attainment (see Table B).
Source: California Air Resources Board 2005

Summary of Air Quality in the California-Baja California Border

The cities of San Diego and Tijuana are either at attainment or close to attainment for the regulated pollutants. In comparison, Imperial County and the municipio of Mexicali have seen some improvements in ozone and carbon monoxide, but PM_{10} and toxic air contaminant levels are still high in Mexicali.

Pollution Sources

Industry

The use of diverse fuels in the region and energy generation and consumption is a significant source of pollutants. In Tijuana in particular, fast food operations continue to increase with few environmental controls. These activities include taco, chicken, and hamburger stands located in both residential and industrial areas. There have been a number of studies pinpointing the amount of emissions from these food stands but they have yet to be incorporated into the national emissions inventories and diagnosis.

Electricity Generation

In Mexicali, the geothermal plants of Cerro Prieto are a source of carbon dioxide, hydrogen sulfide, and methane (Comisión Federal de Electricidad 2004). In addition, there are two new thermoelectric power plants in Mexicali that contribute additional carbon monoxide, nitrogen dioxide (NO_x), and PM_{10} to the already degraded air quality in the region. Issues related to electricity generation and natural gas supply are prominent in public debate and are treated in more detail later in this chapter.

Transport

The consumption of fuels by vehicles constitutes the principal source of emissions in this region. Motor vehicles are primary sources of ozone precursors, carbon monoxide, and toxics. This source of emissions is a central issue because of population growth rates and increased vehicle use. Additional sources on the Mexican side include the large number of used vehicles (which are insufficiently maintained from an emissions perspective) and the significant use of pick-up trucks in the cross-border trade of goods. Another important factor in the transport sector is the idling that occurs in the long lines of cars, pick-up trucks, and diesel trucks at the binational ports of entry.

Area Sources

The categories of area sources contributing the most pollution, particularly PM, are unpaved roads and wind erosion of soils. This is especially true in Baja California's *municipios*, where there are many unpaved streets. Additional area sources of PM are the burning of agricultural waste and trash and open-air grills. Agricultural burning is part of the process of land preparation for new crops and is common in both the Mexicali and Imperial Valleys. Other important categories are the commercialization and distribution of fuels, such as emissions from gasoline service stations, the cleaning of surfaces in industry, and commercial and domestic use of solvents.

The Effects of Air Pollution on Health

The human body has to cope with many forms of air pollution, including those in the form of noxious gases (ozone, carbon monoxide, SO_2, and NO_x) and PM. PM includes dust, soil, mold, pollen, smoke, soot, and ash. Some PM comprises minute droplets of liquid or solids called aerosols. Toxic and cancer-causing agents can attach to PM and be breathed into the lungs. PM can range in size from visible pieces of sand to particles so small that thousands of them could fit onto the period at the end of this sentence. Most PM_{10} is trapped in the nasal passages or upper lungs, where small hairs and mucus move them out of the body. Nonetheless, PM_{10} can be inhaled farther and slip past the body's defenses.

In a study published in 1999, Reyna and Álvarez found respiratory illnesses, hospital admissions, school absences, and premature deaths are more frequent during periods of increased PM pollution. These periods of increased PM levels can exacerbate or cause lung diseases like asthma, bronchitis, and emphysema.

Recent studies indicate the smallest particles can enter the deepest parts of the lungs and remain trapped there, causing even more serious health effects for many people. After a review of more than 3,000 research studies related to PM and ozone (summarized in Sheth and Giel 2000), EPA proposed new air quality standards to regulate the smaller PM-$PM_{2.5}$.

The lungs are very sensitive to air pollution. PM can damage the lungs by inflaming or destroying the lung tissue, damaging or destroying the protective hair lining in the airways, or inflaming lung tissue and restricting air passages. Breathing becomes difficult and symptoms like coughing, wheezing, and shortness of breath occur.

Scientists are concerned about PM's effects on morbidity and mortality in the exposed population. It is estimated that in the United States alone some 64,000 premature deaths are related to PM; these represent 6.5% of the total deaths by cardio-respiratory diseases (NRDC 1996). There are a number of important key studies that show the injurious effects PM_{10} and $PM_{2.5}$ produce on the health of human beings, not only in the cardiorespiratory system but also in the cardiovascular system (Nemmar 2002, Peters 2000,

Task Force of the European Society of Cardiology 1996, and Tsuji 1996). Other studies (Peters 1997 and Brunekreef 2002) point out that the ultra-fine particles (those less than one micron in diameter) have more prejudicial effects due to their capacity to penetrate into the alveolus, which produces local inflammation that can cause changes in the cardiac rhythm and abnormalities in the blood coagulation.

A study conducted by the U.S. Health Effects Institute (HEI) in 90 U.S. cities provides evidence that with every increase of 10 micrograms per cubic meter ($\mu g/m^3$) in PM_{10} concentration, hospitalizations for cardiovascular diseases increase by 1% and cardiopulmonary illnesses increase by 2% (HEI No Date). Other meta-analysis studies suggest that the same increment of PM_{10} concentration (i.e., 10 $\mu g/m^3$) is associated with a 2% increase in deaths due to respiratory problems, a 2.5% increase in hospitalizations for cardiopulmonary obstructive diseases, and a 3% increase in symptoms of asthma and upper respiratory tract infections (Pope 1999).

Like the majority of sister-city pairs in the U.S.-Mexican border region, Mexicali and Calexico form a zone with notable economic dynamism derived from industry, commerce, agriculture, and on a smaller scale, tourism. Despite the benefits of this dynamism and growth, however, the capacity of local governments to carry out programs related to public and environmental health, management of solid waste, environmental education, and other efforts to protect environmental quality has not increased proportionately to the challenges (Canales 1999).

SEMARNAT recently noted that Mexicali is the second-most contaminated Mexican city for PM_{10}, and that the concentrations of carbon monoxide and ozone in the municipio are also consistently above the national standards (Instituto Nacional de Ecología 1998). There is added concern in the Mexicali-Imperial binational population that the two new thermoelectric plants recently constructed in Mexicali (the Sempra and Intergen plants) will further aggravate air quality (Cornejo 2002a and Cornejo 2002b).

Serious health issues have been identified in the region, particularly respiratory system and heart illnesses, according to Instituto de Servicios de Salud Publica. English, et al. (1998) reported on a comparative study of San Diego and Imperial Counties that found

Imperial County has the highest rate of asthma hospitalizations in California for those younger than 14 years old. Additionally, Imperial registered an increase in asthma hospitalizations of 59% from 1983 to 1994, compared to 9% for San Diego. Secretaría de Salud reported that in 1991 in Mexicali for every 10,000 inhabitants under 14 years of age there were 5,740 cases of acute respiratory infection (ARI), and in 2000 that rate increased to 9,688—an increase of 69%.

Regionally, a number of preliminary studies have explored the relationship between air quality and respiratory health (Osornio 1991, Reyna Carranza 2003, Reyna Carranza 2004, Collins 2001, and Collins 2003). To further the understanding of the relationships between air contaminants and diseases due to respiratory disorders, Universidad Autónoma de Baja California has developed a Poisson model for each of the three main morbidity variables—asthma, pneumonia, and ARI—and is preparing a study for publication.

In this study, time series data for the respiratory diseases have been used as response variables. The weather time series (temperature, relative humidity, and quadratic effects of weather), seasonality components, population growth, and the exceedances (days on which air pollutants surpassed the air quality standards) were used as confounding variables. Ambient concentrations of ozone, PM_{10}, and carbon monoxide were included as predictor variables, first individually and then in the three paired combinations of those pollutants. Using Akaike's information criterion (AIC), variables were selected as significant with a p-value $< \alpha$. Finally, the study calculated the percent changes of new cases for each respiratory disease in response to increments of one standard deviation per pollutant. For example, it was estimated that the number of asthma cases increases 7.31% with a confidence interval of 4.31% to 10.39% when the ozone concentration increases one standard deviation (0.0089 parts per million). The estimated increase in cases of each of the diseases, analyzed by pollutant, is shown in Table 7.

Table 7. Mean and 95% Confidence Interval of Increases in the Incidence of Asthma, Pneumonia, and ARI with Increases in Pollutant Concentrations by One Standard Deviation in the California Border Region

Category of Morbidity	Effect of Increase in Concentration by One Standard Deviation					
	Ozone		PM_{10}		CO	
	Δ%	CI%	Δ%	CI%	Δ%	CI%
Asthma	7.31	4.31, 10.39	1.88	0.22, 3.57	2.30	0.06, 4.60
Pneumonia	6.34	2.66, 10.16	5.74	2.91, 8.66	7.49	3.20, 11.97
ARI	2.31	1.93, 2.69	0.40	0.12, 0.69	3.47	2.97, 3.97

ARI = acute repiratory infection
Δ = change in incidence
CI = confidence interval
Source: Universidad Autónoma de Baja California

Perceptions of Air Quality in the Calexico-Mexicali Region

Air quality experts and environmental and public health advocates have stressed the need for governments to resolve air quality problems in the region. But for such efforts to be successful, residents of the affected areas need to believe a problem exists and then participate in the process of developing and implementing programs to solve it.

In the late winter and spring of 2004–2005, San Diego State University-Imperial Valley Campus conducted a survey of perceptions of Calexico and Mexicali residents. Sixty-five heads of household that were designated as middle-class and/or professional were surveyed for between one to two hours each. These surveys included questions regarding their family, education, transportation, sources of news and information, activities, and opinions on various issues. The data were inputted into SPSS (a statistical analysis software) and cross-tabulated. Tables 6 through 14 provide a summary of these results.

As seen in Table 8a, more than half the total residents interviewed had lived their entire lives in the region. This result, however, was significantly skewed by the Mexicali data. In Mexicali, the percentage was approximately 69% (31 of 45), whereas in Calexico it was only 25% (five of 20). Additionally remarkable is the difference between the two cities with respect to the time those interviewees who were not natives had lived locally (see Table 8b). Of the 15 in the Mexicali sample who were born elsewhere, at least nine (four did not answer this question) had lived locally for 10 or more years. Of the 14 interviewees in Calexico who were born elsewhere, only five had lived there for 10 years or more. The data from the survey, therefore, implied that the population subset that was sampled in Mexicali was much more likely to comprise long-term local residents than their counterparts in Calexico (despite the fact that Mexicali and Imperial County had similar overall population growth rates in the 1990s, as shown in Table 1).

Table 8a. Heads of Households Native to City/*Municipio* (Sample Size: 65)

Category	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
Lived entire life in city	5	25.0%	31	68.9%	36	55.4%
Born elsewhere	15	75.0%	14	31.1%	29	44.6%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 8b. Duration of Local Residence of Non-Natives (Sample Size: 29)

Length of Time in Local Area	Number of Households		
	Calexico	Mexicali	Total
Total sample	15	14	29
Less than 1 year	0	1	1
Between 1 and 2 years	1	0	1
Between 2 and 3 years	2	0	2
Between 3 and 4 years	2	0	2
Between 4 and 10 years	5	0	5
More than 10 years	5	9	14
Not answered	0	4	4

Source: California Center for Border and Regional Economic Studies, San Diego State University

As shown in Table 9, a majority of the interviewees in both cities indicated they do not ride public transportation. Considering their socioeconomic circumstances, this is not surprising.

Table 9. Households that Use Public Transportation

Use of Public Transportation	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
Do use	3	15.0%	12	26.7%	15	23.1%
Do not use	17	85.0%	33	73.3%	50	76.9%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

When asked what they liked about living in their respective cities (see Tables 10 and 11), more than three-fourths of the respondents in Calexico noted the peacefulness or sense of security. No single aspect drew a majority response in Mexicali, but the top three were the people, the city, and the peacefulness/security. When asked what they disliked (see Tables 12 and 13), Calexico interviewees most often (25% of them) said "nothing." The second and third most mentioned items in Calexico were traffic and pollution (20% mentioned each). Mexicali's respondents' top three items were the heat (38%), dust (31%), and pollution (27%).

Table 10. What Do You Like about Living in Calexico, California?

Attribute	Number of Times Mentioned	Percentage of Respondents
Peacefulness/aecurity	15	78.9%
Open apace	5	26.3%
City	3	15.8%
People	2	10.5%
Atmosphere	1	5.3%
Family lives here	1	5.3%
Job is here	1	5.3%
Border	1	5.3%
Did not answer	1	5.3%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 11. What Do You Like about Living in Mexicali, Baja California?

Attribute	Number of Times Mentioned	Percentage of Respondents
People	22	48.9%
City	20	44.4%
Peacefulness/security	15	33.3%
Atmosphere	13	28.9%
Border	10	22.2%
Family lives here	9	20.0%
Job is here	8	17.8%
Open space	5	11.1%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 12. What Do You Dislike about Living in Calexico, California?

Attribute	Number of Times Mentioned	Percentage of Respondents
Heat	17	37.8%
Dust	14	31.1%
Pollution	12	26.7%
Planning for growth	8	17.8%
Traffic	7	15.6%
Crime	7	15.6%
No economic growth	3	6.7%
People	3	6.7%
Poverty areas	3	6.7%
Recreation	2	4.4%
Drug addiction	2	4.4%
Nothing	1	2.2%
School system	1	2.2%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 13. What Do You Dislike about Living in Mexicali, Baja California?

Attribute	Number of Times Mentioned	Percentage of Respondents
Heat	17	37.8%
Dust	14	31.1%
Pollution	12	26.7%
Planning for growth	8	17.8%
Traffic	7	15.6%
Crime	7	15.6%
No economic growth	3	6.7%
People	3	6.7%
Poverty areas	3	6.7%
Recreation	2	4.4%
Drug addiction	2	4.4%
Nothing	1	2.2%
School system	1	2.2%

Source: California Center for Border and Regional Economic Studies, San Diego State University

When asked if they crossed the border to visit the other side (see Table 14), 95% in both Calexico and Mexicali indicated they did. A follow-up question asked if they noticed any environmental differences between the two cities (Table 15). Seventy percent of the total respondents stated there were more problems in Mexicali. Approximately 25% thought both cities have about the same problems. The remaining 5% did not answer or did not have an opinion.

Table 14. Number of Respondents Who Cross the Border to Visit the Sister City

Crossing Status	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
Cross	19	95.0%	43	95.6%	62	95.4%
Do not cross	1	5.0%	2	4.4%	3	4.6%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 15. Perception of Environmental Differences between Mexicali and Calexico

Perception	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
There are more problems in Mexicali	15	75.0%	31	68.9%	46	70.8%
Both cities have the same problems	4	20.0%	12	26.7%	16	24.6%
No answer/ without opinion	1	5.0%	2	4.4%	3	4.6%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Finally, interviewees were asked what they worried about most for the future of their children (see Table 16). The majority of the residents from Mexicali (more than 51%) indicated something about the environment or the future health of their children related to the environment. The second highest response in Mexicali was safety and security. For Calexico, 45% were worried about the future of the economy and/or ability to obtain a job in the community. For responses collectively termed "other," most related to education, which tied for second place in Calexico with safety and security. "Other" responses in Mexicali included concerns about education, cultural development, and the influence of drugs on society.

The results of this questionnaire provide insight into the communities of Calexico and Mexicali. Migration probably plays an important role in the perceptions of the residents of Calexico because many are relatively new to the city. This is supported by 2000 U.S. Census data, which indicate more than 50 percent of that city's residents are foreign born, with approximately 88% of those coming from Mexico. Therefore, many of these individuals bring with them the perceptions of where they had lived before and compare that to their present circumstance. This could be one reason why the perceptions of the environment and of the living standards in Calexico are relatively good. In Mexicali, on the other hand, there is a much stronger perception that environmental problems exist, especially with regard to air quality. This qualitative survey is rich in information and will continue to be analyzed to understand the perceptions of local residents.

Research, Ongoing Issues, and Projects with Promise

To better understand the complexities of air quality in the region, a number of studies have been and are being conducted. Table 17 is not comprehensive but is illustrative of the analyses completed or currently underway in the region (and the institutions responsible for them).

Table 16. What Do You Worry about for the Future of Your Children?

Category of Worry	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
Environmental quality/health	2	10.0%	23	51.1%	25	38.5%
Economy/jobs	9	45.0%	3	6.7%	12	18.5%
No answer/ without opinion	4	20.0%	10	22.2%	14	21.5%
Other	4	20.0%	7	15.6%	11	16.9%
None	1	5.0%	1	2.2%	2	3.1%
Missing	0	0.0%	1	2.2%	1	1.5%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 17. Air Quality Studies Completed or Underway in the California-Baja California Region

Title of Study	Lead Institution	Date Completed
"Development of a Pollen Map for Mexicali"	Universidad Autónoma be Baja California (UABC), Mexicali	Underway
"A Poisson Regression Analysis of the Principal Respiratory Diseases and the Air Pollutants that Exceed the Air Quality Standards in Mexicali and Imperial"	UABC, Mexicali	Underway
"Program to Model and Monitor the Air Quality in Mexicali and the Imperial Valley"	Instituto Tecnológico de Estudios Superiores de Monterrey (ITESM)	Underway
"Understanding the Environmental Culture and Sustainable Behavior in the Mexicali-Calexico Region: Developing Environmental Education Products to Improve Air Quality"	The California Center for Border and Regional Economic Studies (CCBRES), San Diego State University-Imperial Valley Campus (SDSU-IV)	Underway
"Sustainable and Renewable Energy Resources for the U.S.-Mexico Border Region: Focus on the California-Baja California Border Region"	San Diego State University	2004
"Assessment of Perceptual and Objective Quality of Life Indicators in Calexico-Mexicali: Towards a Longitudinal Database for the U.S.-Mexico Border Region"	CCBRES, SDSU-IV	Underway
"Imperial Valley/Mexicali Cross Border PM_{10} Transport Study Report"	Desert Research Institute, J.C. Chow and J.G. Watson, University and Community College System of Nevada	1995

Table 17. continued

Title of Study	Lead Institution	Date Completed
"Programa para mejorar la Calidad del Aire, Mexicali, 2000-2005"	Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), Gobierno del Estado de Baja California, Gobierno Municipal de Mexicali, Delegación Estatal de SEMARNAT en Baja California, Secretaría de Salud	2000
"Programa para mejorar la Calidad del Aire, Tijuana-Rosarito, 2000-2005"	SEMARNAT, Gobierno del Estado de Baja California, Gobierno Municipal de Tijuana, Instituto Municipal de Planeación, Gobierno Municipal Playas de Rosarito, Delegación Estatal de SEMARNAT en Baja California	2000
"Analyzing the Association of PM_{10} with Respiratory Diseases in the Populations of Mexicali, B.C. and Imperial County, CA.: A Time Series Study"	CCBRES, SDSU-IV, and UABC, Mexicali	2003
"Particulate Matter Emissions from Agricultural Burns in Mexicali/Imperial Valley Region"	University of Utah, CCBRES, SDSU-IV, and UABC, Mexicali	2003
"Understanding Quality of Life in U.S.-Mexican Border Region: A Case Study of Imperial Valley-Mexicali"	CCBRES, SDSU-IV, and UABC	2003
"Contributions of Organic Compound Pollutants to Ozone and Fine Particulate Matter in Mexicali"	Arizona State University and ITESM	2005

Source: Author

Issues Related to Capacity and Data

Although a number of studies have been undertaken, there is still a lack of quality-assured data, laboratory equipment, and training. Additionally, there is a lack of human capital; only a handful of people are working on air quality in the region. Most importantly, air quality projects are done "on the cheap." Funding is insufficient to explore adequately how to improve air quality, especially in the Imperial Valley and Mexicali.

One of the largest deficiencies is the lack of data that can be statistically validated and that are in a format comparable to data from the other side of the border. This is especially true for health-related data. If analysts and the public are to have a useful understanding of the relationship between air contaminants and respiratory illnesses, there must be similar and comparable sources of reliable data on the health of individuals living in the border region. From the data that do exist, some correlations have been developed, but these are not optimal. The next section discusses in further detail the known relationships between air quality and respiratory health.

Additional information also is needed on the source identification and quantification, as well as on the atmospheric chemistry that produces the particular ambient concentrations measured, especially with regard to ozone. Researchers are currently engaged on these topics to a greater degree in Mexicali and Imperial than in the other urban areas of the region.

Despite their best intentions, local researchers and grant-making institutions such as the Southwest Consortium for Environmental Research and Policy (SCERP) and Academic and Professional Programs for the Americas (LASPAU) are limited by deficiencies in local infrastructure and in agreements to standardize or establish binational procedures in the normalization of data collection. This is especially true for quality-assured binational clinical data, although there are also issues regarding the binational air pollution data. Without a strong, reliable source of data, research in the region is difficult. The following two subsections identify local challenges to conducting epidemiological and ecological studies about the relationship between pollution and health effects.

Air Pollution Issues

Deficiencies exist with respect to both the infrastructure and the available data. With regard to infrastructure, there are problems in three categories. First, there is insufficient equipment for monitoring air pollution and meteorological variables. Second, there is lack of capacity to examine and validate the atmospheric information produced and collected by non-local institutions. Third, there is a problem with accessing materials and equipment that would allow for better experimental designs and quality assurance of samples—for example, a certified air laboratory with capacity for equipment calibration and material conditioning under the appropriate norms.

The data that are available from official institutions fall short in at least two ways. One is that hourly information sometimes cannot be obtained, which makes it difficult to carry out experiments and analysis at a lower resolution. A second problem is that information from some environmental monitoring stations is missing and others have irregularities in their registers; this situation limits geographic sector research, which is particularly problematic in a binational region.

Health Issues

For health data to be optimally useful, more extensive and intensive information needs to be collected. First, it would be helpful to standardize the collection of data on cardiorespiratory and cardiovascular diseases in the border region. These diseases have a documented relationship to air pollution. In Mexico, for example, new case records of mortality and morbidity are reported on a weekly basis. In order to conduct an analysis at a finer resolution, it would be helpful to have a record of mortality and morbidity counts by the hour, or at least on a daily basis. Another inconsistency between the United States and Mexico is that bronchitis is registered by Mexican doctors within the broad disease category ARI. In the United States, respiratory illnesses are categorized separately, though there are some issues in the diagnosis.

Secondly, critical contextual information related to disease diagnoses needs to be recorded and reported. In Mexico, new cases of mortality and/or morbidity only include the disease diagnosis; demographic and geographic aspects of the patient are not recorded. This lack of data makes it difficult to correlate other factors such as location, gender, and age.

If these challenges are not addressed, it will be nearly impossible to carry out projects in this binational region equal in sophistication and usefulness to those being conducted elsewhere. For example, since the 1980s a European project titled *Air Pollution and Health–A European Approach* (APHEA) (Katzouyanni 1997) has studied the short-term effects of air pollution on health in a number of countries in that region. A second and more recent European project titled *Estudio Multicéntrico Español sobre la Relación entre Contaminación Atmosférica y Mortalidad* (in English the *Spanish Multicenter Study on the Relationship Between Atmospheric Pollution and Mortality*) began in 1997. The title was changed in 2000 to the Spanish equivalent of the *Spanish Multicentric Study on the Relationship Between Atmospheric Pollution and Health*. (RedIRIS 2006) when the number of hospitalizations was added to the mortality data. Similarly, researchers in the United States have developed comparable projects such as the National Morbidity, Mortality and Air Pollution Study (Samet 2000).

For the border region, it would be extremely helpful to reach a binational agreement that permits projects of this magnitude. There is a need for projects that analyze both sides of the border and that generate results with a high level of confidence. Such projects are needed not only on the subject of the health effects of air pollution, but also regarding water and soil contamination. Only this approach will produce an understanding of how pollution affects human health that can adequately inform policymakers as they grapple with the challenge of designing effective policies and programs.

Projects Under Way

In response to the recognition that large amounts of PM were being generated from unpaved roads in Baja California, the Direccíon de Ecología Estatal de Baja California worked with SEMARNAT and

the North American Development Bank (NADB) to secure funding for road paving. In 2003 this project received the necessary certification from the Border Environment Cooperation Commission and then partial financing from NADB for the purpose of improving the health of the local residents. A NADB press release described the program as follows (NADB 2003):

> PIPCA [Programa Integral de Pavimentación y Calidad del Aire, in English the Air Quality Improvement and Street Paving Program] is a multiphase program aimed at paving 14.9 million [square meters] m^2 (equivalent to about 926 miles) of street surface area in the municipalities of Tijuana, Mexicali, Ensenada, Tecate and Playas de Rosarito over a four and a half year period ending in December 2007. Full implementation of the project is expected to increase the pavement coverage of all urban streets in the state from around 59% to 80%.

The first phase of PIPCA will pave an estimated 2.3 million m^2 of streets in the five communities over an 18-month period:

- Tijuana: 1,003,000 m^2
- Mexicali: 484,000 m^2
- Ensenada: 352,000 m^2
- Rosarito: 345,000 m^2
- Tecate: 124,000 m^2

Subsequent to the financing, Baja California Governor Eugenio Elorduy declared in his Third Report of Government that a total of 812,060 m^2 had been paved from October 2003 to September 2004, representing an investment of 191,458,000 pesos (approximately $19 million) (Elorduy 2004). Of this total amount, Mexicali accounted for 48.7 million pesos (approximately $4.5 million) and for a paved surface area of 111,634 m^2.

In 1996 Mexicali had unpaved streets covering an area of 7.79 million m^2, equivalent to 38% of the total urban surface. Paving of those streets did not begin until late 2003 (after NADB financing was approved), which could help explain why the PM_{10} levels were

not falling appreciably over time, as seen in Table 6. The first year of the program reduced the unpaved surface area in Mexicali by just 0.54%.

At least two pollution-reduction programs have been implemented across the border in the Imperial Valley. The Emission Reduction Program for Agricultural Burning consists of giving a certificate to farmers who agree not to burn their agricultural residues. Those farmers can then sell the certificate to stationary plants in the Imperial Valley who need to reduce their emissions.

The Carl Moyer Memorial Air Quality Standards Attainment Program (applicable statewide in California and initiated in 1998), provides grants to reduce exhaust emissions from heavy-duty diesel engines. Funding is available for projects to replace diesel engines with new, cleaner engines within existing equipment; to retrofit existing diesel engines with emission control devices; and to purchase new vehicles or equipment with emissions below applicable state and federal standards. In Imperial County in 2005 this program invested $100,000, and for 2006 the figure is $356,000 (the latter includes a $100,000 match by the county) (California Air Resources Board 2004).

In San Diego, financial incentive programs augment traditional control programs to further encourage technology development and provide cost-effective emission reductions not easily achieved by regulations. Eight incentive programs have been implemented in San Diego County in recent years (San Diego County Air Pollution Control District 2004):

- Carl Moyer Program
- Vehicle Registration Fund Program
- Lower Emission School Bus Replacement and Retrofit Program
- Emission Reduction Credit Bank For Peaking Powerplants Program
- Heavy-Duty Diesel Vehicle Retrofit Program
- Back up Generator Mitigation Funds Program
- Congestion Mitigation and Air Quality Improvement Program
- Lawnmower Exchange Program

In addition, the San Diego/Tijuana Clean Diesel Demonstration Project, partially funded by EPA under the Border 2012 Program, focuses on diesel emission reduction technologies for Mexican heavy-duty trucks. It will be implemented in two phases: diesel oxidation catalysis (≥25% PM reduction) and diesel particulate filters (≥85% PM reduction, which requires ultra low sulfur diesel).

Electricity and Natural Gas Issues

The California-Baja California border region has become a focal point for the development of energy infrastructure in the aftermath of the deregulation of power markets in the United States and the liberalization of energy supply in Mexico. Baja California is viewed by proponents of international power and liquefied natural gas (LNG) as an excellent site for projects destined to serve the California market. Such development has significant implications for air quality, as explained in more detail below. In response, strong grassroots movements questioning the strategic need for this infrastructure and demanding higher environmental standards for projects have developed on both sides of the border. These groups have recommended, as an alternative, an accelerated commitment to energy efficiency and renewables in the region, combined with a gradually declining use of domestic natural gas that provides for future growth in energy demand without further compromising regional air quality.

Power Plants

Reducing the generation of NO_x, a precursor in ozone formation, is necessary to solve important aspects of the air quality problems in the California-Baja California border region. One source of NOx is electricity generation using fossil fuels. Reduction must come from both retrofitting existing plants and from minimizing the emissions of new plants. Citizen activism and resulting governmental pressure have enjoyed some recent successes in this regard.

As of 2005, there were 13 major power generation units (nine utility boilers and four gas turbines) located either in San Diego County or exclusively exporting from Mexicali to the California

power market via San Diego County. Only five of them (three utility boilers and two gas turbines) would be equipped with advanced catalytic NO_x control systems had it not been for direct, vocal, and relentless community pressure. Now all 13 plants have the technology.

In the case of the 1,000 megawatt (MW) Encina Power Plant in Carlsbad (in northern San Diego County), the city and local citizens applied sufficient pressure on regulators to ensure all five of the plant's utility boilers were retrofitted with advanced NO_x controls between 2001 and 2003.

Mexicali is the site of two new 600 MW gas turbine combined-cycle power plants owned by Sempra Energy and InterGen, respectively (the plants began exporting power to California in mid-2003). As pointed out earlier in this chapter, neighboring Imperial County is a nonattainment area for ozone and Mexicali's ambient concentrations would lead to a similar designation if Mexico had a system for such determinations. Existing data indicate a high level of pulmonary disease in the area.

Sempra's stated purpose for constructing the export plant in Mexico is "availability of low-cost labor, avoiding some of the stringent environmental rules for new U.S. facilities, and permitting for a new plant takes only 6 to 8 months compared to much longer periods to gain approvals for U.S. projects" (Gas Turbine World 2004). An additional economic reason is that Mexico does not have "offset" requirements—the United States requires that owners of a new emissions-generating facility in an area with pollution problems pay for an equal or greater reduction of emissions in that area.

The Presidential Permits issued by the U.S. Department of Energy (DOE) that are necessary to import power from these two plants to the United States were revoked in May 2003 by a federal court. The court ruled DOE conducted an inadequate environmental assessment prior to issuing the permits. The case is still in progress. A major issue in the case is the need for emission offsets in the shared airshed.

Beyond the issue of offsets, InterGen had not originally planned to install any advanced NO_x controls on the four turbines at its Mexicali plant. After receiving considerable pressure from citizens and government agencies in Imperial County, the company agreed to

install the technology on the two turbines generating electricity for export. Later, responding to pressure from Senator Diane Feinstein and Congressman Duncan Hunter, InterGen also volunteered to install such controls on the remaining two turbines at the plant, which serve the Mexican domestic market. InterGen recently completed these installations, but is attempting to pass on the cost to Mexico's Comisión Federal de Electricidad (CFE). This issue is currently before an international arbitration tribunal in Paris. Congressman Bob Filner (representing part of San Diego County and all of Imperial County) attempted unsuccessfully to amend the energy bill before Congress in 2005 to require that any power plant exporting power to the United States with 25 miles of the border meet all requirements of the adjacent U.S. air district.

Transmission Lines

Although the two Mexicali plants have a combined capacity of 1,200 MW, the two transmission lines connecting the Mexicali export plants to the Imperial Valley are each capable of carrying up to 1,200 MW. There is concern in both the Imperial Valley and Mexicali that additional export plants will be built in Mexicali to take advantage of the transmission capacity.

However, the only outlet for this power at present is San Diego, using the 500 kilovolt (kV) transmission trunkline known as the Southwest Power Link (SWPL) that connects power plants in western Arizona (Palo Verde) with San Diego. On peak demand days, SWPL operates near its 2,800 MW carrying capacity, limiting the additional amount of power that can be exported from Mexico. There are also two existing 230 kV lines in Mexico that run parallel to the border, but these lines are currently limited to 800 MW of capacity and would have to be upgraded to serve as a viable alternative to the SWPL for the export plants.

Currently, San Diego Gas & Electric (SDGE) is in the initial stages of proposing a greenfield 500 kV transmission line that would run from the Imperial Valley to the Southern California Edison (SCE) system via the San Diego County backcountry. This line

would allow the export plants in Mexicali to reach a wider market, as well as offer a pathway for exploiting wind energy potential straddling the border in eastern San Diego County.

The 500 kV line proposed by SDGE follows the "wholesale electricity markets" concept of long-range transport of electricity to allow electricity consumers access to least-cost generation (in theory). A greenfield 500 kV line between the SCE system and western Arizona power plants was recently approved at an estimated cost of $700 million. Presumably the other greenfield 500 kV line proposed by SDGE would also cost in the range of $700 million when fully interconnected with the SCE system.

The San Diego area was especially hard-hit by the economic chaos caused by California's 2000–2001 electricity crisis. The response of the San Diego political, business, and public-interest community was to develop a strategic energy plan to minimize the possibility of that experience repeating itself. The product of this multi-year effort was the *San Diego Regional Energy Strategy 2030*, published in July 2003 (Regional Energy Policy Advisory Committee 2003). This blueprint emphasizes local control of power assets, accelerated development of renewable energy in the San Diego region, and inclusive planning in energy matters. It offers a sharply different vision of the future than the wholesale power markets' vision, with its emphasis on transmission superhighways. The *San Diego Regional Energy Strategy* suggests a "local control" alternative to the proposed greenfield 500 kV line. It proposes upgrading the two 230 kV lines in Mexico from 800 MW to 2,000 MW to assure the reliability of access to the two export plants in Mexicali. Those two plants would be incorporated into the SDGE system.

CFE projects it will construct 1,000 MW of additional baseload (combined-cycle) power plants in Baja California over the next 10 years, in 250 MW increments, as well as 500 MW of simple-cycle peaking plants (Moya 2004). At present, it appears these projects will be built near the principal demand centers of Tijuana and Mexicali, thus minimizing the amount of additional transmission capacity needed.

Liquefied Natural Gas Terminals in Baja California

The initial rush of liquefied natural gas proposals on the West Coast was focused on Baja California, where six LNG terminal proposals were active in 2002. Community opposition derailed two proposals, the El Paso/ConocoPhillips proposal in Rosarito and the Marathon proposal in Playas de Tijuana. Two projects were consolidated into one—the Sempra/Shell Costa Azul LNG terminal. The two additional active LNG terminal proposals in Baja California are the ChevronTexaco offshore artificial island project just below the border, and the Terminales y Almacenes Marítimos de México, SA de CV (TAMMSA) floating offshore project near Rosarito.

The design baseload throughput of one LNG terminal is 1 billion cubic feet per day. Sempra has claimed it will supply half its LNG throughput to Baja California at startup in 2008 and all throughput to Baja by 2015 (Sempra 2004). ChevronTexaco has stated it will supply 70% of its throughput to Baja California at startup in 2008. But the current natural gas demand in Baja California (currently supplied from the United States) is only 85 million cubic feet per day (Moya 2004) and CFE's projections have led it to commit to purchase an average of 130 million cubic feet per day from the Sempra/Shell Costa Azul LNG terminal. This is the only contract announced by the project developers to date. It is unclear, therefore, who the customers are that would comprise the Baja demand projected by Sempra and ChevronTexaco. A more likely scenario is that 90% of the LNG throughput of the Sempra/Shell LNG terminal and 100% of the ChevronTexaco LNG terminal will go to California if these projects are built.

The LNG terminals in Baja California have been controversial because of the risk posed to surrounding populations, the marine impacts of seawater regasification, and incompatible land use. LNG terminals also have the potential to be major sources of air pollution. For example, a ChevronTexaco facility identical to the Baja California proposal but proposed for the Gulf of Mexico has listed potential NO_x emissions of approximately 1,000 tons per year (U.S. Coast Guard 2003). The ChevronTexaco Baja terminal will be approximately 20 miles from downtown San Diego.

The San Diego region and Baja California currently receive all their natural gas from U.S. domestic sources. DOE estimates the United States has at least 60 years of natural gas reserves using existing technology. However, it appears that major oil companies and the federal government are now working against small- and medium-sized independent producers to ensure domestic gas production does not derail LNG import schemes. Multinational oil companies are no longer big players in domestic exploration and production. The DOE announced in February 2005 it was terminating all funding for research and development activities related to oil and natural gas. Independent producers are too small to carry out their own research and development.

The problem for multinational oil companies eager to enter the LNG import business in Baja California is that LNG does not appear to be economically feasible on the West Coast in a rational natural gas market. The average production cost of domestic gas resources is well under $3 per million British thermal units (MMBtu). The cost to land LNG on the West Coast is at least $3.50/MMBtu and potentially more than $4/MMBtu. The current high natural gas prices mask the relative uncompetitiveness of LNG on the West Coast. Natural gas prices have been increasing despite good balance between supply and demand, increasing production, higher rig counts, robust storage, and relatively flat demand. This indicates a flawed market, not domestic gas shortages or permanently high domestic gas prices. If the principal flaws are resolved in the short term—a terrorism (fear) surcharge, trading dominated by speculators, and associated market volatility—LNG will be much less attractive as a substitute for domestic natural gas.

The big-picture view on domestic natural gas and LNG articulated in a technical assessment recently featured in the Natural Gas Intelligence e-newsletter is instructive (Choukas-Bradley 2005):

> We do not see the level of increased domestic production activity from the international majors and certain large North American independents that we would expect to see in a rational, competitive marketplace at current gas prices. The flight overseas of dollars earned by producers from domestic gas prices realized since 2000 … effectively means that the American consuming public is financing

> international projects ... the multinationals appear to be taking the "windfall" profits from high domestic gas prices to invest in overseas projects largely owned by foreign national oil companies (willing to accept as little as $0.50/MMBtu for stranded gas) that they believe offer better investment opportunities ... Such activity, in turn, helps to support the continued high level of domestic gas prices by resulting in a reduced level of domestic production ... In addition, such producers have made a major commitment to the exploitation and importation of LNG to the domestic market in order to capture the benefits of enhanced investment returns in foreign projects, particularly those that are largely dependent on the greater domestic prices, and at the same time have succeeded in selling that program as the domestic market's savior.

The California Public Utilities Commission (CPUC) also made a key decision in favor of LNG imports in September 2004. While highlighting the need to promote natural gas supply diversity to ensure reliability of supply to California, state regulators inexplicably authorized Southern California Gas Company and SDGE (both owned by Sempra) to terminate 1.4 billion cubic feet per day of existing natural gas capacity contracts with two of the four North American natural gas supply basins serving California; 1.4 billion cubic feet per day is sufficient baseload throughput for nearly one-and-a-half LNG terminals. Natural gas supply companies warned against this action as being contrary to the stated purpose of ensuring reliability of supply. This step artificially creates a market for new natural gas supplies in California, even though California's natural gas demand has declined nearly 20% since 2001. The fact that CPUC felt compelled to create an artificial market for LNG underscores the unfavorable economics of importing LNG to the West Coast (in a competitive natural gas market). This CPUC decision is under appeal.

The Best Answer—Energy Efficiency/ Renewables/Domestic Natural Gas

California's May 2003 Energy Action Plan explicitly prioritizes energy efficiency and renewable sources over increased dependence on natural gas. Other border governors, responding to California Governor Arnold Schwarzenegger's call, have officially declared their commitment to maximize the use of energy efficiency and renewable energy in the border region. Reaching the ambitious renewable and efficiency targets would have a dramatic effect on natural gas demand. The California Energy Commission is assisting in implementing a legislative mandate to achieve a 20% penetration by renewables by 2020.

Conclusions and Recommendations

The California-Baja California border region is dynamic and complex, with a significant concentration of population in San Diego-Tijuana and a secondary concentration in Calexico-Mexicali. It is difficult to characterize the entire region uniformly because there are such large differences in climate and other environmental conditions and economic activities. But each of those two population centers comprises a pair of sister cities that form a common airshed. The counties and municipalities, with appropriate cooperation from their respective state and national governments, need to work together to overcome the challenges and improve the quality of life throughout the region.

This final section summarizes a set of recommendations stated or implied in the more detailed analysis above.

Generation, Availability, and Comparability of Data and Other Information

- Establish common formats for monitoring and reporting air emissions in the border region; this will make the data more compatible across the border and more accessible to a broader audience, particularly state and local governments

- Identify, collect, coordinate, and disseminate several types of air quality and public health information

Policies and Programs (general)

- Help policymakers identify and focus on air quality reduction programs for pollutants and sources that pose the greatest public health risk
- Encourage the adoption of a single-airshed approach to each of the sister-city pairs
- Encourage greater harmonization of regulatory frameworks between the United States and Mexico
- Implement public health and air toxics reduction projects for well known problems (such as reduction of PM or characterization of pollen in the border region to prevent allergies) rather than develop additional metrics
- Establish contingency plans in the case of high pollutant events in collaboration with various government institutions in order to protect the community
- Involve academic institutions in air quality research

Clean, Efficient Transport

- Harmonize vehicle inspection and maintenance programs
- Establish a binational vehicle registry to track used vehicle importation into Mexico
- Develop diesel emissions control and mitigation programs for mobile sources and non-road diesel engines

Clean, Efficient Energy Generation, Transmission, and Use

- Coordinate and advocate for efforts to strengthen and harmonize the regulatory framework regarding energy efficiency, including standardizing requirements for energy generation plants within the border region

- Analyze and highlight differences and opportunities on each side of the border for improving air quality through the permitting of stationary sources
- Develop the infrastructure on the Mexican side for more natural gas use in the community and the industry (if the natural gas market prices do not rise too high)

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