The Potential **Environmental** and **Economic** Benefits of **Renewable Energy** Development in the U.S.-Mexico Border Region

December 2011

14 | Fourteenth Report of the Good Neighbor Environmental Board to the President and Congress of the United States

GNEB
Environmental Advisors Across Borders

RENEWABLENERGY

About the Board

The Good Neighbor Environmental Board was created in 1992 by the Enterprise for the Americas Initiative Act, Public Law 102-532. The purpose of the Board is to "advise the President and the Congress on the need for implementation of environmental and infrastructure projects (including projects that affect agriculture, rural development, and human nutrition) within the States of the United States contiguous to Mexico in order to improve the quality of life of persons residing on the United States side of the border."

The Board is charged with submitting an annual report to the President and the Congress. Management responsibilities for the Board were delegated to the Administrator of the U.S. Environmental Protection Agency by Executive Order 12916 on May 13, 1994.

The Board does not carry out border-region activities of its own, nor does it have a budget to fund border projects. Rather, its unique role is to serve as a nonpartisan advisor to the President and the Congress and recommend how the federal government can most effectively work with its many partners to improve conditions along the U.S.-Mexico border.

The Board operates under the provisions of the Federal Advisory Committee Act and membership on the Board is extremely diverse. By statute, the Board is composed of:

(1) "representatives from the United States Government, including a representative from the Department of Agriculture and representatives from other appropriate agencies;
(2) representatives from the governments of the States of Arizona, California, New Mexico, and Texas; and
(3) representatives from private organizations, including community development, academic, health, environmental, and other nongovernmental entities with experience on environmental and infrastructure problems along the southwest border."

The Board also includes representatives from Tribal governments with lands in the border region.

The recommendations in this report do not necessarily reflect the official positions of the federal departments and agencies that are represented on the Board, nor does the mention of trade names, commercial products, or private companies constitute endorsement.

To request a hardcopy of this report, contact the National Service Center for Environmental Publications at 1-800-490-9198 or via e-mail at nscep@bps-lmit.com and request publication number EPA 130-R-11-001.
(English version) http://www.epa.gov/ofacmo/gneb/gneb14threport/English-GNEB-14th-Report.pdf

Tribute to **Daniel Marks Reyna**
1951 - 2011

The Good Neighbor Environmental Board and the U.S.-Mexico Border Region suffered a tremendous loss this year when Board member Dan Reyna passed away suddenly. For more than 25 years, Dan advocated throughout the U.S.-Mexico border region as a national expert on border health issues. Most recently, Dan had been serving as the General Manager of the U.S. Section, Office of Global Affairs, Office of the Secretary, U.S. Department of Health and Human Services (HHS) in El Paso, Texas. He also was instrumental in founding and directing border health programs with the Texas and New Mexico Departments of Health.

A retired Colonel in the U.S. Army Reserve, Dan served as Company Commander of the 205th Chemical Company, Fort Bliss, Texas, and Battalion Commander of the 413th Civil Affairs Battalion in Lubbock, Texas. His active duty service included Bosnia-Herzogovina (Hungary) in 1996 and combat service in Afghanistan from 2003 to 2004.

Saddened by the loss of our dear colleague, HHS Office of the Americas Director Craig Shapiro, M.D., described Dan as having "dedicated his career to improving the health and quality of life for persons living along the U.S.-Mexico border. His ability to bring national, regional and local partners from both countries together to discuss health issues of mutual interest, as well as his commitment and passion for the U.S.-Mexico border region, made him the ideal candidate to represent HHS in the capacity of General Manager of the U.S. Section of the Office of Global Affairs. His dedication was well-known throughout HHS, and his reputation and success preceded him in the field of border health."

Dan will be sorely missed and the border region has lost a true advocate. It is in that spirit that his memory will live on as we continue to work towards a better future for the border region. The Board dedicates this 14th Report to the memory of our esteemed colleague, Dan Reyna.

Tribute to **Patti Krebs**
1949 – 2011

The Good Neighbor Environmental Board and the U.S.-Mexico Border region suffered another tremendous loss this year when Board member Patti Krebs passed away suddenly.

For the past 17 years, Patti served as the Executive Director of the San Diego-based Industrial Environmental Association (IEA). During her time at the public policy organization, Patti was "instrumental in leading the creation of a San Diego Regional Sustainability Partnership—bringing together businesses, military, governmental, public interest groups, academic and faith-based organizations—to identify and carry forward an agenda to promote practices to support sustainable communities," Vilmarie Rodriguez, the association's president, said in a statement. "Her involvement extended to South of the Border as she was instrumental in the Border Waste Wise Program."

Patti also worked for elected officials, including former Governor Pete Wilson and Congressman Brian Bilbray, before joining IEA. "Patti's love for environmental and sustainable causes was an inspiration to all," Ms. Rodriguez said. "Her tenacity and effective leadership were of benefit to all Southern California residents."

Patti served on the San Diego Association of Governments' Energy Working Group, Port of San Diego's Maritime Advisory Committee, and San Diego Regional Airport Authority Technical Advisory Group, and helped organize the San Diego Regional Sustainability Partnership.

She also was a member of the Board of Directors of the San Diego Transit Corporation, San Diego Natural History Museum, and San Diego Symphony, and held a bachelor's degree in communications from San Diego State University.

Patti was a true advocate for the border region and she will be deeply missed. It is in that spirit that her memory will live on as we continue to work towards a better future for the border region. The Board dedicates this 14th Report to the memory of our esteemed colleague, Patti Krebs.

Table of **Contents**

GNEB
Environmental Advisors Across Borders

GOOD NEIGHBOR ENVIRONMENTAL BOARD

Presidential advisory committee on environmental and infrastructure issues along the U.S. border with Mexico

Chair
Diane Austin

Designated Federal Officer
Mark Joyce

President Barack Obama
Vice President Joseph Biden
Speaker John Boehner

December 14, 2011

On behalf of the Good Neighbor Environmental Board, your independent advisory committee on environment and infrastructure along the U.S. border with Mexico, I am submitting to you our 14th report, *The Potential Environmental and Economic Benefits of Renewable Energy Development in the U.S. - Mexico Border Region*.

The 14th report responds to the request of the White House Council on Environmental Quality that we provide recommendations on responsible ways to take advantage of the abundant renewable energy resources in the border region while fostering sound economic development in the area. In this report we consider the following renewable energy resources: solar, wind, biomass, geothermal, and hydropower.

This report illustrates why this is a special region with both unique opportunities and considerable challenges related to the development and application of renewable energy technologies. To facilitate the careful development of these resources, the Board supports an approach that identifies priority areas for potential energy development and emphasizes coordination of local, state, tribal, and federal partners. In addition, we encourage the implementation of energy efficiency projects and initiatives as a partial or complete alternative prior to and in conjunction with the development of renewable energy projects.

The Board, in the development of this report, and following a tradition that has been maintained since its inception, has been driven by its desire to work through consensus in constructing all its recommendations. We hope that this report is useful to you and other U.S. government officials as we continue to think about how we can best achieve a healthier environment and a better quality of life for all of our citizens. We appreciate the opportunity to serve you and provide these recommendations and respectfully request a response.

Very truly yours,

Diane E Austin

Diane Austin, Chair
Good Neighbor Environmental Board

Executive Summary

Renewable energy production is expected to increase sharply in the United States. The U.S.-Mexico border region has a unique abundance of renewable resources that have been and can be used to produce energy, and the region is likely to play a significant role in this expansion. Increased production and use of renewable energy is important to the United States for many reasons: it can help foster our nation's energy independence; it can reduce harmful air emissions commonly associated with fossil fuel energy production; and it draws upon a supply of energy that is inexhaustible. The ability to harness renewable resources will be vital to the United States' future, especially as the nation's population and energy needs continue to grow. The U.S. states along the border with Mexico and the specific communities within the border region will make significant contributions in this area.

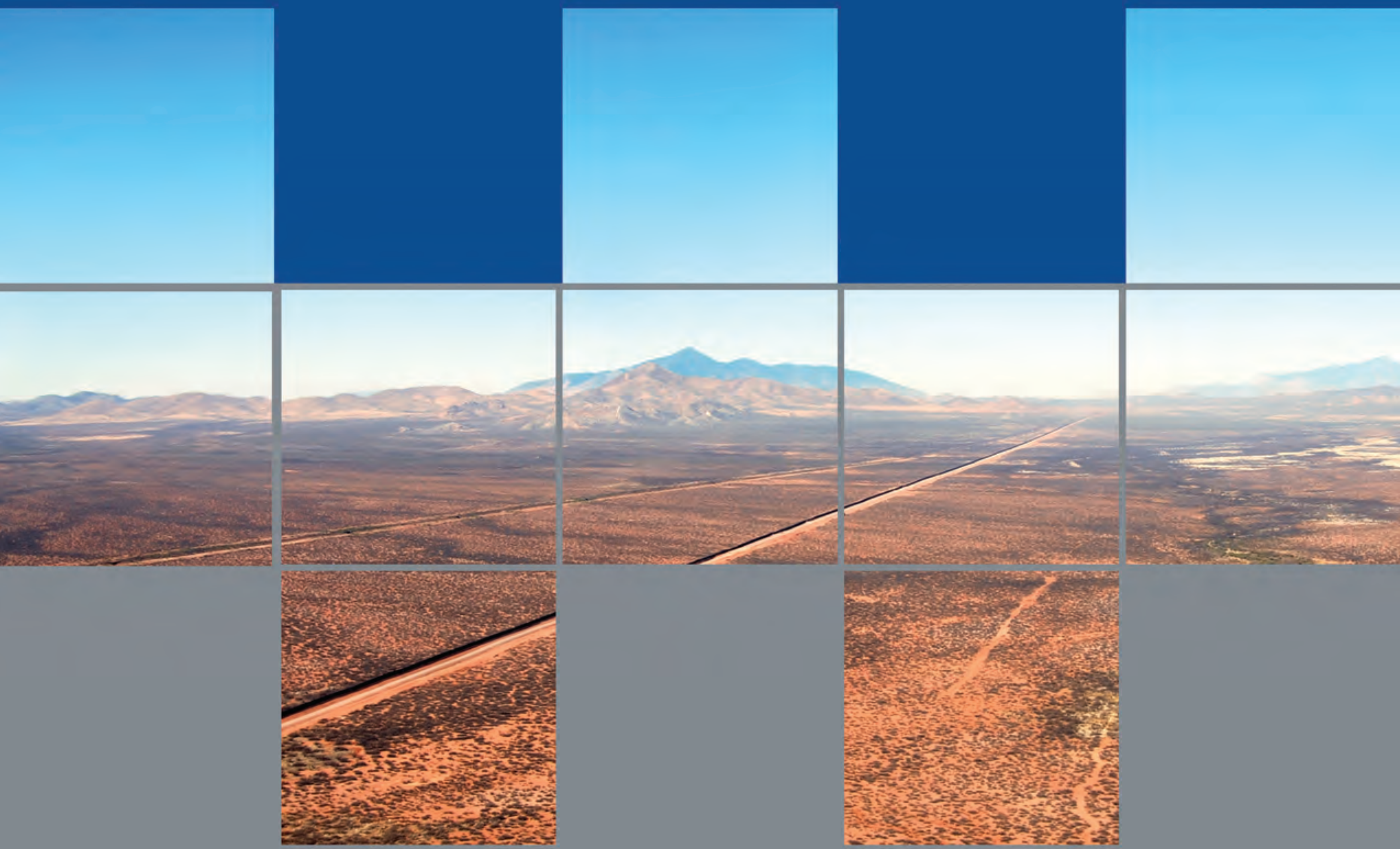
There are a number of characteristics of the border region that make it fundamentally different from other regions within the United States. Many communities suffer from poor air and water quality, insufficient water supply, inadequately managed hazardous and solid waste, habitat and species protection concerns, and conservation challenges. The region is defined by rapid economic and population growth, rapid urbanization, its location along the international boundary, asymmetries with Mexican infrastructure and social services in communities across the border, international commerce and trade flows, high rates of poverty, and a distinct ethnic identity.

Energy-related jobs may help address high rates of unemployment and underemployment. Yet, the border region should not become merely an exporter of energy to other parts of the United States. Existing and potential impacts of renewable energy development have led to conflicts with communities and natural resource conservationists, and these will continue unabated unless more attention is paid to the scale and form of this development and to pre-development analysis of natural resources and community conditions and needs. Local communities should benefit directly from renewable energy development.

In this *Fourteenth Report to the President and Congress of the United States,* the Good Neighbor Environmental Board (GNEB, the Board) discusses existing and potential development of solar, wind, biomass, geothermal, and hydropower resources along the border. The Board considers availability, technology, production capacity, environmental impacts of production and transmission, and the mitigation of negative effects. The Board also examines economic opportunities such as job creation, municipal energy savings, increased revenues, and investments in operating capital, infrastructure and equipment.

Energy needs along the border are growing, and careful development of abundant renewable energy resources can help address those needs. The Board encourages responsible efforts to take advantage of the energy resources in the border region while at the same time improving economic conditions. GNEB endorses the careful planning and execution of projects and regional initiatives to ensure that any negative impacts are identified early and avoided to the greatest extent possible, and that any remaining unavoidable impacts are minimized or mitigated. The Board also promotes the implementation of energy efficiency projects and initiatives as a partial or complete alternative prior to and in conjunction with the development of renewable energy projects. In sum, GNEB supports an approach that identifies priority areas for potential energy development and emphasizes coordination of local, state, tribal and federal partners to optimize local benefits while protecting the habitats, ecosystems, and all of the communities of this unique region.

Overview and Background



1 Chapter

Introduction

At the request of the White House Council on Environmental Quality, the Good Neighbor Environmental Board (GNEB, the Board) accepted renewable energy in the border region as the topic of its 14th annual report. In 2011, energy continues to be one of the pressing issues facing the United States, and the U.S.-Mexico border region provides examples of renewable energy, combined with energy efficiency, that can be a model for the nation. With ample wind and solar energy available, the border region highlights what can be achieved with renewable energy.

By renewable energy, the Board means any type of energy that is a flow (e.g., solar, wind, hydropower) as opposed to a stock that will be depleted, such as oil, coal, or natural gas. Energy efficiency means accomplishing necessary activities while using less energy.

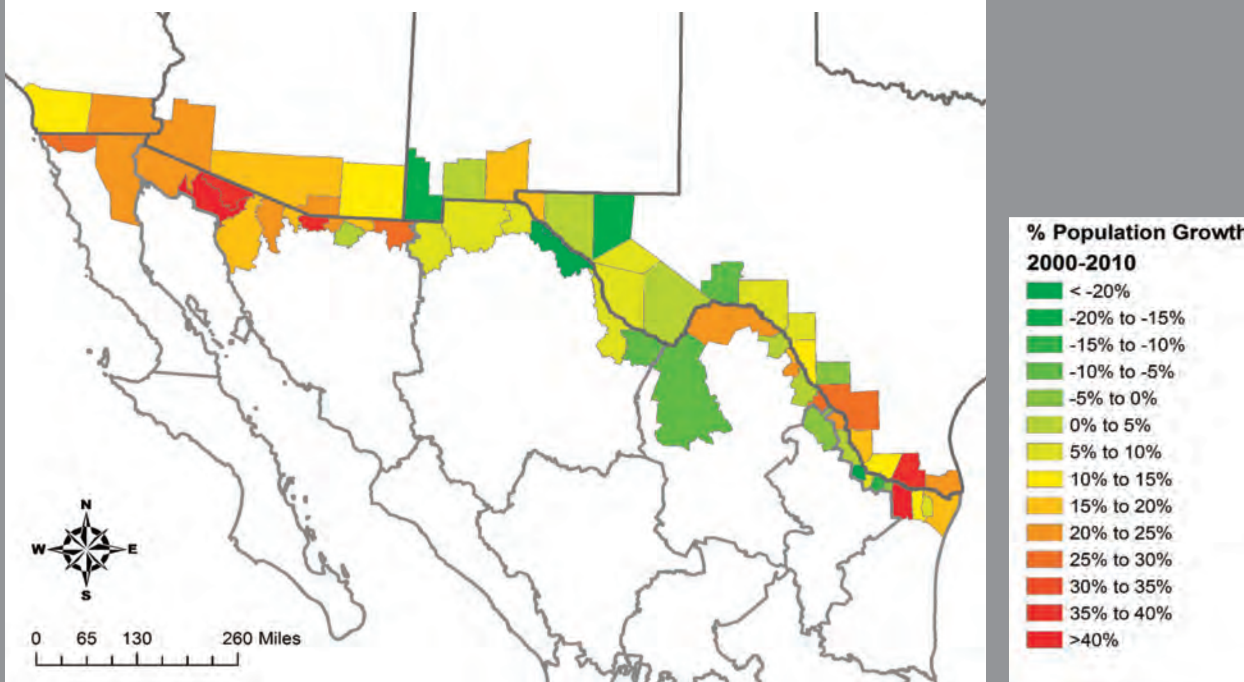
This 14th report examines the effects of renewable resource development, including environmental and economic effects, on the border region. The report captures not only the perspective of Board members, but also those of border residents and communities. Many local and state government, tribal, and nongovernmental Board members live and work in border communities, and GNEB federal members also are experts on border issues pertaining to their respective agencies' mandates. During 2011, the Board met twice in border communities to hear firsthand from local residents about the opportunities and challenges that they face with regard to renewable energy development.

Background and Objectives

The increased development of renewable energy is important to the United States for many reasons. First, renewable energy is critical to the energy security of the United States: energy produced from wind, solar, or another renewable power source helps to increase our nation's energy independence. Second, renewable energy sources like sun and wind do not produce any harmful air emissions, such as nitrogen oxides, sulfur oxides, or particulate matter, commonly associated with fossil fuel energy production; thus, there is a clear environmental and public health benefit.[1] Third, the supply of renewable energy from the sun and wind is inexhaustible, making the ability to harness these resources vital to the United States' future, especially as the nation's population and energy needs continue to grow.[2] Finally, the potential for creating jobs in renewable energy also is extremely important to this region. At the same time, existing and potential impacts of renewable energy development are many, and these require careful attention to the scale and form of this development and to pre-development analysis of natural resources and community conditions and needs.

The U.S.-Mexico border region is defined as the area of land that is 100 kilometers (62.5 miles) north and south of the international boundary. It stretches approximately 2,000 miles from the southern tip of Texas to California. This region contains a unique abundance of natural renewable resources that have been and can be used to produce energy. In 2008, the Texas State Energy Conservation Office

Figure 1. Border Population Growth 2000-2010

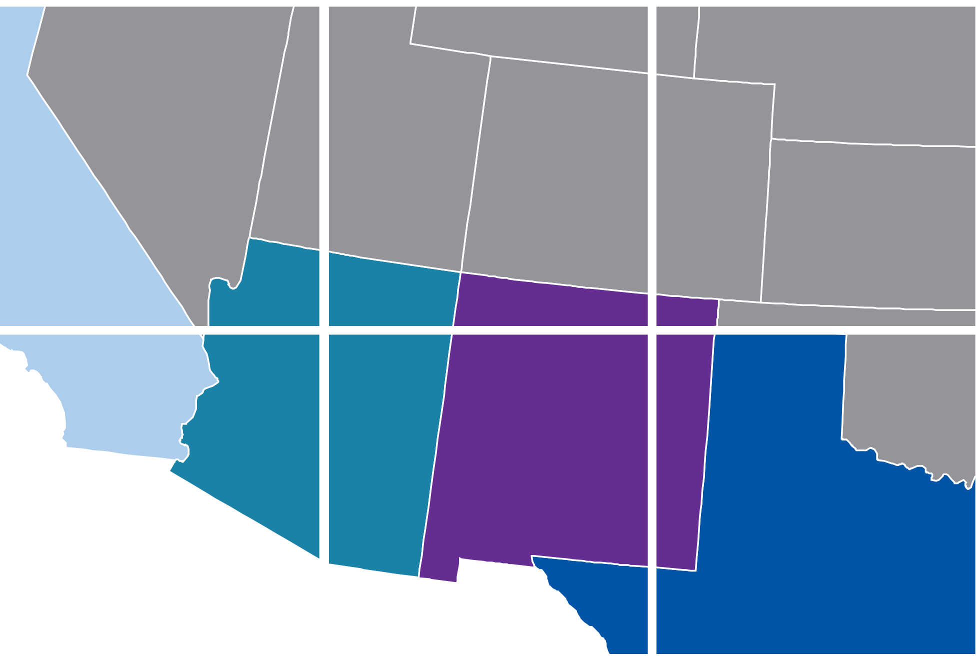


Source: U.S. Census Bureau, INEGI, and James Peach, New Mexico State University

reported that Texas was home to vast solar, wind, geothermal and biomass resources that potentially made it the largest market for non-hydro renewable energy production in the United States. Much of this potential was found along the border, particularly for solar energy in far West Texas. Similar reports by the California Energy Commission and the Western Governors' Association (WGA) have identified abundant resources in Arizona, New Mexico, and California, including vast potential in the borderlands. In fact, the two largest developers of installed renewable energy capacity to date have been Texas—mainly because of wind power—and California, with its combination of solar, wind, and geothermal power.[3] New Mexico and Arizona have similarly large potentials for renewable energy, mainly because of their sunny days. In terms of individual resources, California, Arizona, and Texas were the top three in the long-term solar index, and Texas topped the wind index.

The availability of renewable resources along the border aligns well with a strong need for more energy and energy-related jobs in that part of the country. The population in the U.S.-Mexico border region is growing at a faster rate than other locations in the United States, and its energy needs are increasing rapidly (see Figure 1). Also, border communities tend to be low-income areas characterized by high unemployment, with unemployment rates often 250 to 300 percent higher than in the rest of the nation.[4]

This report will provide an overview of current renewable energy issues in the border region, beginning with the role of the federal government, and also will examine economic opportunities and issues and provide recommendations. The Board chose to highlight only the following renewable energy resources (the list order does not imply a hierarchy of importance): solar, wind, biomass, geothermal, and hydropower. The Board believes that negative impacts of renewable energy can be avoided or minimized through careful planning. ***It is the objective of this report to provide recommendations on responsible ways to take advantage of the abundant renewable energy resources in the border region while fostering sound economic development in the area.***



Background: Energy and the Environment

The role of the federal government in renewable energy differs markedly in the United States and Mexico because of the way energy markets in each country operate. In the United States, electricity generation, transmission, and distribution primarily are carried out by public utilities or private firms, resulting in a decentralized system shared by the public and private sectors. The United States lacks a comprehensive federal policy on renewable energy, and federal agencies do not dictate how renewable energy develops in different regions. In addition, most energy regulation is carried out at the state level; state, county, and local governments often have their own regulations, permit applications, and approval procedures for renewable energy generation and transmission. These governments can influence the adoption of renewable energies by enacting laws and ordinances, offering incentives, and developing their own generation sources and transmission infrastructure. Tribal governments also use these mechanisms to actively participate in renewable energy development.

By contrast, energy is almost entirely a public monopoly in Mexico. The Mexican Constitution mandates that electricity generation, transmission, and distribution are the purview of Mexico's government-owned electric utility, the Federal Electricity Commission (CFE), giving the federal government considerable influence over the renewable energy market. Changes to Mexican law in 1992 opened certain categories of the generation sector to private participation and allowed the involvement of small producers, co-generators and independent power producers. In November 2008, the Mexican Congress passed the Renewable Energy Development and Financing for Energy Transition Law

(LAERFTE). The law makes it possible for the first time for private companies to build power plants and sell the electricity they produce to the CFE grid. It also permits companies or public or private entities to construct renewable or efficient cogeneration electricity generation facilities or to use CFE's network when they contract with private energy generators to meet their energy needs. In addition, CFE increasingly has bid out contracts for construction of renewable facilities (mainly for wind farms) to private companies.

U.S. Federal Structure

Several U.S. federal agencies play a role in regulating and promoting renewable energy along the border. The Department of Energy (DOE) is responsible for implementing Executive Order (EO) 10485, which was amended by EO 12038. It authorizes exports of electric energy and issues Presidential permits for the construction, operation, maintenance, and connection of electricity transmission facilities at the international border. Before a permit can be issued, DOE must establish that the permit is consistent with the public interest and has received favorable recommendations from the U.S. Departments of State and Defense. In determining consistency with the public interest, DOE considers the potential environmental impacts of the proposed project under the National Environmental Policy Act of 1969 (NEPA), implements other relevant executive orders such as EO 13186 regarding the responsibilities of federal agencies to protect migratory birds, determines the project's impact on electric system reliability (including whether the proposed project would adversely affect the operation of the U.S. electric power supply system under normal and contingency conditions), and considers any other factors that DOE may find relevant to the public interest. DOE also finances research and development for renewable energy and energy efficiency technologies.

Many other federal agencies, including the U.S. Departments of Defense (DoD), Agriculture (USDA), and Interior (DOI), are responsible for managing certain lands and properties within the border region and are involved directly in renewable energy development there. The Department of Housing and Urban Development is responsible for national policy and programs that address housing needs and for improving and developing U.S. border communities. The agency's Energy Efficient Mortgage program helps homebuyers or homeowners finance the cost of adding energy efficiency features to new or existing housing as part of their Federal Housing Administration (FHA)-insured home purchase or mortgage refinancing. The Department of Transportation oversees the national transportation system, promotes intermodal transportation, and negotiates and implements international transportation agreements. The U.S. Section of the International Boundary and Water Commission (IBWC), United States and Mexico, operates and maintains the U.S. hydropower plants at Falcon and Amistad International Dams on the Rio Grande. The Environmental Protection Agency (EPA) is responsible for developing and maintaining regulations, policies, and guidance for the protection of human health and the environment, working closely with state, tribal, and local governments to accomplish this. EPA also has developed a variety of voluntary programs and partnerships to help address and identify clean energy opportunities. Other federal agencies, such as the Department of Homeland Security, the Department of State, and the Federal Energy Regulatory Commission, which regulates the interstate transmission of electricity, also have direct responsibilities that affect renewable energy development within this region. All of these agencies also must comply with NEPA and implement executive orders.

Mexican Federal Structure

Several different federal agencies share responsibility for the promotion, production, and regulation of renewable energy in Mexico. The Secretariat of Energy (SENER) designs the national energy policy. SENER has made renewable energy one of the two major planks of Mexico's national climate change mitigation strategy. As a result, LAERFTE, which came out of the 2008 energy reforms, set up a fund of almost $250 million (U.S.) a year for the promotion of renewable energy. CFE controls electricity generation, transmission, distribution, subsidy implementation, and cost. CFE functions as a public monopoly and is obligated by law to purchase electricity from third parties at the lowest cost, which favors energy produced from fossil fuels. All cross-border electricity transmission using public transmission lines is subject to CFE control. The Mexican Section of the IBWC partners with CFE in the operation and maintenance of Falcon and Amistad International Dams and hydropower plants.

In addition, the National Commission for Energy Efficiency (CONUEE) encourages energy conservation and efficiency through the promotion of sustainable technologies, information sharing and regulations in the household, industrial, and commercial sectors. The Energy Regulatory Commission (CRE) regulates the natural gas and electricity industries, grants permits for energy generation, approves umbrella contracts for energy provision, and provides the methodologies to calculate rates for private energy suppliers. The Institute for Electricity Research (IIE) is responsible for research and development in the national electricity sector, including renewable energy. Unlike the United States, the Mexican federal government does not provide subsidies or tax incentives to the renewable energy industry to stimulate energy generation and transmission. The federal government, however, along with several Mexican states and municipalities and in coordination with nongovernmental organizations and international financial institutions, has enacted programs that offer financial incentives for households that use energy efficient technologies, such as solar heaters.

Bilateral Efforts to Promote Renewable Energy

The differences between the U.S. and Mexican electrical grid systems, as well as the differences in how each country manages renewable energy policies, complicate cross-border transmission. Currently, the U.S. and Mexican electrical grid systems are not synchronized in a way that allows for a great deal of renewable energy trade. Baja California's electrical grid is connected to the U.S. grid in a few locations. Texas has various connections to the Mexican electrical grid, with one commercial connection, but the rest are principally for emergency electricity transmission. Furthermore, state and local governments in the United States generally have more authority to set renewable energy policy than federal agencies, while the opposite holds true in Mexico.

Despite the challenges, the United States and Mexico are working together on a wide variety of renewable energy and energy efficiency projects. The U.S. Agency for International Development (USAID) is working with Mexico to develop a national Low-Emission Development Strategy (LEDS) for Mexico and also is working with Mexican federal, state, and municipal governments on a range of programs, from encouraging the use of renewables to energy efficient mortgages and renewable standards.

In 2010, the United States and Mexico expanded their Methane to Markets Partnership with the launch of the Global Methane Initiative (GMI) to expand and accelerate global methane reductions. In addition, EPA cooperates with the Mexican Secretariat of Environment and Natural Resources (SEMARNAT) on reducing heavy vehicle emissions through Mexico's Transporte Limpio program, which is based on EPA's SmartWay program, aimed at reducing transportation-related emissions by creating incentives to improve supply chain fuel efficiency. DOE and SENER share information on smart grid, renewable energy, and energy efficiency technologies, and work with EPA and SEMARNAT on a partnership to develop a program similar to ENERGY STAR to promote the use of more efficient building materials and appliances in Mexico. Mexico has taken the lead within the Energy and Climate Partnership of the Americas on an Energy Efficiency Working Group for the region, and supports regional interconnections and energy access efforts. Mexico also is part of the Clean Energy Ministerial process, where it leads with other countries on energy efficiency, smart grid, and renewable energy initiatives. Finally, as part of a 1993 bilateral agreement to the North American Free Trade Agreement (NAFTA), the United States and Mexico formed the North American Development Bank (NADB) and Border Environment Cooperation Commission (BECC), which recently have begun assessing and financing some renewable energy projects in the border area.

Renewable Portfolio Standards

A renewable portfolio standard (RPS) is a law or regulation that requires certain absolute or relative contributions from renewable energy sources to an electricity grid (and therefore is sometimes called a renewable electricity standard).

As of 2011, 29 U.S. states and the District of Columbia, including all four U.S.-Mexico border states, have established these standards. A national RPS never has been approved by the U.S. Congress, although legislation has been proposed multiple times. In the absence of national policy, states have taken the lead on renewable energy policy and implementation. Texas, for example, leads the nation in wind energy production, taking the initiative from state law.

Although the regulatory details of an RPS vary from state to state, the responsibility for implementation generally falls on the companies supplying end-use customers with electricity. Most states establish a system of tradable credits, so that one supplier can purchase credits (renewable energy certificates

[RECs]) from another. The definitions of which categories are considered renewable vary, with some states carving out niches or special credit for specific categories. Furthermore, although most states tie the requirement to electricity generated and sold (megawatt-hours [MWh]), a few link the requirement to generation capacity (megawatts [MW]).

State Policies Affecting Renewable Energy Development

Given the state-level authority for renewable energy and energy efficiency policies in the United States, the Board provides this comparison of the four U.S. border states. No similar analysis is provided for the Mexican states because the Mexican federal government is the main energy provider and policymaker there. Each U.S. state also has its own economic development and workforce policies, as well as its own public utility agencies. For example, with the support of elected public officials, 64 public, private, and nonprofit entities in the New Mexico border region have drafted a Memorandum of Understanding to coordinate state and federal rural economic development programs that focus on the particular needs of small communities, allowing for a coordinated marketing and development effort based on a sophisticated use of renewable energy promotion and energy conservation strategies that include industrial development and job training. New Mexico also has a specific agency, the Renewable Energy Transmission Authority, to help plan and develop the necessary transmission systems so that New Mexico can move renewable energy to in-state and out-of-state markets.

Although all four U.S. border states have state agencies responsible for energy planning and policy, their renewable energy and energy efficiency programs differ. For example, Texas, with the longest international border with Mexico, is unique in that it has an electrical grid that is mostly separate from the rest of the nation's grids, so it has an agency just to manage the grid. Each of the four U.S. border states has energy policies that promote renewable energy and energy efficiency. Table 1 lists a few of the major policies in these states.

Still, the four states have similar policies to promote workforce development that focuses on training in specialized areas for jobs in the renewable energy sector. They all engage in workforce development through postsecondary educational institutions and the activities of state workforce commissions, labor unions, and nonprofit entities.

As shown in Table 1, border states are acting at a statewide level to implement renewable energy programs at that level. In addition, individual cities, tribes, and utilities also are taking action in these areas. The border region offers important opportunities for renewable energy development from which both nations can benefit.

Table 1. Comparison of Border State Renewable Energy and Energy Efficiency Requirements

State	Renewable Energy Requirements	Energy Efficiency Requirements	MW of Wind Power, 2010	MW of Solar Power, 2010
California	33% of electricity from renewables by 2020	2010-2012 plan provides funding and program requirements for investor-owned utilities (IOUs) to reduce electricity use by a combined 7,000 gigawatt hours and capacity needs by 1,500 MW.	3,253	1,021
Arizona	15% of electricity from renewables by 2025	Regulated utilities with annual revenue > $5 million are required to achieve cumulative savings equal to 22% of their retail electric sales by 2020.	N/A	110
New Mexico	Renewables must comprise 10% of investor-owned electric utilities' sales by 2011; there is a target of 20% by 2020 for IOUs and 10% by 2020 for co-ops	Utilities are required to achieve a 5% reduction from 2005 electricity sales by 2014, and a 10% reduction by 2020. SB 418 (signed into law in March 2007) calls for a goal of 5% reduction by January 1, 2020, in total retail sales to New Mexico customers (adjusted for load growth). A 20% energy usage reduction in state buildings and transportation is called for by 2015.	700	43
Texas	5,880 MW from renewables by 2015	Investor-owned electric distribution utilities are to cover 20% of residential and commercial load growth with efficiency programs by 2009; 25% by 2012, and 30% by 2013.	10,089	34

Sources: For wind and solar power, 2008 State Renewable Electricity Profiles, Energy Information Administration, http://www.eia.gov/cneaf/solar.renewables/page/state_profiles/r_profiles_sum.html

Year-end power capacities: U.S. Department of Energy, "Wind Powering America," http://www.windpoweringamerica.gov/wind_installed_capacity.asp#current.

Solar power by state: Larry Sherwood, Interstate Renewable Council (IREC), "U.S. Solar Market Trends 2010," http://irecusa.org/wp-content/uploads/2011/06/IREC-Solar-Market-Trends-Report-June-2011-web.pdf.

Energy Requirements: The California Energy Commission, 2008 Building Energy Efficiency Standards, http://www.energy.ca.gov/title24/2008standards/, and EPA, State and Local Energy Climate Program, http://www.epa.gov/statelocalclimate/state/tracking/individual/nm.html#a01.

Energy Efficiency Standards

Rather than creating new energy sources, energy efficiency makes better use of existing resources by making appliances or buildings more energy efficient, or making the generation of energy more efficient, such as utilizing combined heat and power. Similar to energy efficiency, demand response programs can help manage when energy is used, thus avoiding use at the time when it is most expensive and hardest to provide.

In addition to an RPS, many states have adopted energy efficiency requirements that property owners and utilities must meet. Although these requirements generally are met through traditional energy efficiency programs like weatherization, incentives for more efficient homes, or even demand response programs, they also can include incentives for technologies that save money, like solar PV systems. All four border states have basic efficiency mandates that certain utilities must meet. Arizona imposes a public benefit fee on all residents, part of which goes into energy efficiency programs, and also has efficiency targets for the state and its utilities.

As the costs of renewable energy devices drop, or as incentives for their use are combined with more comprehensive and cost-effective energy efficiency programs, it is likely that the energy efficiency goals that utilities are required to meet will include such technologies.

Tribes and Renewable Energy

Border tribes, too, have begun to implement renewable energy programs. For example, the Campo Band of Mission Indians of the Kumeyaay Nation operates a wind farm that annually produces power sufficient for about 30,000 homes and saves approximately 110,000 tons a year in greenhouse gas emissions compared with equivalent fossil fuel generation.[5] The Tohono O'odham Nation is working with the University of Arizona to develop a comprehensive plan to address economic development, housing and transportation, natural resources and land use, energy, public service and facilities.[6] The Nation currently is pursuing projects that improve energy efficiency and use renewable resources to provide economic and social benefits to the Tohono O'odham people.

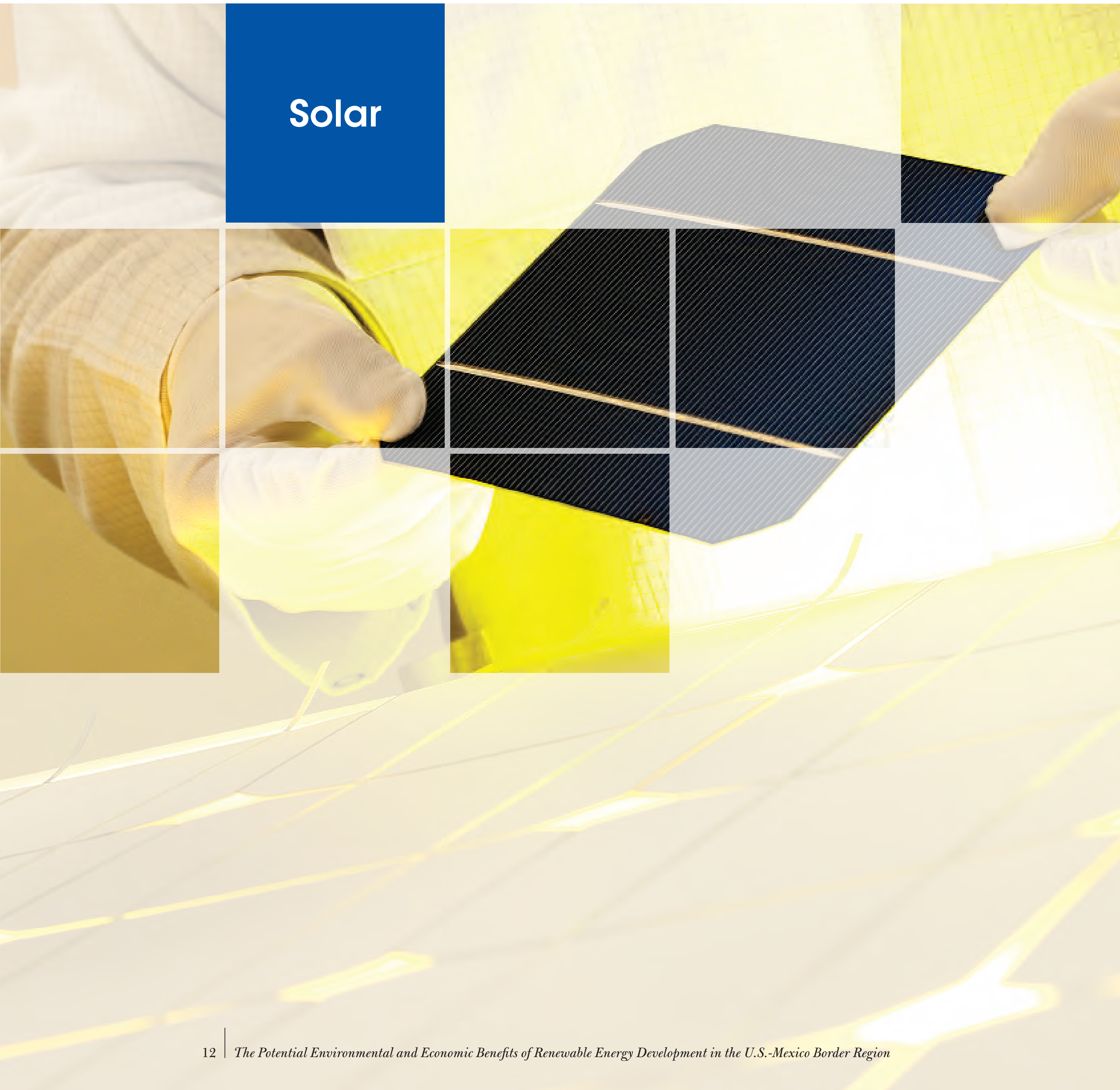
Federal laws and executive orders, including EO 13175, *Consultation and Coordination with Indian Tribal Governments,* Section 106 of the National Historic Preservation Act, and EO 13007, *Indian Sacred Sites*, require federal agencies to consult and collaborate with tribal officials on a government-to-government basis in developing federal policies that have tribal implications and in assessing the effects of federal undertakings on properties to which they may attach religious or cultural importance. In addition, DOE's Tribal Energy Program promotes tribal energy sufficiency and fosters economic development and employment on tribal lands through the use of renewable energy and energy efficiency technologies.[7] From 2002 to 2008, the program funded 93 tribal energy projects, nine of which were for tribes in the border region.[8]

The remainder of this report includes information on energy efficiency, renewable resource potentials, and related economic possibilities in the border region, followed by recommendations.

Resource Potential and **Environmental Impacts**
of Renewable Energy Development Along the
U.S.-Mexico Border

2 Chapter

Solar



"Potential impacts of renewable energy development are many, and these require careful attention to the scale and form of their development."

Electric power generated from the sun is adaptable to a variety of needs but generally can be divided into large utility-scale systems designed to serve large populations and smaller distributed generation systems installed in remote locations as well as near existing infrastructure and population centers.

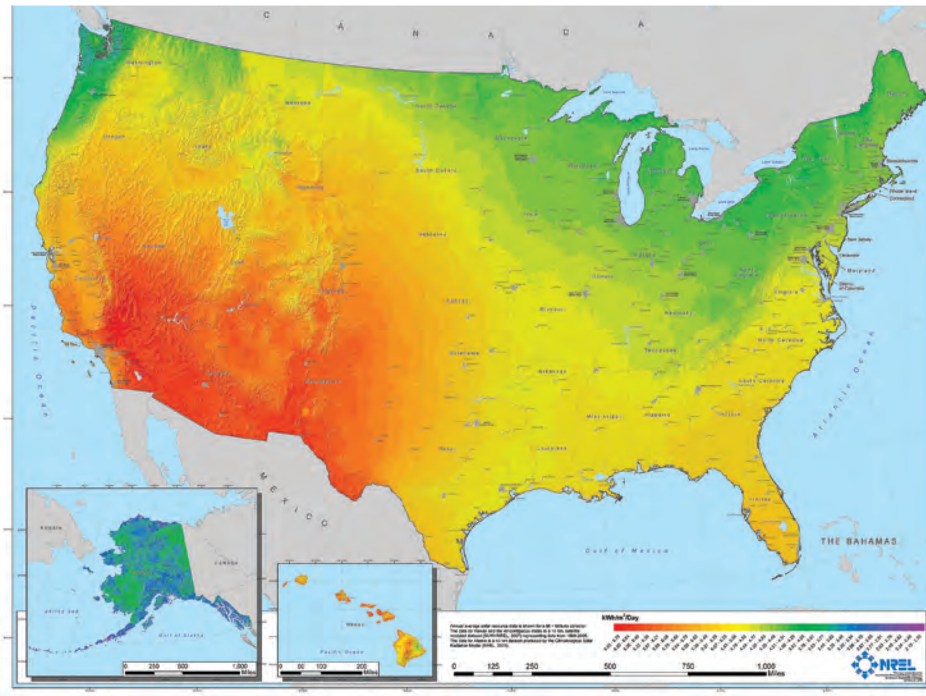
Solar technologies for generating electricity can be divided generally into photovoltaic systems (PV), which convert sunlight directly into electricity, and concentrated solar power systems (CSPs), which use mirrors or lenses to concentrate the sun's heat to boil water or another liquid to turn a turbine and generate electricity.[9] Solar technologies also are used for heating water at residential, commercial, and industrial sites.

Technologies

Photovoltaic Solar

Both utility-scale and distributed generation have become part of the electricity mix in the United States during the past 10 years. Although far behind leaders Germany, Spain, Japan, and Italy, the United States now constitutes some 5 percent of the world's PV market, and has seen the number of megawatts (MW) installed grow from just 3.9 MWs in 2000 to 435 MWs in 2009 to 878 MWs in 2010.[10] Although this is just a tiny fraction of the electricity market in the United States, this incredible rate of growth far outpaces traditional sources of energy. Also of interest is that the 878 MWs installed as of 2010 were evenly divided between utility-scale PV plants, residential PV, and commercial PV, showing tremendous opportunity in all three areas. Figure 2 shows the solar resource availability to power PV in the United States.

Figure 2. United States Photovoltaic Solar Resource: Flat Plate Tilted at Latitude



Source: National Renewable Energy Laboratory.

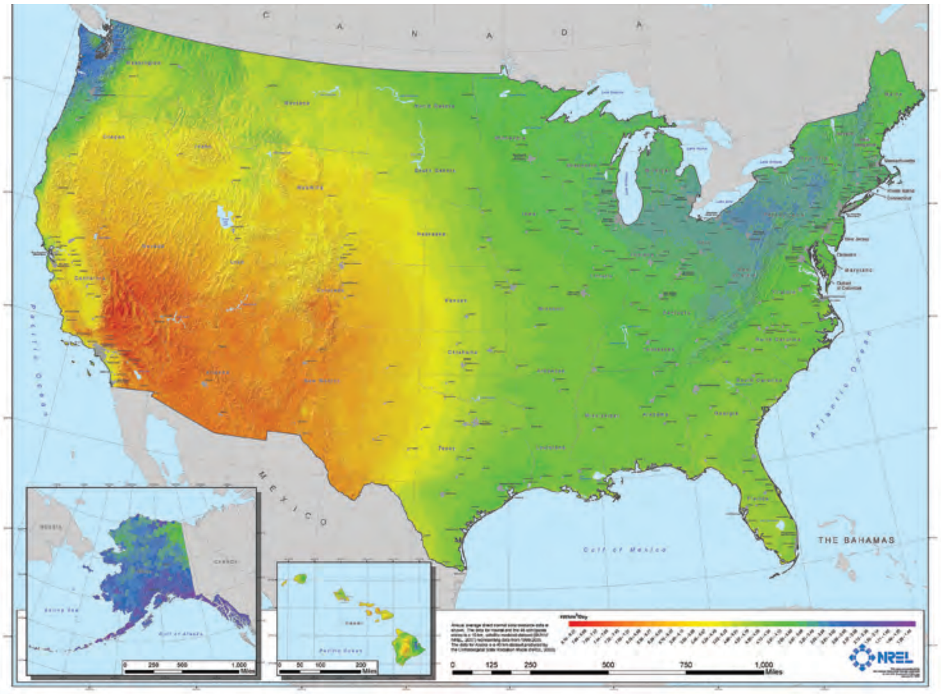
Concentrated Solar Power (CSP)

CSP systems consist of two parts, one that collects solar energy and converts it to heat, and another that converts heat energy to electricity. These systems can be sized for small village-scale power generation (10 kilowatts) or for grid-connected applications (up to 100 MW). CSP systems may use parabolic troughs, towers, or parabolic dishes to concentrate the sun's rays. Despite a flurry of activity in the late 1980s and early 1990s, the development of thermal solar plants—sometimes called concentrating or concentrated solar plants—was relatively dormant until recently. Figure 3 shows the resource availability of concentrated solar power in the United States.

State Updates

The four U.S. states bordering Mexico were responsible for much of the recent growth in PV. Although in 2007, only California and three other non-border states had installed more than 10 MWs of PV, by 2010, five states had installed more than 50 MWs in 1 year alone, including California and Arizona. In 2010, all four border states, including for the first time New Mexico (#7) and Texas (#10), made the top 10 list of states with installed PV capacity (see Figure 4).

Figure 3. United States Concentrating Solar Power Resource: Direct Normal

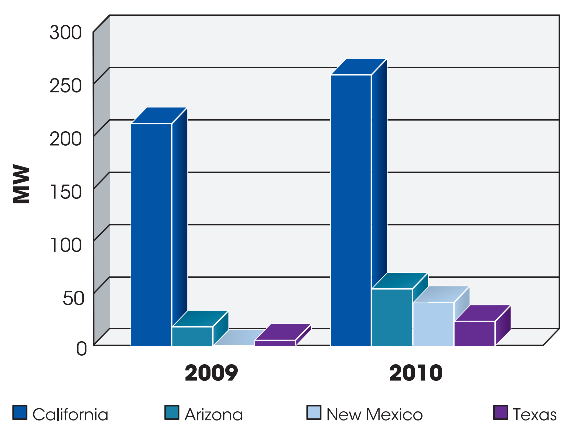


Source: National Renewable Energy Laboratory.

California

California continues to be the leader, in large part because of its strong commitment to solar energy through targeted state programs and its aggressive renewable portfolio standard (RPS) target. The RPS recently was expanded in California to commit the state to obtaining 33 percent of its energy from renewable resources by 2020, one of the most aggressive goals in the country. Further, recently elected Governor Brown has committed to a 12,000 MW distributed generation goal by 2020. In addition, a statewide solar program stemming from state Senate Bill SB1, which provides ratepayer funding to a variety of small and larger scale PV projects, is scheduled to provide more than $3.3 billion in an effort to reach 3,000 MWs of solar power installed by 2020. The statewide program's three components include: (1) the California Solar Initiative–1940 MW goal by 2017 installed by the three investor-owned utilities in the state; (2) California Energy Commission's New Solar Homes Partnership–360 MW goal; and (3) other solar programs offered

Figure 4. Installed PV Capacity in 4 Border States, 2009-2010



"Renewable energy sources like sun and wind do not produce any harmful toxins providing a clear environmental and public health benefit."

through publicly owned utilities—700 MW goal.[11] Through the first quarter of 2011, more than 924 MW at 94,891 individual sites had been installed through the California Solar Initiative.

In addition, a solar thermal program was initiated by the California Public Utilities Commission to provide incentives to residential and commercial utility customers to replace water heating systems powered with electricity or natural gas. The funding for this program is $350.8 million used to install 200,000 systems (http://www.cpuc.ca.gov/PUC/energy/Solar/swh.htm).

Incentivized by American Recovery and Reinvestment Act (ARRA) funds and the Department of Energy (DOE) Loan Guarantee program, 3,000 MW of utility-scale solar projects were permitted in California in 2010 and an additional 1,000 MW of solar projects already have been permitted in 2011. Additionally, several utility-scale projects have been announced in California's border region. For example, San Diego Gas and Electric (SDG&E) recently announced a contract with Tenaska Solar Ventures to build a 150 MW PV plant in El Centro in Imperial County (an area which has abundant desert sunlight for solar power generation).[12] This contract follows a November 2010 agreement SDG&E signed with a CSOLAR Development subsidiary for up to 130 MW of solar PV capacity on a 900-acre site in southern Imperial County called the Imperial Solar Energy Center South. That project is slated for completion in 2014 and is expected to bring up to 250 new construction jobs to the Southern California area.

Additionally, SDG&E signed two 20-year power-purchase agreements (PPAs) with an LS Power subsidiary to procure up to 175 MW of PV solar energy from the proposed 1,350-acre Centinela Solar Energy I and II facilities in the Imperial Valley. Upon completion in 2014, the new facilities will send up to 175 MW of solar power to SDG&E's service territory across the 117-mile Sunrise Powerlink transmission line that has been designed and approved to carry renewable energy from the Imperial Valley to San Diego.

California also pursued CSP well in advance of other states. Although nine smaller projects totaling 354 MWs were built in San Bernardino County in the 1980s and 1990s, some 4,192.5 MW of large utility-scale CSP had been approved by the California Energy Commission by December 2010, and another 300 MWs were under review. Of these, one project—the 709 MW Imperial Valley Solar Project—was located in the border region, while three other projects totaling 900 MWs were located just north in Riverside County.[13] For example, BrightSource's Ivanpah 392 MWs solar thermal system located in the Mojave Desert began construction in October 2010, and will be the world's largest solar plant.[14] Additionally, although currently stalled, the Imperial Valley Solar project potentially could be built out to 750 MWs on some 6,000 acres of federal land.[15]

Arizona

The abundance of solar resources and an RPS of 15 percent by 2025 have made Arizona an ideal location for the development of PV and CSP for both utility-scale and distributed generation. The Renewable Energy Standard (RES), as it is called in Arizona, directs utilities to obtain 15 percent of their electric load with renewable energy. Thirty percent of the RES must come from distributed generation projects and 50 percent of that from the residential segment of the market; solar water heating is included in the technology mix. New rules require that an increasing percentage of the state's RPS be achieved through the construction of distributed generation.[16] As of 2009, however, the state generated approximately 14 MW (or less than 1%) of its electricity from solar energy and still relied heavily on fossil fuels.[17]

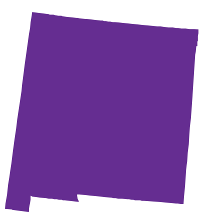
Several projects under development throughout the state (including the border region) promise to greatly increase not only the quantity of solar energy for domestic use, but also the potential to export to other states as well. Of the 31 solar projects currently pending Bureau of Land Management (BLM) approval, 4 projects are located in border counties, totaling a proposed 2,150 MW of power generation on 64,070 acres of land. The 500 MW Palomas and 800 MW Wildcat Quartzsite CSP projects in Yuma County, along with the 250 MW Safford Solar Energy PV project in Northern Cochise County, will increase solar capacity in the state greatly, but represent a small portion of the 15,000 MW awaiting approval by BLM.[18]

The Agua Caliente project in Yuma County still is pending approval by BLM. Once completed in 2013, the site will supply electricity using PV thin film technology to produce 290 MW of electricity. Pacific Gas and Electric (PG&E) has signed an agreement with majority owner NRG Energy to purchase the project's output for 25 years, guaranteeing a steady source of revenue for the project. A recently approved $967 million federal loan guarantee from DOE played a significant part in its development.[19]

Other private projects in the desert southwest also have been developed, such as the Abengoa Solana facility that currently is being built near Gila Bend, Arizona, with a net capacity of 250 MW; it is expected to deliver enough electricity to meet the annual needs of approximately 80,000 Arizona households.[20] It is likely that in the coming years, potentially thousands of MWs of CSP projects will be built in the southwestern United States. The industry remains dynamic, as evidenced by the recent decisions of several developers to switch their previously approved large-scale solar farms from solar thermal to photovoltaic technology due to the significant drop in PV panel prices in the past 18 months.

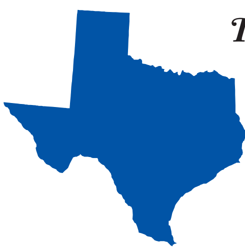
BLM's Arizona Restoration Design Energy Project, which was funded through ARRA funds, provides an example of how the federal government can play an important role in developing state-level solar capacity while helping to minimize impacts to sensitive, undisturbed desert ecosystems. The project initially identified roughly 80 areas on disturbed or damaged sites for renewable energy development, including solar energy. These sites include hazardous material sites or brownfields, unreclaimed mining sites, inactive mineral materials sites, and former landfills. Reutilizing these disturbed and damaged lands is important in providing viable areas for development at a good value to the taxpayer while minimizing the footprint associated with solar projects.[21]

In addition to the PV utilities on the ground, state RPS requirements in California, New Mexico, and Arizona are likely to lead to further installations of utility-scale PV plants, including in the border region. El Paso Electric (EPE) and PNM in New Mexico, APS and Tucson Electric Power (TEP) in Arizona, and Southern California Edison (SCE) and PG&E in California all are likely to invest in solar power plants in the coming years to meet RPS targets, potentially in the border region.[22]



New Mexico

In New Mexico, the RPS and associated regulations require EPE, which also serves eastern New Mexico, to supply 10 percent of its retail jurisdictional energy sales through renewable energy resource procurement in 2011 and 2012, increasing to 15 percent by January 2015, and 20 percent by January 2020, and thereafter. To achieve this, EPE has issued a 2011 Request for Proposals (RFP) to solicit competitive proposals for solar energy projects and for dispatchable renewable energy resources, the latter being those sources that can be ramped up or shut down in a relatively short amount of time. In addition to contracts with residential and commercial customers, EPE is contracting to have a 20 MW photovoltaic plant built in New Mexico. The Roadrunner Solar Electric Facility will be one of the first large-scale utility projects in the state and the second largest PV facility in the State of New Mexico. Covering 210 acres in Santa Teresa, the entire facility will be built on privately owned land previously zoned for industrial use.[23] In addition to the contract for 20 MWs, EPE also proposes to enter into PPAs with SunEdison to obtain energy and RECs, available in 2012 from 24 MW solar PV facilities located in southern New Mexico, and with the village of Hatch for energy and renewable energy certificates (RECs) from a 5 MW solar PV facility available during 2011.[24]



Texas

Texas, despite good solar resources, particularly in Western Texas, has lagged behind in development of solar power. Through 2010, the only utility-scale PV plant built has been the 14 MW Blue Wing Solar plant in San Antonio, contracted with the municipal utility, CPS Energy. Both the lack of a statewide solar incentive program and the failure of the legislature and the Public Utility Commission to implement the 500 MW target for non-wind renewables as part of Texas' RPS have slowed solar development in Texas.[25] Nonetheless, in February 2011, the City of Austin adopted the 2020 Austin Energy Generation Plan, committing the municipal utility to purchase at least 200 MW of solar energy by 2020, potentially from the border region in West Texas. In addition, CPS Energy has committed to adding an additional 30 MWs of solar energy through small plants near San Antonio and recently has announced plans to invest in a 400 MW plant, which could be located in the sun-rich border region.[26]

Several other projects announced for the competitive market in Texas have secured interconnection agreements, although there is no guarantee that they will be built.[27] Of the 800 MWs of potential solar development that have been announced, roughly one-half are planned in counties on or near the Mexican border. Two solar projects near the Marfa area have been delayed due to local residents' concerns about the mirrored satellite dishes they would incorporate. Still, it is likely that development of CSP or utility-scale PV within the border area could occur in the coming years.

The Texas General Land Office (GLO) also has announced a series of RFPs to lease state lands in West Texas for solar development. First, a GLO/Austin Energy Solar Lease would lease lands for a 150 MW CSP or PV plant, and an additional three leases in El Paso and Hudspeth Counties would provide space for 30 MW projects.[28]

Distributed Solar

Although most distributed solar initiatives are outside of the border region, there has been some limited PV development activity in places such as El Paso, Texas; Las Cruces, New Mexico; and San Diego, California.

These efforts largely have resulted from specific incentive programs run by utilities, whether as part of a rebate program or as a result of federal grants, many of which were connected to ARRA funds. Thus, federal grants distributed via ARRA have led to some PV development at municipal public buildings within the border region.

A number of the utilities serving the border currently offer PV programs to their rate payers. In Texas, the utility companies serving the border region—Texas New Mexico Power, EPE, American Electric Power (AEP) Central and AEP North—have begun small-scale solar rebate programs as part of their energy efficiency programs, while in New Mexico, both EPE and PNM offer incentives for extra energy produced by distributed systems and purchase the RECs.

In California, the California Solar Initiative and Solar New Homes Program are coordinated with the individual utilities. There is a strong correlation between incentive programs and the installation of distributed solar PV. Many of the most successful programs have been linked to wider energy efficiency and weatherization programs because solar PV systems are far more cost-effective when combined with such efforts. For example, in California, all homes applying for solar rebates first must undergo an energy audit.

In Arizona, many of the electric cooperatives, such as Trico Electric Cooperative, participate in a SunWatt rebate program to help meet their RPS obligations, while TEP has a more extensive incentive program for residents. Several utilities, including TEP, have begun solar farm programs in which residents can purchase part of a community solar plant. This is a new and innovative way to support the development of distributed solar power without the need for costly home installation.

Finally, another opportunity to grow the distributed generation renewable markets in the border region comes from wholesale distributed generation programs, whereby the project is built at or near electricity loads and the energy is sold to the utilities through short- or long-term contracts. Examples of programs are feed-in tariffs, reverse auctions, and competitive solicitations administered by utility companies.

Understanding and Addressing Environmental Impacts of Solar Energy Development Along the U.S.-Mexico Border

Although solar energy development is an important step toward addressing the nation's energy needs, development of solar projects must be tempered by an awareness and consideration of the potential impacts on surface and ground water, land, and wildlife. Some solar technologies use enormous quantities of water, a scarce resource in deserts, and all utility-scale solar projects, no matter their fundamental technologies, require large tracts of land.[15]

Potential Impacts on Water Resources

Concentrated Solar Power Systems May Use Large Quantities of Water

CSP systems typically use steam to generate electricity and often consume water for cooling. CSP plants employ a steam cycle to spin a turbine, in turn generating electricity. Because the water in the steam cycle is recycled continuously, the amount of water consumed by the steam cycle itself is quite small. Substantial quantities of water, however, generally are used in the cooling cycle.

There are three main types of cooling systems for CSP facilities with varying levels of water use: open-loop cooling; closed-loop cooling; and air or dry-cooling. The amount of water used in open-loop systems is a function of the amount of power produced, the type of cooling system installed, and the highest temperature in the system. Open-loop CSP facilities generally require up to 1,000 gallons of water per MWh of electricity produced, equaling or exceeding the amount of water used at water-intensive nuclear and coal plants.[29] Closed-loop cooling systems lose significant quantities of water during each cooling cycle through evaporation and discharge to keep salt concentrations in check. Air or dry-cooling systems do not use any cooling water, but rather depend on ambient air temperatures for cooling. Hence, their efficiency increases during cooler winter months and decreases during hot summer months. As an example, one air/dry-cooled power plant was found to produce 5 percent less energy than a water-cooled plant during the course of a year, thereby increasing the electricity cost 7 to 9 percent over a water-cooled plant.[30]

CSP facilities using wet cooling can consume more water per unit of electricity generated than traditional fossil fuel facilities with wet cooling.[31] Even when using closed-loop thermal technologies similar to traditional coal, natural gas, and nuclear plants, CSP plants consume, on average, 300 percent more water because they are less efficient at electricity production and therefore require more water for steam production used in generating electricity.[32] Concerns about the water requirements of CSP raise questions about whether and how to invest in large-scale deployment of CSP within the border region and what kinds of solar technologies are most appropriate for areas susceptible to water supply constraints.[31] In California, some developers of large-scale thermal systems in the desert have recognized such concerns and switched to dry cooling.

PV Systems May Save Water in the Southwest

Electricity generation via conventional pathways accounts for a major part of water demand. The U.S. Geological Survey (USGS) estimated that in 2005 thermoelectric power plants withdrew approximately 41 percent of U.S. freshwater.[32] In contrast, PV uses little water during operation, only that needed to wash the solar panels and operating equipment periodically.[31] Although water is necessary for the production of several components in solar panels, a detailed life-cycle analysis concluded that PV would save water use in the Southwest because of the lack of water used for cooling.[33]

Potential Impacts to Ground Water

Where ground water will be used for a solar project, the review of environmental impacts requires assessment of the potentially affected groundwater basin as well as the potential impacts to surface water and biologic resources. Key elements of a thorough analysis include:

- A discussion of the amount of water needed for a proposed solar generation facility and where this water will be obtained;
- A discussion of availability of ground water within the basin, annual recharge rates, and a description of the water right permitting process and the status of water rights within that basin, including an analysis of whether water rights have been over-allocated;

- A discussion of cumulative impacts to groundwater supply within the hydrographic basin, including impacts from other large-scale solar installations that also have been proposed;
- An analysis of different types of technology (e.g., PV) that can be used to minimize or recycle water;
- A discussion of whether it would be feasible to use other water sources (i.e., potable water, irrigation canal water, wastewater, or deep-aquifer water);
- An analysis of the potential for alternatives to cause adverse aquatic impacts such as impacts to water quality and aquatic habitats; and
- An analysis on how existing and/or proposed water sources may be affected by climate change and a discussion of impacts to water supply and the adaptability of the project to these changes.

Water conservation measures such as appropriate use or recycled water for landscaping and industry, xeric landscaping, and water conservation education can be implemented to reduce water demands.

Potential Impacts to Surface Waters

Surface waters are scarce in the desert—a precious resource critical to the health and vitality of its unique biodiversity and rapidly growing population. Recent court decisions have dramatically impacted the federal government's ability to implement the Clean Water Act in these desert environments. Loss of these waters thus is accelerating, with predictable impacts to endangered species habitat, groundwater recharge and the natural flood control services that surface streams provide.

Unless criteria are established for the conservation of desert aquatic resources, renewable energy production may come at the expense of conserving the desert's biodiversity. Less than 1 percent of the vegetation in deserts is riparian (streamside), yet most desert animal species, whether birds, mammals, reptiles, or amphibians, rely on riparian habitat for at least part of their life cycle.

Desert streams also recharge ground water by storing and circulating water in the stream network across a landscape. A recent study in Arizona's San Pedro River basin showed that the network of ephemeral streams accounts for up to 40 percent of annual regional aquifer recharge during wet years.[34] In many populous areas in the southwest, groundwater pumping already outstrips replenishment rates, so recharge is critically important to sustaining drinking water and agricultural supply.

Land management agencies can embrace a more environmentally sustainable approach to public lands management by incentivizing impact avoidance for streams and other sensitive natural resources in their right-of-way (ROW) approval process.

To protect and manage the desert's fragile and invaluable ecosystems effectively, project reviewers must have information about the distribution of aquatic resources on a project site—regardless of Clean Water Act jurisdictional status. An agency's approval criteria then can be modified to reflect this information, potentially speeding review and approval of sites selected for minimal presence of aquatic resources.

Also, with this information, agencies can programmatically shift important renewable energy development toward more disturbed lands with fewer natural resource conflicts. Early coordination with federal and state partners can promote the nation's complementary goals of sustainably advancing domestic renewable energy production and, as stated in the Clean Water Act, of "restoring and maintaining the physical, chemical and biological integrity of Waters of the U.S."

Examples of specific measures that will help avoid and minimize direct and indirect impacts to desert washes (such as erosion, migration of channels, and local scour) include:

- Avoid placement of support structures in desert washes.
- Utilize existing natural drainage channels on site and more natural features, such as earthen berms or channels, rather than concrete-lined channels.
- Commit to the use of natural washes, in their present location and natural form and including adequate natural buffers, for flood control to the maximum extent practicable.
- Minimize the number of road crossings over washes and design necessary crossings to provide adequate flow-through during storm events.
- Avoid complete clearing and grading of the site by evaluating the mounting of PV panels at sufficient height above ground to maintain natural vegetation and reduce impacts to drainages.
- Discuss and ensure the availability of sufficient compensation lands within the project's watershed to replace desert wash functions lost on the project site.

Potential Impacts on Air Quality

Because 100 percent solar-powered systems generate no air pollution during operation, the primary environmental, health, and safety issues revolve around manufacturing, site construction, equipment installation, maintenance and, ultimately, system decommissioning and disposal. The energy used to manufacture and install solar components and any nonrenewable fuels used for this purpose will generate emissions. Although this varies depending on the technology being implemented, the energy balance is generally favorable to solar systems in applications where they are cost effective, and it is improving with each successive generation of technology.

A 2011 study quantified the lifecycle greenhouse gas emissions, criteria pollutant emissions, and heavy metal emissions from four types of major commercial PV systems and showed that the emissions are insignificant in comparison to the emissions that they replace when introduced in average U.S. grids. The analysis found that central PV systems present significant environmental benefits over grid electricity, including 89-98 percent reductions of greenhouse gas emissions, criteria pollutants, heavy metals, and radioactive species. Rooftop dispersed installations are expected to have greater reductions as the loads on the transmission and distribution networks are reduced, and part of the emissions related to the lifecycle of these networks are avoided.[35]

Through close coordination with local and state air quality management agencies, project proponents can ensure that individual project impacts, as well as cumulative impacts from the construction of multiple simultaneous large-scale installations, adequately address construction vehicular, as well as fugitive dust, emissions.

Potential Impacts on Land

When used to generate electricity on a commercial scale, solar energy facilities require large tracts of land. The land requirements for CSP systems are approximately 5 to 10 acres of land per MW of capacity.[36] A very large, single utility-scale solar plant may occupy up to 50 square miles, or nearly 32,000 acres. The 27 CSP applications to BLM in Arizona have requested 400,779 acres of public land.[18] These companies have estimated an aggregate generating capacity of 18,575 MWs. A rule of thumb used by the TEP is that PV requires 8 acres of land per MW of power produced.

Development of these large-scale solar projects may transform the lands on which they are constructed, precluding most other uses. These preparations can be very disruptive to native flora and fauna and may require regular herbicide application to keep the area under the collection devices free of any growth and of soil stabilizer applications to control dust that may block sunlight from reaching the mirrors.

Utility-Scale Systems May Fragment Habitats and Directly Harm Flora and Fauna

The deserts in the southwest are biologically rich ecosystems with a vast array of animals and plants that have adapted to the harsh conditions over millions of years and contain rare wildlife and sensitive habitats. They are fragile and slow to recover from disturbance. Any large, artificial structures built in a pristine natural area are likely to have significant negative impacts on the surrounding natural environment.[37] Once disturbed, the site remains impaired for the life of the project because the large fields of solar collectors interfere with natural sunlight, rainfall, and drainage at the facility, causing microclimate alteration. These effects are compounded at large facilities due to the number of mirrors that cover and cool the ground while simultaneously reflecting light and heating the air.[37]

Utility-scale solar projects also may affect migratory populations by cutting off migration corridors, impacting mating and as a result, genetic diversification. Habitat fragmentation inevitably leads to smaller populations of wildlife and threatens biodiversity by increasing the possibility of extinction for entire populations or species. Wildlife also may be harmed or killed during the construction of these facilities.[38]

Environmental analyses evaluate impacts and mitigation for species and require:

- Baseline conditions of habitats and populations of potentially impacted species.
- A clear description of how avoidance, mitigation, and conservation measures will protect and encourage the recovery of the covered species and their habitats in the project area.

- Monitoring, reporting, and adaptive management efforts to ensure species and habitat conservation effectiveness.

Developers may acquire compensation lands to mitigate potential impacts to identified species, and comprehensive environmental analyses require:

- Information on the compensatory mitigation proposals (including locations, quantification of acreages, estimates of species protected, costs to acquire compensatory lands, etc.) for unavoidable impacts to waters of the United States and state as well as biological resources.
- Identification and quantification of available lands for compensatory habitat mitigation for the project, as well as reasonably foreseeable projects in the project's vicinity.
- Mitigation, monitoring, and reporting measures that result from consultation with the appropriate officials, and incorporation of lessons learned from other solar projects and recently released guidances to avoid and minimize adverse effects to sensitive biological resources, for example, habitat for desert tortoise.
- Adoption of provisions that will ensure the habitat selected for compensatory mitigation will be protected in perpetuity.

Public Lands Are of Value to Communities

Public wild lands often are of special importance to people who live nearby, and the use of these public lands for solar energy development must be justified against the long-term loss of that land to citizens. Some areas are economically dependent on the recreation opportunities associated with surrounding public lands. Revenue from outdoor activities and other forms of recreation potentially may be lost if solar facilities are installed on lands holding special value to people.[39]

PV Systems May Cause Less Land Disturbance Than Conventional Systems

Solar systems pose a distinct advantage from conventional fuel cycles in that they do not disturb land by extracting and transporting fuel to the power plants, and they eliminate the necessity of reclaiming mines or securing additional lands for waste disposal. Once the infrastructure of a system is constructed, there is no need for further extraction of resources. In contrast, nonrenewable energy systems continuously transform some land in search of fuels.[33] Even when considering the entire life cycle stages, a PV's life cycle involves less disturbance of land than do nonrenewable- and other renewable-fuel cycles. Furthermore, integrating PV modules within buildings, structures, or on already disturbed lands such as "greyfields", which are declining urban properties such as shopping malls, will further minimize the amount of land disturbed.[33]

Other Impacts

Manufacturing and End-of-Life Hazards

PV production involves many of the same materials as the microelectronics industry and therefore presents many of the same hazards.[40] The production can involve the use of toxic and explosive gases, corrosive liquids, and suspected carcinogenic compounds.[41] Exposure to these materials can occur during the manufacturing process, leaching from cracked or broken modules, or from the combustion of modules; however, the greatest risk to human health is associated with manufacturing. The production of solar panels can involve the use of toxic and flammable gases, carcinogenic materials, and heavy metals and therefore poses health risks.[40]

The disposition of solar panels at the end of their usefulness (approximately 25 years or more) also is a concern. Solar PV products contain many of the same materials that end up as electronic waste and use new and emerging materials that present complex recycling challenges. These challenges include finding ways to recycle the small amounts of valuable materials on which many of the new solar PV technologies depend. To avoid a repeat of the e-waste crisis, decommissioned solar PV products must be recycled responsibly and not enter the waste stream. Attention must be paid to the full product life cycle and production and purchasing practices guided by efforts to: (1) minimize environmental impacts during raw material extraction; (2) manufacture solar components in a zero-waste facility; and (3) provide future solar disassembly for material recovery for reuse and recycling.

Transmission Lines

The issue of transmission lines can create interstate conflicts and resistance from property owners, indigenous peoples, and individuals and organizations concerned about habitat and other environmental impacts. For example, proposed transmission projects involve the construction of hundreds of towers, each more than 100 feet tall, through important ecosystems and north-south migratory bird flyways, potentially affecting hundreds of bird species.[42] Important elements of environmental analyses for specific transmission projects or multi-state transmission lines are the proximity and capacity of existing transmission facilities to support new solar development and an estimate of the costs and potential impacts associated with building new lines or upgrading existing infrastructure. Where transmission is an integral component of solar energy development, the development of transmission facilities requires analysis in comparable detail to that of solar initiatives and individual solar projects.

Wind

"Energy produced from wind, solar, or another renewable power source helps to increase our nation's energy independence."

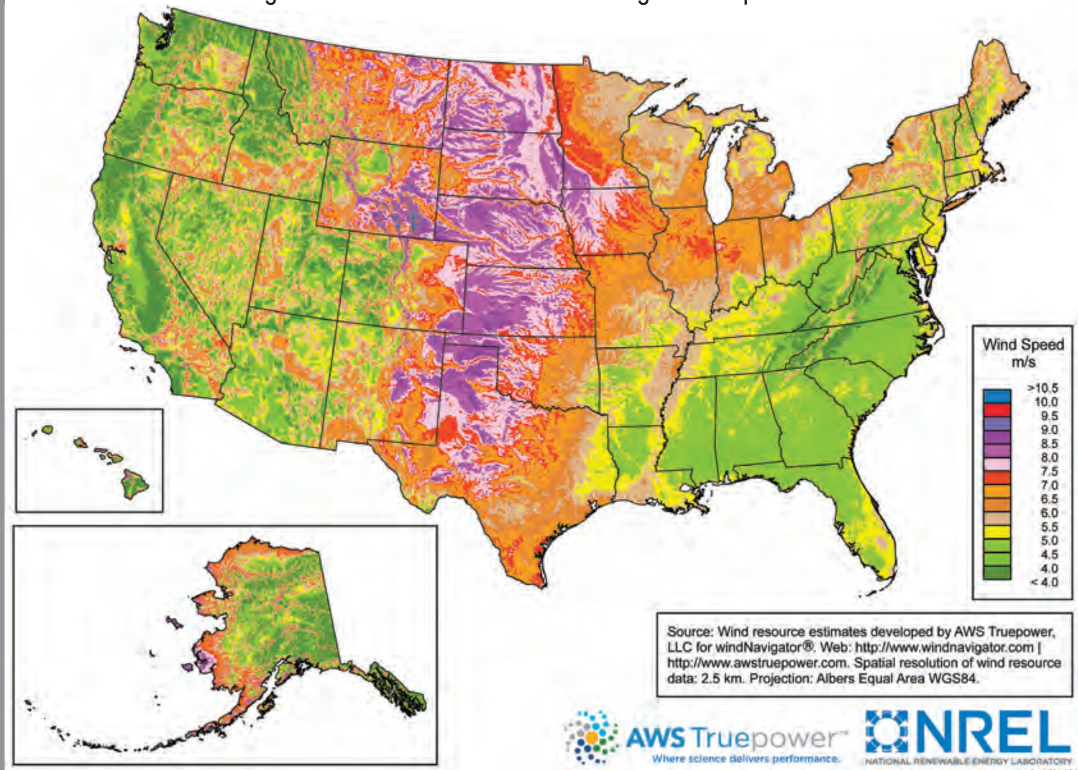
Wind energy is the renewable "fuel" that has enjoyed the most success during the past 15 years in the generation of electricity. This has occurred worldwide, as well as in the United States, including the states bordering Mexico. The principal reasons for this growth have been the relatively low costs of production combined with federal and state government policies that pushed for more renewable energy. The four U.S. border states differ in the availability of this resource, with Texas having by far the greatest potential in the region and Arizona the least.

Resource Availability and Benefits Along the Border

Figure 5 shows the distribution of wind regimes by average wind speed throughout the United States at a height of 80 meters (about 265 feet) from the ground.

A wind resource is generally considered economically useful for generating electricity if the mean wind speed is 6.5 meters per second (about 14.5 mph) or better at 80 meters elevation,[43] although various factors can lead to adjustments in that threshold; in other words, the areas colored orange, red, or various shades of purple in Figure 5 are economically useful for generating electricity, with the brown

Figure 5. United States - Annual Average Wind Speed at 80m



Source: U.S. Department of Energy, "80-Meter Wind Maps and Resource Potential," http://www.windpoweringamerica.gov/wind_maps.asp

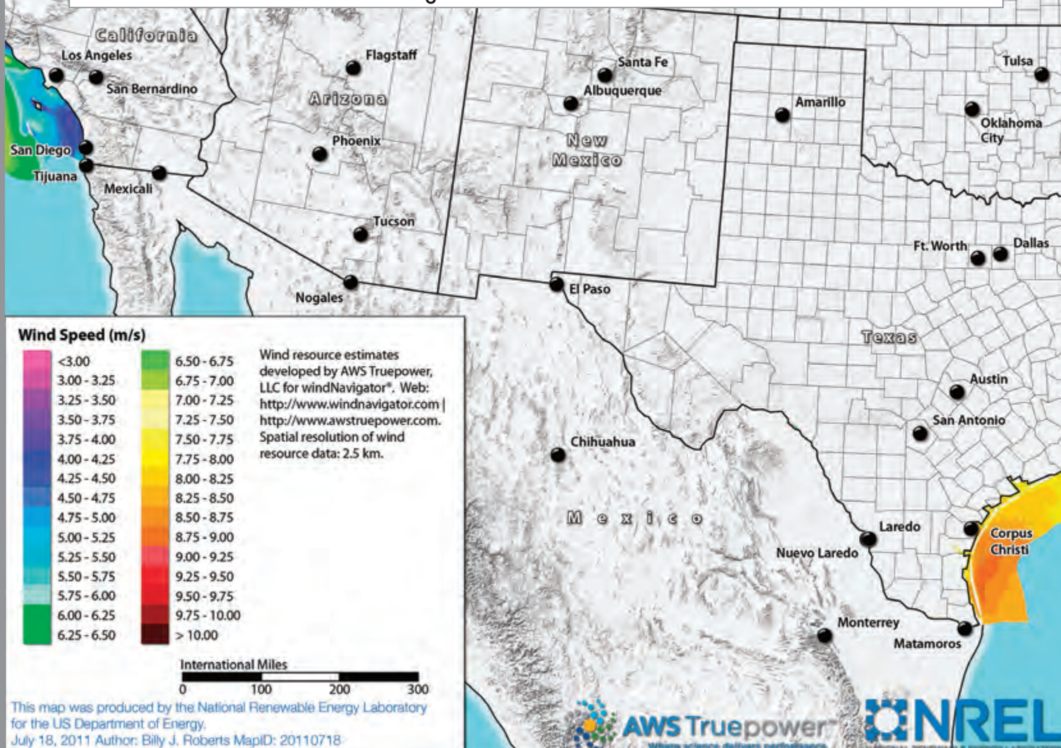
areas being marginal. Because the amount of useful energy that can be derived from wind varies with the cube of the wind speed (e.g., a doubling of the speed can produce eight times as much electricity), small differences in wind speed can significantly improve performance. Wind, somewhat like solar, is an intermittent resource. Economically exploitable winds vary by season, time of day, and location.

Although many states in the United States have one or more areas where the wind regime is strong enough to support generation of electricity, Figure 5 shows that the greatest wind resources are found in a band down the middle of the country. This band extends from Montana, North Dakota, and Minnesota in the north to New Mexico and Texas in the south.

Texas has some of the best resources in the country, and New Mexico has some promising areas. California has a few selected areas with economic resources in the southern part of the state, as well as just east of San Francisco Bay. Arizona has very limited useful wind resources.

Many offshore areas in the United States also offer excellent wind regimes, as demonstrated in Figure 6, which shows the resources available at 90 meters elevation from sea level. Texas and California both have economically exploitable resources off their coasts.

Figure 6. 90m Offshore Wind Resource of the United States Along the U.S. - Mexico Border



Source: National Renewable Energy Laboratory

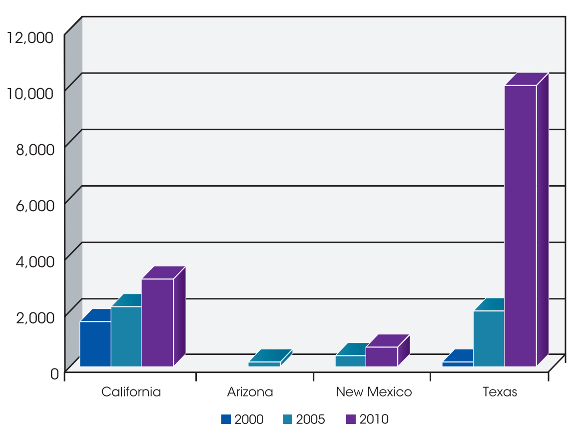
Virtually all wind development has taken place in so-called wind farms, where numerous large turbines are placed at appropriate distances from one another over a relatively large area.

The generation of electricity from wind energy became competitive with some conventional sources in the mid-1990s. Although part of the reason for this was the availability of federal tax credits, other sources of electricity generation (principally fossil fuels and nuclear energy) have long enjoyed government subsidies (at different parts of the fuel cycle) larger than those more recently available to renewable energy. A 2007 report by the U.S. Government Accountability Office (GAO) concluded that in fiscal years 2002-2007, direct subsidies for electricity (appropriations plus tax expenditures) from fossil fuels totaled $16.8 billion, for electricity from nuclear energy $6.2 billion, and for electricity from renewable energy $4.2 billion.[44]

Current Status

During the 2000-2010 decade, installed capacity of wind turbines worldwide increased from 17,400 MW to 197,000 MW,[45] or just greater than 1,000 percent. In the United States, installed capacity increased from 2,539 MW to 40,180 MW, or by some 1,480 percent, with installed capacity in the four border states increasing from 1,801 MW to 14,090 MW, or about 680 percent.

Figure 7. Growth in Wind Capacity in Border States, 2000-2010 (in installed MW)



Source: U.S. Department of Energy, U.S. Installed Wind Capacity. Online: http://www.windpoweringamerica.gov/wind_installed_capacity.asp.

Figure 7 shows these increases in the individual border states during the decade in 5-year increments. As noted earlier, Arizona's relatively small capacity results because the state has fewer wind resources available. Texas, with more than 10,000 MW of capacity at the end of 2010, had the most of any state in the country, and by itself trailed only five countries in the world (including the United States). California, with 3,177 MW, was third nationally (Iowa was second).

Early wind farms in the 1980s used turbines with a capacity of 50 kW each, but with increased technological experience, the average size has grown dramatically. Most wind farms built today use turbines rated at 1 MW or higher each. Meanwhile, the costs of electricity production per MW-hour have decreased significantly.

California

In 2010, wind energy provided 3 percent of total in-state generation in California, and electricity imported from outside the state brought the total contribution to 4.7 percent of the state's demand.[46]

Wind farms have a longer history in California than in any other U.S. state. Private developers began to build wind farms in the Altamont Pass, about 1 hour east of San Francisco in Alameda County, in 1981. This activity was a result of 1979 legislation, which required utilities to offer purchase contracts at so-called "avoided costs," for electricity from facilities up to a certain size built by independent generators.

During the 1980s, developers in California also began to build wind farms in two other areas with good wind resources: San Gorgonio Pass (southeast of Bakersfield) and Tehachapi Pass (near Palm Springs, east of Los Angeles). By 1995, 30 percent of all the wind-generated electricity in the world came from these three areas.[47] Subsequently, additional resources were exploited in Solano County, a few miles north-northeast of Altamont Pass.

Although about 95 percent of the wind farms in California today are in the areas named above, there are additional sites with potential in the southern part of the state, and the current installations include a small number in the border region. The nation's first wind farm on tribal lands was developed on the Reservation of the Campo Band of Mission Indians of the Kumeyaay Nation in Imperial County in 2006, with a capacity of 50 MW and providing electricity to San Diego. Since mid-2009, SDG&E has announced its intentions to collaborate in the development of additional wind projects in eastern San Diego County and in Imperial County (as well as in Northern Baja California in Mexico). One of those projects is additional development on the Campo Band Reservation.

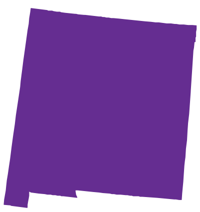
"Renewable energy is critical to the energy security of the United States."

As in other states, transmission constraints must be overcome to enable greater use of the wind potential. Two transmission-related projects currently are under way. Southern California Edison's Tehachapi Renewable Transmission Project in Los Angeles and Kern Counties involves both new and upgraded lines, and when all phases are completed in 2015, it will allow delivery of another 4,500 MW of wind production.[48] Farther to the south, and within the 100-km border region, SDG&E is building a new 500 kilovolt transmission line from Imperial County to San Diego County, which when completed will be able to carry 1,000 MW from a combination of solar, wind and geothermal projects. The Imperial County project has received opposition from some local residents. One of their primary concerns is the belief that they were not sufficiently involved in the planning process.

Arizona

At the end of 2010, Arizona had 128 MW of installed wind capacity, all located at a project in Navajo County in the northeastern part of the state built in two phases and just completed in 2010. The electricity is purchased by the Salt River Project, a state agency and Arizona's second largest electric utility.

Another 110 MW of capacity were expected to go online at two wind farms by the end of 2011, and several hundred MW of additional projects currently are in various stages of the permitting process.[49] They all would be located in the northern part of the state, where most of Arizona's relatively limited wind resources exist. Further development may be possible without encountering transmission constraints, depending on the possible retirement of old fossil fuel plants.[49]

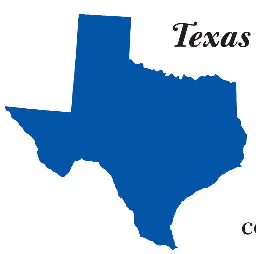


New Mexico

The first wind farm in New Mexico went online in 2003, and by the end of 2010 the state had seven projects in operation with 700 MW of installed wind capacity. Those projects met 5 percent of the state's total demand that year.[50]

The best wind resources in New Mexico are generally in the eastern high plains region of the state. The existing wind farms are in Guadalupe, Quay, De Baca, Cibola, Torrance, Roosevelt, and Curry Counties.[51] In addition, a report prepared by the Western Governors' Association, as part of its Western Renewable Energy Zones project, identified an area in southeastern New Mexico, just north of El Paso County, Texas, with some wind potential. Some of this area is within the 100-km border region.[52]

During the next 2 to 3 years, two more projects totaling 254 MW are expected to come online.[53] To address transmission constraints for development of solar and wind resources for the longer term, in 2007 the New Mexico Legislature established the Renewable Energy Transmission Authority. In late 2010, the Authority issued its first $50 million worth of bonds for the purpose of transmission upgrades.[54] For the longer term, developers of projects totaling more than 14,000 MW have paid the necessary fee to the Federal Energy Regulatory Commission to get into the transmission queue.[50]



Texas

In 2010, wind power met almost 8 percent of the total electricity demand within the service area of the Electric Reliability Council of Texas (ERCOT, the independent grid system that covers most of the state). This production met a much smaller percentage of the load at time of peak demand,[27] because most wind development in Texas so far has been in the western half of the state, where a majority of the exploitable wind speeds occur during night-time, off-peak hours.

The first wind farms in Texas were built in an area roughly 100 miles north of the U.S.-Mexico border, northeast of Big Bend National Park. Development subsequently expanded in that area and also jumped further north toward the Panhandle. By the middle of the past decade, it became clear that the major constraint to much greater development was the lack of transmission capacity to carry the electricity from the resources in the west to the demand that existed in the urban centers of Dallas, Fort Worth, Austin, San Antonio, and Houston in the eastern half of the state.

The state legislature in 2005 required the Public Utility Commission of Texas (PUCT) to identify and meet transmission needs for "Competitive Renewable Energy Zones" to address transmission capacity issues. Competitive Renewable Energy Zones in the western half of the state and proposed routes for transmission lines have been identified, with companies selected to be involved in negotiations with property owners and then build the lines. The state has decided to apply the transmission costs to the rate base of all the state's utilities. The PUCT and ERCOT still are conducting studies to optimize operations of the transmission additions, expected to come online within the next 1 to 3 years. A recent report suggests that when build-out is complete, Texas will be able to incorporate 18,500 MW of wind into its grid from the affected areas.[55]

Of the 10,000 MW of capacity statewide by the end of 2010, 13 projects with 1,500 MW of capacity have been developed in the border region, and an additional 10 projects totaling some 1,900 MWs obtained interconnection agreements within ERCOT and were scheduled to go online between 2011 and 2014. Within this region are three areas with significant resources: a mountainous area in Presidio, Culberson, Pecos, and El Paso Counties; the high plains around Laredo in Webb County; and on the coast of the Gulf of Mexico (such as Cameron and Kenedy Counties). The first two wind farms in the coastal area, totaling 687 MW of capacity, went online in 2010. The coastal resources, in contrast to those in western Texas, are predominantly daytime winds, and significant additional coastal resources remain to be developed, perhaps at some point also requiring additional transmission capacity.

Finally, the Texas General Land Office (GLO), which manages both significant amounts of state-owned onsite land and coastal resources, has been encouraging the private sector to take interest in off-shore development. The GLO has leased four offshore sites with an estimated potential of at least 250 MW each. Two of these are located within the border region. Most recently, in 2010 the GLO granted leases to a company that proposes to build 500 wind towers, each of which could provide between 5 and 6 MWs of power, 6 to 14 miles off the coast of Texas in three locations (two in the border area). The project still must undergo extensive research and regulatory processes, including potentially an environmental impact study.

Understanding and Addressing the Environmental Impacts of Wind Energy Along the U.S.-Mexico Border

As with any source of energy, there are positive and negative impacts associated with the development of wind energy. A significant limitation of wind energy development is that in most places the wind does not blow continually at an optimal speed for the turbines. The average output as a proportion of theoretical output at full capacity averages between 28 and 48 percent,[56] lower than the capacity factor of conventional plants used for baseload power. In addition, the timing of the wind speeds is not entirely predictable. For both these reasons, some dispatchable back-up power must be available, although at substantially less than a one-to-one ratio of capacity.[57]

From an institutional perspective, most wind turbines are approved through local zoning boards and state authorities, and these entities, and the federal agencies that play a role in wind energy development, have been critiqued for their lack of experience anticipating, reviewing, and assessing their impacts.[58]

Potential Impacts on Water and Air Quality

When in operation, wind-energy facilities generate no atmospheric pollutants and use virtually no water. Spinning wind turbine rotors generate vertical turbulent motion, causing heat and water vapor to mix, resulting in horizontal heat transport that affects the meteorological conditions downwind.[59,60]

Wind turbines require steel, concrete, aluminum, and other materials in their manufacture and these are transported using energy-intensive processes. Some models require neodymium, a rare-earth metal. Life-cycle analysis indicates that the payback period for carbon dioxide (CO_2) emissions, when comparing energy produced by the wind turbine with that produced by fossil fuels, is about 9 months.[61]

Potential Impacts on Land and Wildlife

Wind-energy facilities require large tracts of land and can affect landscapes, views, wildlife, and habitats. The average wind farm requires 17 acres of land to support each MW of capacity,[62] although the footprint of each individual turbine foundation and infrastructure is small. The construction and maintenance of these facilities alters ecosystems through the clearing of vegetation, soil disruption, and the potential for erosion and noise. These changes can lead to habitat loss and fragmentation. When development takes place in agricultural and ranching regions, wind farms can be installed and operated alongside those other economic activities through leasing arrangements. The turbines interfere minimally with those activities and can generate extra income for landowners through royalty payments from the wind farm owners. In the United States, the construction of wind installations is a relatively recent phenomenon, so the long-term effects of wind-energy projects on property values are difficult to assess.

Potential effects of wind-energy facilities on wildlife result from both the disruption of soils, vegetation, and habitats caused by the placement of wind farms in various ecosystems (deserts, mountain ridges, forests, and, for offshore installations, marine environments) and by the specific impact of the operating turbines on bird and bat mortality, behavior, and migration corridors, and other factors that may affect the animals' risk of collisions with turbines, especially when these are located in migratory paths.[63,64] Mitigations and technological "best practices" (curtailment of operations under certain conditions) can address some effects.

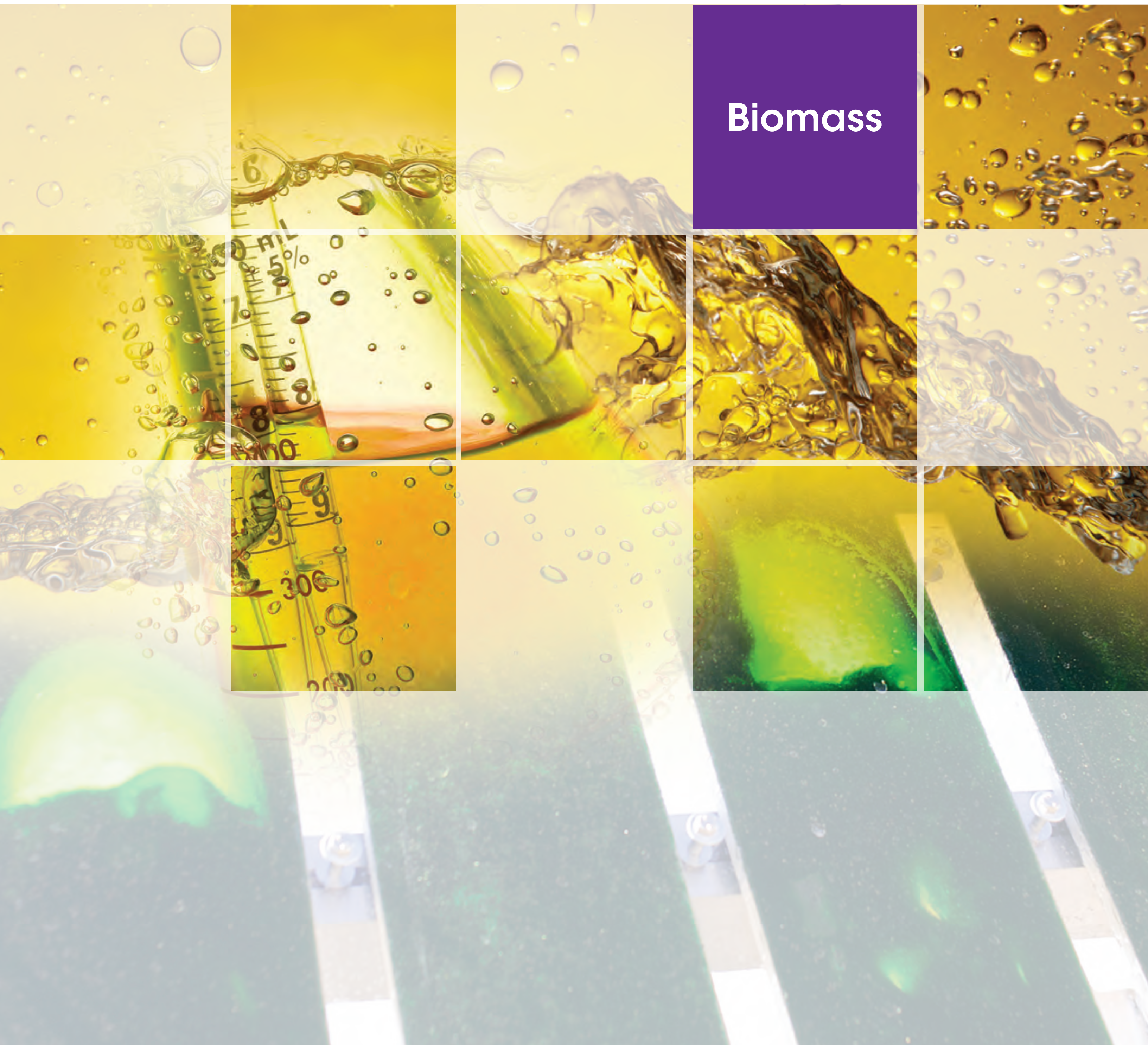
Significant impacts on viewscapes and aesthetics depend on the particular landscape being affected, the proximity to people's homes, and individual perceptions of the relative positives versus negative attributes of the technology. The turbines often are taller than regulated by any local zoning ordinance, are impossible to screen from view, and have moving blades that are likely to draw attention.[65] Approaches have been developed to assess potential visual impact and to involve the public early in project discussions.

Other Potential Impacts

Spinning wind turbines can create electromagnetic interference with television and radio broadcasting, cellular phones, and civilian and military radar systems, depending on proximity and specific siting characteristics. All wind farm developers must submit an application to the Federal Aviation Administration for review and possible mitigation measures.[66] Several studies are under way to identify solutions to the interference problem.

Selected aspects of the sound produced by turbines as they rotate in the wind can cause annoyance depending on proximity, although sensitivity varies greatly by individual. Mitigating technological refinements have been made and are being developed further.[67]

Biomass



Resource Potential and Benefits Along the Border

Although wind and solar are considered the most uniquely abundant sources of renewable energy along the U.S.-Mexico Border, the potential for energy produced from biomass also deserves consideration. Recent projects and partnerships illustrate the localized opportunities to use biomass as a renewable energy source. Biomass—waste from biological material and the feedstock for biofuels—has the flexibility to be utilized as a fuel for direct combustion, gasified for combined heat and power technologies, or used in biochemical conversion. Biomass includes agricultural residues, forest resources, perennial grasses, woody energy crops, wastes (animal, municipal solid waste, urban wood waste and food waste), construction debris, and algae.

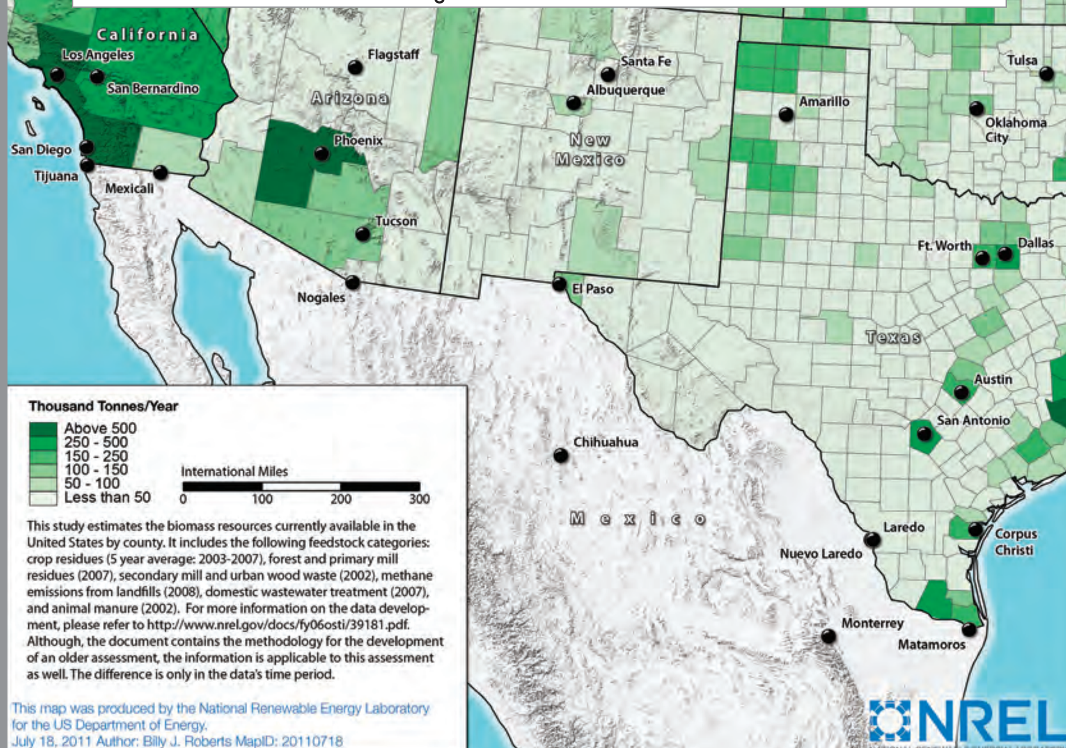
There are four different sectors in which biomass energy plays a role: (1) transportation (feedstock can be useful to manufacture biofuel for the transportation or aeronautical industry), (2) electricity (biomass used to generate electricity for facilities or boiler systems), (3) agriculture, and (4) heating applications for industrial processes.

The potential for the growth and expansion of biofuels along the U.S.-Mexico border is determined by the biomass feedstock potential that exists along these border states. The DOE's National Renewable Energy Laboratory (NREL) has conducted some extensive work showcasing where the various feedstocks currently exist in the United States. Along the border, the majority of biofuel resources (Figure 8) are found in the southern counties of California and Arizona with some pockets along the New Mexico-Texas corridor known as the Paso del Norte and the Lower Rio Grande Valley of Texas. The San Diego County area has the greatest biomass resource available from the border counties, followed by Hidalgo County in South Texas and El Paso County in West Texas. Both urban wood and methane emissions from landfills in all three counties are potential resources.

"Energy continues to be one of the pressing issues facing the United States and the U.S.-Mexico border region"

The full potential to convert biomass to energy along the border is not being achieved. Some of the biomass resources being tapped include capturing methane emissions from landfills and anaerobic digester gas from wastewater treatment plants, and converting cooking grease, food, and other wastes to energy. Only a small fraction of methane gas is captured from animal manure operations.

Figure 8. Biomass Resource of the United States Along the U.S.-Mexico Border



Source: National Renewable Energy Laboratory

Electricity, Direct Energy From Biomass

Often, landfill gas (LFG) simply is collected and flared (burned) to meet basic environmental requirements for destroying toxins in the gas. The LFG at landfills could be captured, converted and used as an energy source. Possibilities include generation of electricity for another user, direct onsite use as fuel for a boiler or other thermal application, or use in cogeneration projects (combined heat and power). The Miramar Landfill in San Diego County is operating a landfill recovery project that fuels a 6.4 MW cogeneration system at the Metro Biosolids Center (MBC) and the 3.8 MW North City Cogeneration Facility (NCCF) at the North City Water Reclamation Plant (NCWRP). In Southern New Mexico, the Camino Real Landfill in Sunland Park is generating electricity and selling back to the local utility with its landfill recovery system. El Paso, Texas, which sends 3,420 tons of waste to landfills each year, resulting in 46,091 tons of CO_2-equivalents,[68] also is developing a landfill gas recovery project in an effort to reduce its city operations' carbon footprint.

Capturing LFG to produce bioenergy destroys methane, a potent greenhouse gas. It also potentially reduces air pollution by offsetting the combustion of nonrenewable hydrocarbon resources, and reduces landfill odors. It is not always feasible or economically viable, but enhanced access to better tools may assist increased exploitation through earlier planning and more efficient landfill design and retrofit features.

Another potential source for bioenergy is gas produced in anaerobic digesters, either from large wastewater treatment plants or from manure operations at large combined animal feeding operations (e.g., cow farms). Very few of the border wastewater treatment plants appear to be generating electricity from recovered anaerobic digester gas. Along the U.S.-Mexico border, very few manure anaerobic digester projects currently operate. One limiting factor is the cost for installing and operating anaerobic digesters. It often is difficult to offset those higher costs through energy benefits in current markets.[69]

Biodiesel, Biofuel for Transportation

With the U.S. transportation sector heavily dependent on fossil fuels, during the past decade there has been an increase in research and development of alternative biofuels in the U.S.-Mexico border region. Because of its geographic location, the main feedstocks that have been driving biodiesel along the border have been plant seeds, waste grease from restaurants, tallow, and algae. There are a number of advantages as well as disadvantages in utilizing biodiesel as a transportation fuel. As an alternative fuel, biodiesel, if blended with petrodiesel in low concentrations, can be accepted by unmodified engines. In addition, handling and transportation of biodiesel is relatively safe compared to petroleum diesel because of its high flash point and biodegradability. Depending on the type of biodiesel blend used, biodiesel has shown a significant reduction in various pollutant emissions (Table 2).[70]

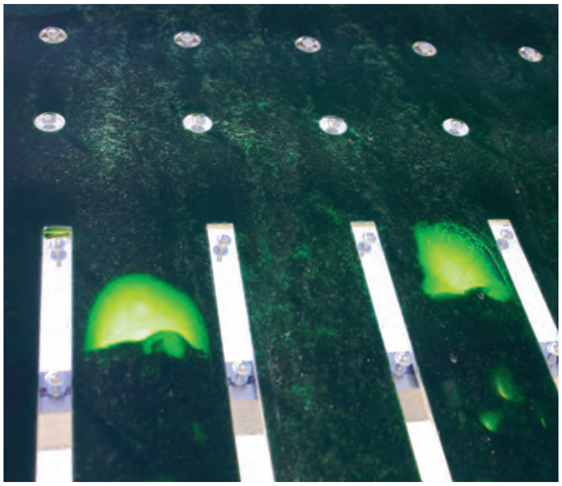
Table 2. Average Changes in Mass Emissions from Diesel Engines Using the Biodiesel Mixtures Relative to the Standard Diesel Fuel (%).[71]

Mixture	CO	NO_x	SO_2	Particulate Matter	Volatile Organic Compounds
B20	-13.1	+2.4	-20	-8.9	-17.9
B100	-42.7	+13.2	-100	-55.3	-63.2

B20 refers to a diesel formula comprised of 20 percent biodiesel, etc.

Algae Biofuel

One feedstock that has been gaining significant attention is algae. To produce algae fuel, plenty of land, sunlight, carbon dioxide, water, and nutrients are required. During the past several years, researchers turned to the U.S.-Mexico border region, as it is a potential corridor that meets some of these important criteria for algal growth.[72] Using algae as a biofuel over other plant seeds and waste oil has several advantages. First, algae can be grown in a variety of environments, including on land not normally suitable for crops



or in fresh or brackish water. Additionally, algae have shorter growth cycles compared to other crops, and the energy production potential per acre is significantly higher than other plant crops. A last advantage to utilizing algae as a biofuel is that, although the process of growing the algae for a biofuel uses a great deal of CO_2, it is possible to use CO_2 from other source emitters (i.e., power plants and chemical plants) to sequester this greenhouse gas (GHG) and "recycle" it into algae farms. One such example is through a very recent partnership between Sapphire Energy and Linde Group. Sapphire Energy is set to begin development of an open point algae cultivation farm just outside of Columbus, New Mexico. The commercial demonstration facility is set to utilize approximately 10,000 metric tons of CO_2 to grow the algae. Sapphire anticipates that this partnership with the Linde Group, which has developed technology to "recycle" CO_2 from industries that emit the pollutant, will make it easier to bring down the technological and operational costs that would otherwise exist for such a large-scale undertaking. It should be noted, however, that algae technology is still very much in its infancy and considerable research still is needed to understand the full potential.

Understanding and Addressing Environmental and Social Impacts of Biomass Energy

Unlike for much of the United States, bioenergy potential along the border rarely contemplates growing and harvesting biomass (e.g., corn) specifically for use as an energy stock or fuel (e.g., ethanol). Thus, many of the negative implications associated with full life-cycle impacts of agriculture for biofuels (nutrient and pesticide use, runoff, etc.) are not as prevalent along the border. One social concern with certain biomass to energy programs is that extensive use of vegetable oils as a feedstock could contribute to food shortages in developing nations[73] or cause domestic food prices to rise, putting stress on poorer populations. Along the U.S.-Mexico Border, the biomass sources with the most potential for energy production are based primarily on feedstocks that originate from waste products (i.e., municipal solid waste, wastewater treatment sludge), landfill gas, or more recently, algae farms. Based on these potential feedstock sources, positive impacts may include, indirectly, decreased reduction of air emissions such as less methane emissions from diverted "waste" from landfills or agriculture waste, and reduced carbon dioxide, sulfur oxides, and nitrogen oxides emissions in biofuels.

The combustion of biomass, however, still produces air pollutants that could include carbon monoxide, nitrogen oxides, and particulates. It is important that proper air pollution control technology is utilized to minimize the environmental impacts. Although the use of algae-based biofuel certainly would have some positive impacts such as reduction of air emissions that fossil-based fuels produced, this type of technology is still in its infancy and more needs to be learned about all of its implications.

Some biomass projects in the United States have not been without controversy (see Table 3). Both the sustainability of the source of the biomass and the pollution controls used on the electricity plants themselves have been identified as important issues.[74]

Table 3. Summary of Benefits/Impacts of Biofuels in U.S. Border States

	Positive/Benefits	Negati Concerns/Impacts
Landfill Gas (LFG) Capture	• Reduced methane emissions • Reduced carbon dioxide emissions • Reduced on-site odor • Reduced pathogens • Landfill fuel gas sells for roughly same as natural gas • Reduced explosion threats at landfill due to reduction of trapped methane • Decrease in demand on local utility for electrical needs if LFG is used to meet facility power needs	• Potential safety risk to operators—high levels of hydrogen sulfide and ammonia are produced in anaerobic digester container; container must be cleaned thoroughly and vented prior to entry[75] • Low Btu fuel: Btu content is one-half that of natural gas, so there are some limitations to its utilization • Possible increased odors if LFG is piped to a nearby location • Initial high cost to install technology
Methane Capture at Wastewater Treatment Plants	• Reduced air pollution from flaring of methane gas	• Cost of conversion from aerobic to anaerobic digesters If converted, indirect costs associated with additional operator trainer and maintenance • Considered a low Btu fuel, so limitation to use
Methane Capture From Manure Management	• Reduced methane emissions • Reduced carbon dioxide emissions • Reduced odor • Reduced pathogens • Reduced waste that might otherwise be diverted to landfill	• Cost of installation and technology utilized, especially to smaller operations; 50% failure rate of such systems documented • Cost of laboratory characterization of biosolids prior to permit authorization from federal/state government
Biodiesel From Waste Vegetable Oil	• Use of a waste product • End product use: decrease in particulate matter, hydrocarbon, and carbon monoxide emissions	• End product: slight possible increase in NOx emissions
Biodiesel Algae	• Can utilize wastewater for growth that would otherwise be unsuitable for agriculture or municipal use • Versatility to be grown in diverse climatic conditions • CO_2 capture mechanism, possible CO_2 reduction from "recycling" from other CO_2 producing facilities[75]	• Possible utilization of large quantities of water • Technology is very expensive and not yet available on a commercial scale along the border

Secondary Mill Residues: Secondary mill residues include wood scraps and sawdust from woodworking shops—furniture factories, wood container and pallet mills, and wholesale lumberyards.

Urban Wood Waste: This analysis includes wood residues from municipal solid waste (wood chips and pallets), utility tree trimming and private tree companies, and construction and demolition sites.

Geothermal

Resource Potential and Benefits Along the Border

The term geothermal comes from the Greek "geo" meaning earth and "therine" meaning heat; thus, geothermal energy is energy derived from the natural heat of the earth. The Earth's temperature varies widely, and geothermal energy is usable from room temperature to well over 300° F (150° C). A geothermal reservoir capable of providing hydrothermal (hot water and steam) resources is necessary for commercial use. Geothermal reservoirs are typically classified as being either low temperature (< 300° F) or high temperature (> 300° F). Generally speaking, the high temperature reservoirs are the ones suitable for, and sought out for, commercial production of, electricity. Geothermal reservoirs are found in "geothermal systems," which are regionally localized geologic settings where the Earth's naturally occurring heat flow can bring steam or hot water to the surface. Examples of geothermal systems include the Yellowstone Region in Idaho, Montana, and Wyoming, the Geysers Region in Northern California, and in the border, the Imperial Valley in Southern California.

One advantage of geothermal energy is that it can provide baseload power 24 hours per day, 7 days per week, with reliability comparable to that of conventional power plants and on a scale sufficient to power up to 200,000 homes. Geothermal can help utilities meet state RPS. Geothermal power plants also guard against volatile electricity prices because their lifetime fuel is secured at the initiation of the project through long-term leases with landowners, and the costs to drill the resource in advance of plant startup are capitalized so that future fuel cost risk shifts from the consumer back to the developer and/or operator.[76] In addition, there are few harmful gases or by-product pollutants associated with the use of geothermal energy.

"Renewable energy is critical to the energy security of the United States."

As seen in Figure 9, the border region, especially in the western half, possesses sufficient geothermal resources to consider development. California has the greatest number of existing geothermal plants along the border. Most of California's border geothermal energy is generated in the Imperial Valley. California is and will continue to be a leader in the development of geothermal energy. As shown in the recent map developed by the National Renewable Energy Laboratory (NREL), California leads the nation with more than 2,500 MWs of geothermal energy development, while virtually no

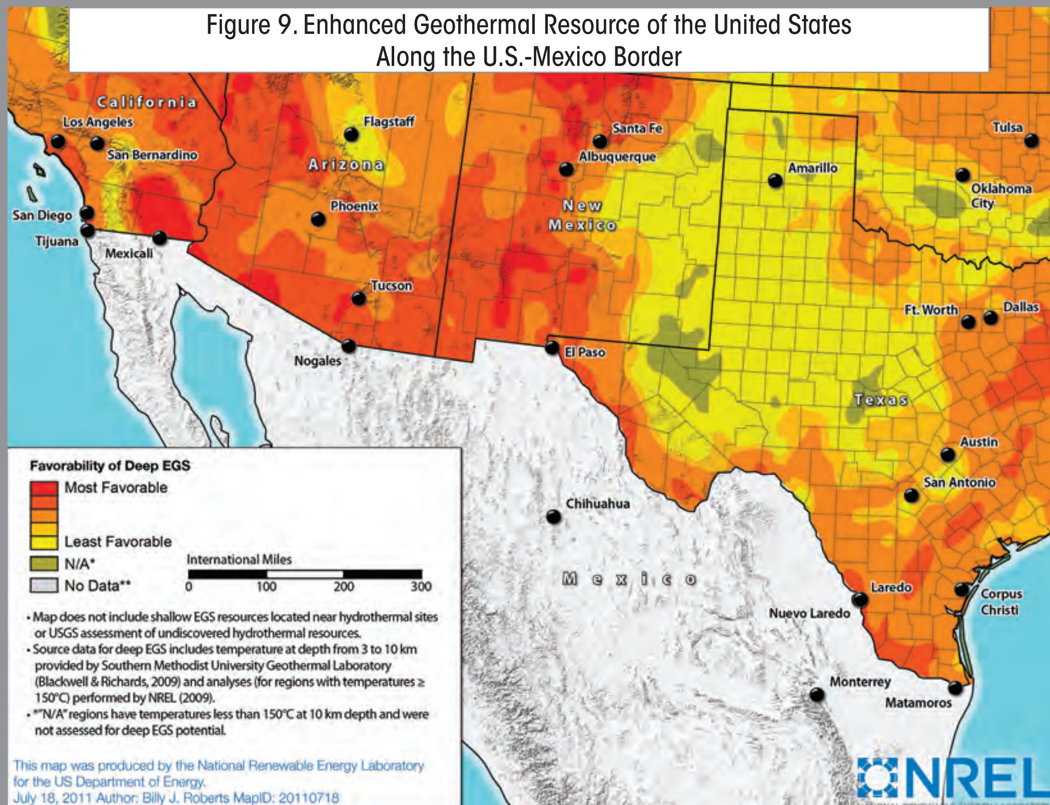


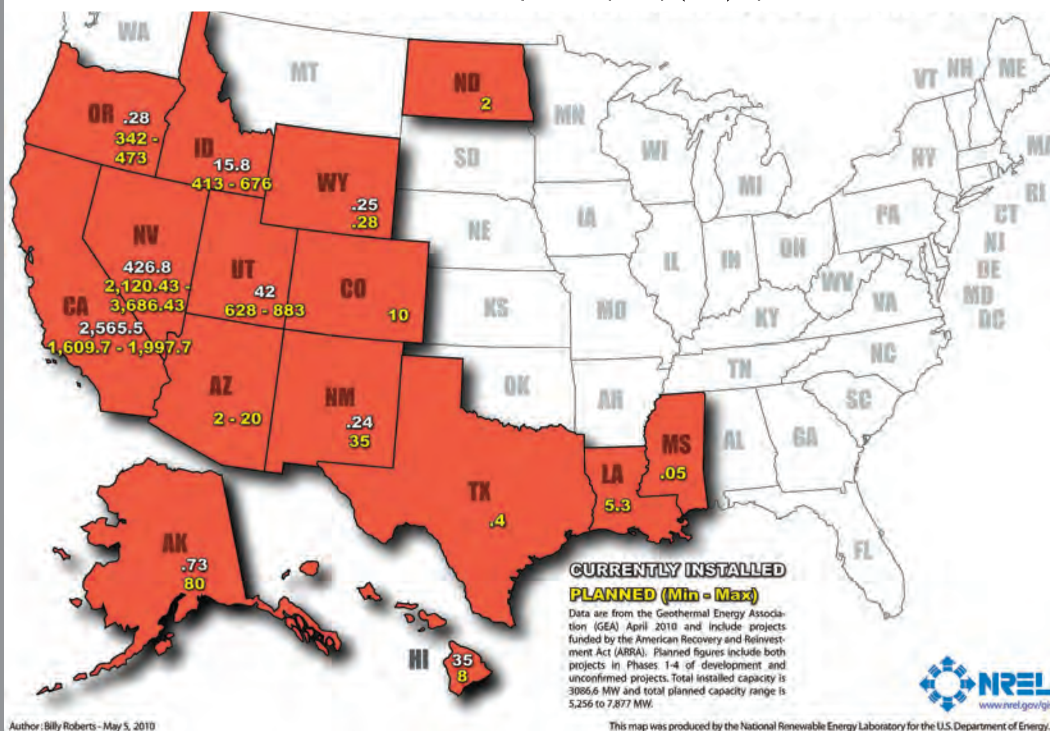
Figure 9. Enhanced Geothermal Resource of the United States Along the U.S.-Mexico Border

Source: National Renewable Energy Laboratory

development has occurred in the other three border states in the United States (Figure 10). There are some potential projects, however, under development in these states. Moreover, a map of deep geothermal resources shows that the border states, and border area in particular, are rich in geothermal resources. Thus, programs, policies, and efforts that provide research and incentives to develop geothermal energy could benefit the border region while providing more renewable energy.

In September 2010, DOE awarded $2 million to Utah-based GreenFire Energy to demonstrate how naturally occurring CO_2 found in the region located at the Arizona-New Mexico border known as St. John's Dome, can be used to generate geothermal power when injected underground and recaptured.[77] In 2009, New Mexico's first geothermal plant (10 MW capacity) began operations. Cyrq Energy (formerly Raser Technologies, who constructed the plant) is working on expanding the plant to a capacity of 25 MWs by the end of 2011, providing geothermal energy to the Phoenix area.[78] Recently, the Texas General Land Office announced that it had leased lands on Padre Island for geothermal development along the southeastern coast.[78] In Texas, thousands of old non-producing oil and gas wells provide ready-made testing grounds and potentially are vehicles for the development of geothermal resources.

Figure 10. Geothermal Power Generation
Current and Planned Nameplate Capacity (MW) by State



Source: National Renewable Energy Laboratory

Geothermal Power Plant Technology

Currently, there are three geothermal power plant technologies being used to convert hydrothermal fluids to electricity: (1) dry steam, (2) flash, and (3) binary cycle. The type of conversion used depends on the state of the fluid (whether steam or water) and its temperature. Dry steam power plant systems were the first type of geothermal power generation plants built. They use the steam from the geothermal reservoir as it comes from wells and route it directly through turbine/generator units to produce electricity. Flash steam plants are the most common type of geothermal power generation plants in operation today. They use water at temperatures greater than 360°F (182°C) that is pumped under high pressure to the generation equipment at the surface. The steam eliminates the need to burn fossil fuels to run the turbine, also eliminating the need to transport and store fuels. Binary cycle geothermal power generation plants differ from dry steam and flash steam systems in that the water or steam from the geothermal reservoir never comes in contact with the turbine/generator units. In binary cycle plants, the heat from geothermal steam typically is used to heat a different "working fluid" (with a lower vaporization temperature than water), which then is vaporized and used to power a turbine.

Understanding and Addressing Environmental Impacts of Geothermal Energy Use Along the U.S.-Mexico Border

In September 2005, DOE commissioned a Massachusetts Institute of Technology (MIT)-led interdisciplinary assessment panel to evaluate the technical and economic feasibility of enhanced geothermal systems (EGS) becoming a major supplier of primary energy for the United States by 2050. The 2006 MIT report summarized the findings of multiple studies on the environmental impacts of geothermal energy.[79] According to the report, most of the potentially important environmental impacts of geothermal power plant development are associated with groundwater use and contamination, and with related concerns about land subsidence and induced seismicity as a result of water injection and production into and out of a fractured reservoir formation. Issues of air pollution, noise, safety, and land use also merit consideration.

Potential Impacts on Water

Geothermal systems can have significant water requirements during development and operation. Geothermal plants use approximately 5 gallons of freshwater per MWh, while binary air-cooled plants use no fresh water. This compares favorably with 361 gallons per MWh used by natural gas facilities.[80]

One type of operation uses fresh water in the geothermal plant's cooling tower. The cooling towers are used to cool down hot geothermal fluids from production wells used to turn the turbines that generate the electricity before they are reinjected into the reservoir. In addition, during the cooling process some fresh water evaporates and must be replaced. The use of makeup water (water added to the system to replace the evaporative losses) contributes to depleting the already limited supply of fresh water resources along the border such as in Imperial County and other locations where geothermal energy is being exploited. A challenge for geothermal power companies would be to engineer new geothermal power plants that use less or no water for cooling.

Protection of water quality in aquifers is another potential issue, as evaporation of water during the cooling process also increases the total dissolved solids in the freshwater. Therefore, it often is necessary to contain the cooling tower water to meet standards to prevent degradation of aquifers.

Waste residuals from the various processes used to generate geothermal energy also can create environmental concerns. Often, the dry sludge that is produced during drilling operations or sludge from holding ponds or brine ponds such as those used in Imperial County must be removed and transported to licensed off-site locations for disposal because they can contain various contaminants. These contaminants can include oil derivatives, polycyclic aromatic hydrocarbons (PAH), phenols, cadmium, chromium, copper, lead, mercury, nickel, chromate and barite, which could damage ecosystems if not disposed of properly. In addition, the holding ponds will be used at times for other uses such as to retain geothermal brines and cooling tower blow-down during emergency situations, maintenance operations, spills and water from hydroblasting, portable shower effluent, vehicle wash station effluent, water from the plant conveyance system, lime sump effluent, and effluent from emission abatement equipment. Disposal of the sludge can be expensive depending on the concentrations of the chemicals that are present. Geothermal power companies should develop and use drilling techniques that reduce hazardous chemicals in the drilling to the maximum extent practical to preserve fragile, stressed ecosystems.

Brine routinely is piped from the brine pond back to a clarifier for reuse in the geothermal process. In that process, solids are removed prior to reinjection, often resulting in a filter cake being produced as a by-product of treatment. The filter cake also contains heavy metals that must be disposed of in a regulated facility. CalEnergy constructed and secured a permit for a solid waste facility solely for the purpose of disposing of filter cake from its geothermal plants. A challenge for geothermal power companies would be to engineer new systems to eliminate the filter cake and brine ponds.

Surface runoff is controlled by directing fluids to impermeable holding ponds and by injection of all waste streams deep underground. Well casings are designed with redundant barriers inside the well and adjacent formations to guard against fluids leaking into aquifers. Well monitoring during drilling and subsequent operation is important to detect and manage potential leakage in the event of casing failures.

Potential Impacts on Air Quality

Geothermal plants produce minimal air emissions, especially when compared to conventional power plants. Table 4 shows a summary of emissions into the atmosphere. Nitrogen oxides (NOx) and sulfur dioxide (SO_2) are negligible in the air emissions from geothermal steam and flash plants. Carbon dioxide emissions are far lower than fossil-fueled power plants.

Table 4. Air Emissions Summary

Plant Type	Nitrogen Oxides Lbs/MWh	Sulfur Dioxide* Lbs/MWh	Carbon Dioxide Lbs/MWh	Particulate Matter Lbs/MWh
Coal	4.31	10.39	2191	2.23
Coal, Life-Cycle Emissions	7.38	14.8	Not available	20.3
Oil	4	12	1672	Not available
Natural Gas	2.96	0.22	1212	0.14
EPA Listed Average of All U.S. Power Plants	2.96	6.04	1392.5	Not available
Geothermal (flash)	0	0.35	60	0
Geothermal (binary and flash/binary)	0	0	0	Negligible
Geothermal (Geysers steam)	.00104	.000215	88.8	Negligible

***Although geothermal plants do not emit sulfur dioxide directly, once hydrogen sulfide is released as a gas into the atmosphere, it eventually changes into sulfur dioxide and sulfuric acid. Therefore, any sulfur dioxide emissions associated with geothermal energy derive from hydrogen sulfide emissions.**

Source: Alyssa Kagel, Diana Bates and Karl Gawell, Geothermal Energy Association, "A Guide to Geothermal Energy and The Environment," 2007, http://www.geo-energy.org/reports/Environmental%20Guide.pdf.

Total non-condensable gas (NCG) emissions from geothermal resources typically comprise less than 5 percent of the total steam emitted.[80] If the NCGs contain toxic gases, they must be scrubbed to reduce the toxic gases to within the federally established emission limits. Some of the more common toxic gases that could be present are hydrogen sulfide (H_2S) and mercury vapor.[81,82] The concentration of these gases in the steam depends on the temperature in the area and the chemical composition of the ground, which can vary from one area to another.[83]

The removal of H_2S from geothermal steam is mandatory in the United States, and the most common process is the Stretford process, which produces pure sulfur and is capable of reducing H_2S emissions by more than 90 percent.[84] Since 1976, hydrogen sulfide emissions have declined from 1,900 lbs/hr to 200 lbs/hr or less, although geothermal power production has increased from 500 MW to more than 2,000 MW. Although such H_2S emissions usually do not pose a health risk and do not contribute to global climate change, the odor they produce has created objections in many areas.[85]

In total, the savings from present geothermal energy production in the United States, both electricity and direct-use, amounts to 45.7 million barrels (6.86 million tons) of fuel oil equivalent per year, and reduces air pollution by 6 million tons of carbon annually. CO_2 reduction is estimated at 17 million tons.[85]

Potential Impacts on Land

Geothermal power plants usually are built at or near the geothermal reservoir because long transmission lines degrade the pressure and temperature of the geofluid. Consequently, land footprints for such plants vary by site because the properties of the geothermal reservoir fluid and the best options for waste stream discharge are highly site specific. Well fields can cover 5 to 10 km^2 or more, but the well pads themselves cover only about 2 percent of this area. Directional drilling techniques enable multiple wells to be drilled from a single pad to minimize land use. The footprint of the power plant, cooling towers, and auxiliary buildings is relatively modest. Holding ponds for temporary discharges can be sizeable but still represent only a fraction of the total well field.

Compared to nuclear and conventional fossil-fuel power plants, geothermal technologies have lower land use impacts, ranging from 7 to 50 times less area needed for geothermal plants compared to these other plants.[79] In geothermal technologies, there is no physical mining in the conventional sense, or transportation over long distances from the energy source. The adverse environmental impacts of mining and transportation of the fuel are well documented.

Wastewater Injection:

Success at The Geysers

A wastewater injection project was initiated in December 2003, at The Geysers geothermal reservoir, a complex of 22 geothermal power plants, drawing steam from more than 350 wells located in the Mayacamas Mountains 72 miles north of San Francisco, California. Treated wastewater from the nearby community of Santa Rosa previously had been discharged directly into the Russian River, prompting state water quality regulators to take action against the community. Now, 11 million gallons of treated wastewater from Santa Rosa are being pumped daily to The Geysers for injection into the geothermal reservoir. Any residual biological contamination in the wastewater is instantly sterilized upon contact with the reservoir rock (usually above 400°F). The project also has been of great help in maintaining the sustainability of the geothermal reservoir. The additional water being pumped into the geothermal reservoir has helped recharge the resource to make full use of the heat still trapped in the Earth's rock and has slowed the decline of the resource. The $250 million project has proved successful so far in reducing surface water pollution for the community of Santa Rosa, and also has helped to improve the sustainability of the geothermal reservoir.

Other Potential Impacts

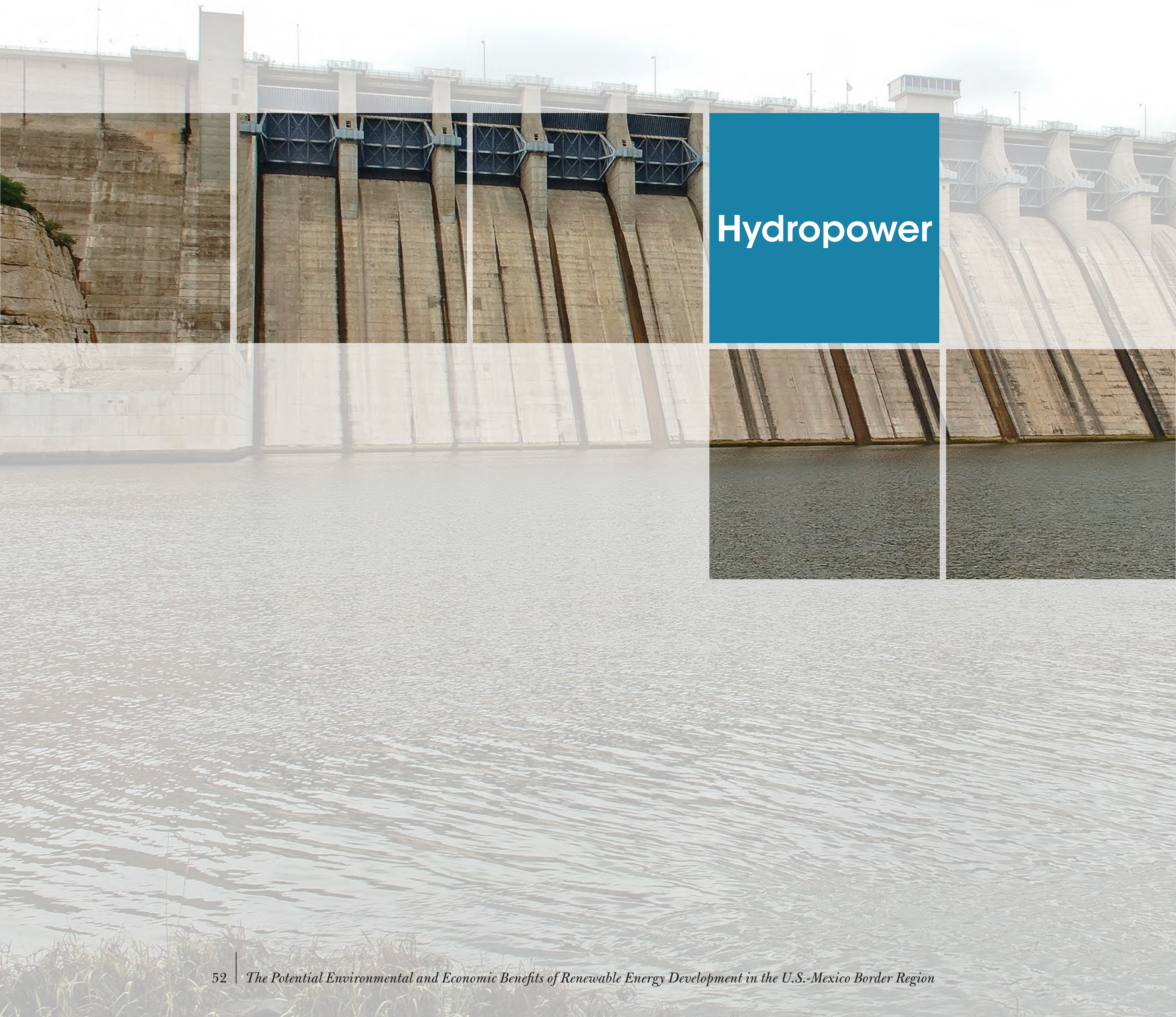
Noise Pollution

Noise from geothermal operations is typical of many industrial activities, with the highest noise levels produced during well drilling, stimulation, and testing (80 to 115 decibels).[79] Noise levels during normal geothermal power plant operation range from 71 to 83 decibels (comparable to a congested urban area) at a distance of 900 m, dropping rapidly with increased distance from the source.[79]

Disturbance of Wildlife, Vegetation, and Scenic Vistas

Development of geothermal fields may result in removal of trees and brush to facilitate installation of well pads, holding ponds, and so on. Geothermal plants tend to have a low profile and are less conspicuous than wind turbines, solar power towers, or coal plants. Any power generation facility built where none existed will alter the view of the landscape, but with care and creativity, geothermal plants can be designed to blend into the natural surroundings. Once the geothermal plant is built, reforestation and plantings can help restore an area to a semblance of its original natural appearance, helping to mask the presence of building and other structures. Several geothermal power plants co-exist with agricultural fields in the Imperial Valley of California.

Hydropower



"The potential for creating jobs in renewable energy also is extremely important to this region."

Although much of the border region is desert, hydropower plays a significant role in providing renewable energy to the U.S. border region. In particular, the Colorado River is a major source of power generation for the region while the Rio Grande's hydropower resources, although more limited, are unique because of the existence of international dams where power is generated for both the United States and Mexico. By using the power of water to generate electricity, hydroelectric power plants provide a reliable source of renewable energy.

Federal Hydropower in U.S. Border States

Along or near the Mexico border in California, Arizona, New Mexico, and Texas, federal hydropower resources on the two major transboundary rivers—the Colorado River and the Rio Grande—are produced by the following dams and projects. All are operated by the Bureau of Reclamation (Reclamation), part of the U.S. Department of the Interior (DOI), unless indicated otherwise.[86,87,88]

Hoover Dam: Straddling the Colorado River outside of Las Vegas at the Arizona-Nevada border, Hoover Dam at Boulder Canyon creates Lake Mead. The Hoover Power Plant produces about 2,074 MW, enough electricity for nearly 8 million people. About 58 percent of power generated at Hoover Dam is delivered to California, 19 percent to Arizona, and 23 percent to Nevada.

Parker Dam: Parker Dam on the Colorado River, which forms Lake Havasu near Parker, Arizona, is 155 miles downstream from Hoover Dam. The capacity of the power plant is 120 MW.

Davis Dam: Davis Dam, on the Colorado River near Laughlin, Nevada, and Bullhead City, Arizona, is 67 miles below Hoover Dam. Its capacity is 255 MW. The combined Parker-Davis Project includes transmission lines in Arizona, southern Nevada, and California, to supply power to 26 municipalities, cooperatives, federal and state agencies, and irrigation districts.

Glen Canyon Dam: Located on the Colorado River near Page, Arizona, Glen Canyon Dam's power plant has a generating capacity of 1,320 MW.

Elephant Butte Dam: The hydroelectric plant at this dam on the Rio Grande in Truth or Consequences, New Mexico, has a capacity of nearly 28 MW.

Falcon Dam: Falcon Dam, located near Laredo, Texas-Nuevo Laredo, Tamaulipas, is one of two international storage dams on the Rio Grande built and operated by the International Boundary and Water Commission, United States and Mexico (IBWC). The United States and Mexico operate separate power plants on each side of the Rio Grande. The U.S. Section of the IBWC operates the U.S. portion of the project, including the U.S. power plant with a capacity of 31.5 MW.

Amistad Dam: The other major IBWC dam, Amistad, is located near Del Rio, Texas-Ciudad Acuña, Coahuila. Like at Falcon Dam, each country has its own power plant. The U.S. power plant's capacity is 66 MW.

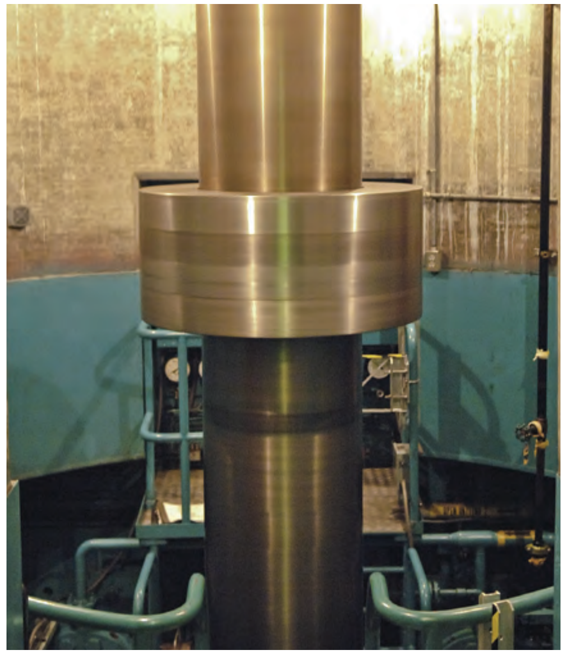
Border Region Hydroelectric Facilities Owned by Reclamation but Operated and Maintained by Others

As part of Reclamation's **Boulder Canyon Project** (which includes Hoover Dam), there are various smaller power plants along the All-American Canal, a U.S. irrigation canal that parallels the U.S.-Mexico border in portions of Arizona and California. The Imperial Irrigation District operates these plants with a total generating capacity of 87 MW.

The Central Arizona Project has the New Waddell Pump/Generating Plant in Phoenix, with a capacity of 36 MW, operated by the Central Arizona Water Conservation District.

The Salt River Project, also in Phoenix, includes seven power plants operated by the Salt River Valley Water User's Association, with a total capacity of 239 MW.

Improving Existing Hydropower Plants



Following the 1973 oil embargo, Reclamation's power plants were reviewed to determine if they could be uprated to a higher capacity to produce more energy. Uprating existing hydropower plants to utilize the available water resource fully for additional energy and peaking capacity was recognized as one of the better long-range additions to help solve the energy problem. In 1978, Reclamation and the DOI established, as one of their major program goals, the investigation and implementation of all viable opportunities to improve existing plants by modernizing and uprating the generating equipment. Since 1978, Reclamation initiated a power uprating program to increase the capacity of Reclamation facilities as funding and unit availability allowed. In addition, there have been a number of generator rewinds where no appreciable uprate potential existed but winding condition was poor.

Uprating hydroelectric generator and turbine units at existing power plants is one of the most immediate, cost effective, and environmentally acceptable means for developing additional electrical power. As a result of the uprating program, Reclamation's generating capacity has increased by approximately 2,000 MW.

Through this initiative, rehabilitation of the power plant at Hoover Dam is planned for 2012 with installation of wide head turbines, providing greater efficiency at lower lake levels. A rewind project at Davis Dam is forecast for 2018.

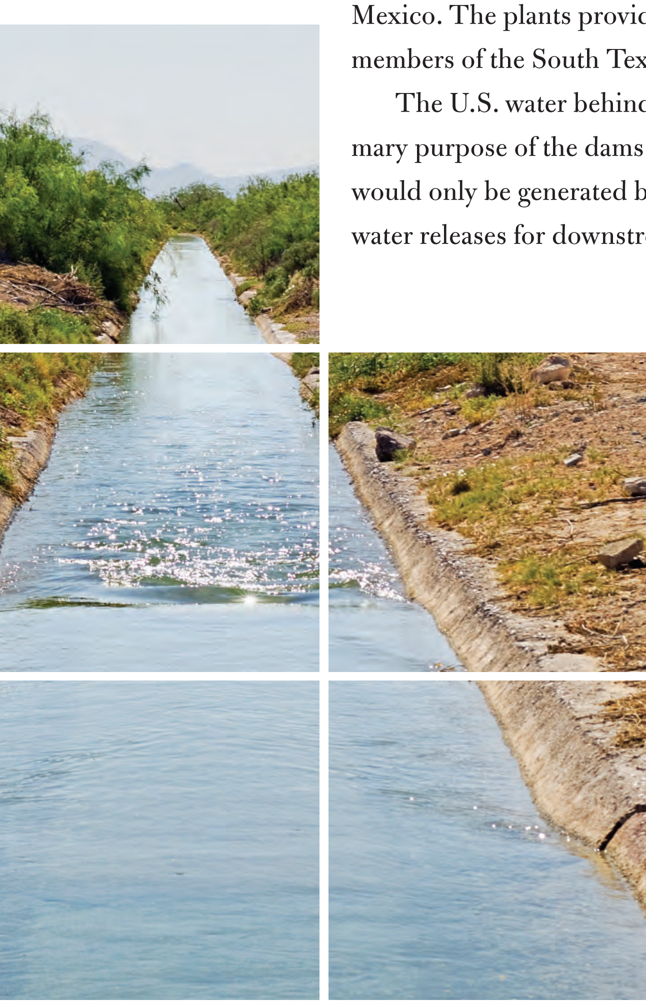
Low-Head Generation

In a region known more for deserts than water resources, the importance of hydroelectric power may be surprising. Unfortunately, drought that routinely affects the U.S.-Mexico border region and that is projected to worsen due to the effects of climate variability, affects not only the availability of water but of hydroelectric power. The IBWC undertook a study to see if new technologies in low-head hydropower generation could produce power during these periods of drought in the border region.

During the Rio Grande drought of the 1990s and early 2000s, water releases from Amistad and Falcon Dams were so low that water could not be run through the turbines and generators at the hydroelectric power plants in the United States and Mexico. In accordance with the 1944 Water Treaty between the two countries, water released from the dams generates power equally for both countries regardless of the national ownership of the water being released.

Currently, the Amistad Power Plant cannot generate electricity at releases of less than 30 cubic meters per second (1,059 cubic feet per second) while Falcon cannot generate below 14 cubic meters per second (494 cubic feet per second). A low-head generator would produce power at lower release levels, potentially generating 26 to 56 gigawatt hours per year at Amistad or 3 to 6 gigawatt hours per year at Falcon. The increased power generation would be shared between the United States and Mexico. The plants provide a portion of power to, and therefore would benefit, some 170,000 U.S. members of the South Texas Electric Cooperative.

The U.S. water behind the reservoirs belongs to Texas water rights' holders. Because the primary purpose of the dams is to store water for agricultural, municipal, and industrial uses, power would only be generated by the low-head turbines if Mexico or the State of Texas were to request water releases for downstream users.



In December 2010, both countries through the IBWC agreed to move forward on the development of a report that would outline how a low-head power generation turbine project would be planned, designed, and constructed. The report is expected to be completed in 2012.

Preliminary research indicates that it is more feasible to install a unit on the Mexican plant at Amistad because of existing infrastructure there and it can be done with minimal disruption of power generation. If installed at the U.S. power plant, however, power production would be shut down for 12-18 months and construction of a coffer dam and building expansion would be required. Likewise, because of existing infrastructure at Falcon Dam, conditions there are much more favorable for installation of the low-head unit on the U.S. side as compared to the Mexican plant.

Budgetary estimates project the cost to be in the range of $7 million for the unit at Falcon and possibly $11 million at Amistad. Final cost estimates are subject to detailed designs. Potential funding sources include the Western Area Power Administration and Mexico's Federal Electricity Commission. If the project is undertaken, these low-head units would allow IBWC to continue to generate clean hydroelectric power even during drought conditions.

Retrofitting Existing Dams or Locks with Hydroelectric Capacity

In March 2011, DOI released a report titled "Hydropower Resource Assessment at Existing Reclamation Facilities,"[89] which indicates that DOI could generate up to 1 million MWh of electricity annually and create jobs by adding hydropower capacity at 70 of its existing facilities. The report cited 70 sites with the highest benefit cost ratio, including a few in the U.S.-Mexico border region, identified in Table 5. The ratio used incorporates incentives, such as rebates, tax credits, or grants available from existing federal and state programs for developing clean renewable energy, including hydropower.

Table 5. Reclamation Facilities Along the U.S.-Mexico Border Region With Positive Benefit Cost Ratio for Installation of Hydroelectric Power Generation

Facility Name	Installed Capacity (kW)	Annual Production (MWh)	Benefit Cost Radio
Arizona			
Gila Gravity Main Canal Headworks (Gila River)	223	1,548	1.17
Imperial Dam (Colorado River)	1,079	5,325	1.61
New Mexico			
Caballo Dam (Rio Grande)	3,260	15,095	1.45

Source: U.S. Bureau of Reclamation, http://www.usbr.gov/power

Low-Head Hydroelectric Power in Irrigation Canals

The Elephant Butte Irrigation District (EBID), which serves more than 90,000 acres of farmland with Rio Grande water in southern New Mexico, has started generating electricity at its irrigation canals. EBID built its first station in 2009 near Las Cruces, New Mexico, and recently completed a second. As water flows through a canal toward a 12-foot drop, it powers the turbines, which generate electricity used to pump water from the canal to a farmer's fields. Given high fossil fuel prices, the use of hydroelectric power in the irrigation district could significantly reduce the energy costs for farmers to run pumps.

EBID has identified more than 100 sites within the district where such a system could be installed. EBID has a vision of eventually selling power generated from the district's canals to the electric company. However, to do so requires a license from the Federal Energy Regulatory Commission. According to EBID officials, the costs associated with obtaining one license can be more than $100,000, which could make the plan to sell the power cost prohibitive.

Bureau of Reclamation Commissioner Mike Connor stated that the report is not a feasibility study but "provides information that allows DOI and developers to prioritize investments in a more detailed analysis that focuses on sites demonstrating reasonable potential for being economically, financially, and environmentally viable."[90]

Much of the current focus for federal hydroelectric power projects is to improve existing projects through application of innovative technologies and efficiency improvements rather than to construct new facilities. In the border region, these types of efforts can help to increase the generation of clean hydroelectric energy without requiring construction of new dams. At the same time, some of the negative environmental impacts of existing dams can be mitigated.

Understanding and Addressing Environmental Impacts of Hydropower Along the U.S.-Mexico Border

Hydropower is practically emissions-free, yet the environmental impact of hydroelectric power plants still can be significant.[91] This section will discuss some of the environmental benefits of hydroelectric power and negative impacts, particularly to wildlife, caused by disrupting a river's natural flow through the construction of dams.

Hydropower is considered environmentally beneficial in that it is renewable and generated with little or no direct combustion emissions. Hydropower facilities have the ability to start generation without an outside source of power. This so-called "Black Start" capability exists at Hoover, Elephant Butte, Amistad, and Falcon Dams, allowing system operators to provide auxiliary power to more complex generation sources that could otherwise take hours or even days to start. Hydropower output can be changed quickly in response to changes in electrical demand because of the ability to control the flow of water. This ability is considered essential to electric transmission grid stability. Once a facility has been built, hydropower is one of the least expensive sources of electricity to operate because there is no fuel cost. Maintenance of dams and infrastructure is the major ongoing expense to generate electricity. Some dams serve multiple purposes, as water stored for irrigation or flood control purposes also can support recreational activities.

The extent to which hydroelectric projects affect riparian ecosystems depends on many key variables, most notably, the amount of water that is stored for electric generation.[92] When dams flood significant portions of land upstream, turning rivers into lakes, the change in habitat can affect wildlife and have especially dramatic affects on migratory fish populations. Similarly, the development of dams can adversely affect water quality, as the clearing of trees can result in soil erosion and landslides that can lead to a buildup of sediments and clogged streams. Spilling water from dams can force atmospheric gases into solution in the basin water below, making the basin water supersaturated and potentially killing fish.

Water quality for aquatic life also can deteriorate if reservoirs limit the natural flow of water downstream. Water can become stratified, with warmer water collecting at the surface and cooler water staying at the bottom. Because the bottom water is isolated from aeration, it loses its oxygen. Many fish cannot live in these conditions. When this deep water passes through hydropower turbines, it is still low in dissolved oxygen and it also can affect the quality of water downstream of the dam. A lack of oxygen in deep reservoir water can cause certain metals to dissolve more readily from surrounding rocks, and these metals can be released to the downstream river where they can cause water to become toxic.

Even if the water quality is not degraded, major habitat impacts can occur if the natural hydrology of the river is changed (i.e., “in-stream flow” effects). If the amount of water released downstream changes, either on a seasonal basis or even on an hourly basis, adverse effects on fish and other organisms can result.

Mitigation

There are some measures that can be taken to address continuing environmental impacts. It is important to remember that these measures are part of a much larger and complex whole. One incentive for hydroelectric facilities to help mitigate their overall impact on the environment is through renewable power certification. The Low Impact Hydropower Institute’s (LIHI) mission is to reduce the impacts of hydropower dams through market incentives.

LIHI is a nonprofit 501(c)(3) organization dedicated to reducing the impacts of hydropower generation through the certification of hydropower projects that are well sited and well operated in accordance with objective and scientific environmental standards.

The Certification Program’s goals are to reduce the environmental impacts of hydropower generation, and to create a credible and accepted standard for consumers to use in evaluating hydropower. The Certification Program’s objective to meet these goals is to establish certification criteria that hydropower facilities must meet in the following eight areas: (1) river flows, (2) water quality, (3) fish passage and protection, (4) watershed protection, (5) threatened and endangered species protection, (6) cultural resource protection, (7) recreation, and (8) facilities recommended for removal. A hydropower facility meeting all eight certification criteria will be certified as a Low Impact Hydropower Facility, and will be able to use this certification when marketing power to consumers.[93] The Institute has certified 73 hydropower facilities in the United States, none of which are in the U.S.-Mexico border states.

Improvement of hydropower resources along the U.S.-Mexico border presents a mix of opportunity and potential problems that are inherently site dependent. Decisions about these resources should reflect this individuality, the fact that some of the opportunities can be better utilized, and the reality that all river resources need to be managed for multiple uses, not just energy.

Economic Impacts of **Renewable Energy**
Development in the U.S.-Mexico Border Region

3 Chapter

Market Opportunities for Utility-Scale Renewables

From solar to wind power, biomass to hydropower, and to some geothermal capabilities, the U.S.-Mexico border region presents market and economic development opportunities. These opportunities are due both to the natural resources present as well as the economic drivers, which include both the increasing demand for electricity in general and the specific demand for renewable energy. Market opportunities also derive from combining programs and policies to "co-locate" energy efficiency, demand response and renewable energy, and these could lead to the expansion of the use of renewable energy, and particularly distributive renewable energy. For example, building codes governing water conservation, energy, and building materials can encourage the construction of more energy-efficient buildings, incorporating the use of technologies such as combined heat and power systems, solar water heating, photovoltaic (PV) and geothermal heat pumps, among others. Likewise, building retrofits can add both energy efficiency and technologies for saving energy, including the use of renewable energy. The recent American Recovery and Reinvestment Act (ARRA) included billions of dollars in grants that states could use to provide monies for retrofit and add-ons of renewable technologies to existing buildings. Moreover, because of a variety of new U.S. environmental regulations under development, many utilities are considering the retirement of older fossil fuel plants, which could expand the potential for renewable energy development.

When coupled with job training and incentives for job creation, the use of renewable energy sources also has the potential to create linkages with local economies and encourage the location of suppliers and manufacturers within the border region. This could lead to complementary economic policies or create enclaves, increasing the potential for the border to serve as a good location for the renewable projects. Local communities have concerns, however, that the majority of the wealth and jobs that are created may not stay in the region.

Finally, the special characteristics of the border area open up some potential opportunities as power plants on the U.S. side could serve demands on the Mexican-side of the border, and vice versa. In the latter case, if some of the parts were manufactured or designed in the United States, specifically in U.S. border communities, these plants could generate employment as well as potential environmental benefits for the U.S. border states. Obtaining resources within Mexico, however, is controversial, as such efforts would require careful monitoring of compliance with environmental regulations and could potentially undercut U.S. job creation. The development of renewable resources in northern Mexico should consider benefits to economic and social interests in the United States and the border state electricity markets, while honoring commitments under trade agreements.

Job Growth and Job Growth Potential

The "clean energy economy" already has created thousands of jobs in the border states. A 2009 Pew study found that California and Texas were the leaders in the creation of jobs from a combination of energy efficiency, renewable energy development, pollution control equipment, and research and development.[94] A more recent Brookings study using a broader definition of clean economy found an even larger number of jobs had been created between 2003 and 2010. The Brookings study also looked at the most populated 100 individual cities, which included two border cities and another just outside of the border region: San Diego, California; El Paso, Texas; and Tucson, Arizona.[95] The analysis offers a contrast in terms of the number of jobs nationwide created in the "clean" economy. El Paso ranked 92nd with 2,695 jobs, Tucson ranked 79th and San Diego ranked 21st with 22,862 jobs.

Studies conducted on the potential of a federal Renewable Electricity Standard (RES) have pointed to the advantages it might provide to certain areas of the country, including the Southwest, while also providing the renewable energy industry with more certainty by establishing a national standard as opposed to individual state goals. A Union of Concerned Scientists study in 2009 found that a "25 percent by 2025" national RES would lead to some 300,000 jobs, and create three times as many jobs as producing the same amount of electricity from fossil fuels.[96] Similarly, a 2009 report released by the Blue-Green Alliance showed that a 10-year effort to introduce 185,000 megawatts (MW) of renewables—the rough equivalent of

a 15 percent RES—had the potential to create 850,000 jobs with $160 billion of investments in manufacturing.[97] Interestingly, under this scenario the most job growth would occur in Texas and California, although the report did not detail what geographic regions within each state would receive the most benefit.

Job growth is even greater if studies look not only at renewable energy generation but also at energy efficiency. A recent study in Texas found that if policies were changed to raise the requirements for meeting all demand growth through energy efficiency and designed to encourage the use of combined heat and power systems, some 46,900 jobs would be generated in Texas.[98]

The benefits of job growth depend on the type of jobs created, and a key factor in attracting well-paying and secure jobs is a skilled labor force. Currently, labor departments (often now referred to as "departments of workforce solutions") in each state are devising programs for labor training based on economic assumptions of relative demand.

To facilitate a long-term job development strategy, it is necessary to develop assumptions about the medium- and long-term behavior of the economy as a whole and the interactions among sectors within it. As an example, input-output analysis such as provided by JEDI II, a program developed at the NREL, is a useful tool for this purpose.[99]

To benefit from new economic opportunities, in addition to understanding what job skills may be required according to assumptions about economic growth and corporate repositioning, border residents also must have access to a training infrastructure, which may not be in place yet. Significantly, high school curricula are being developed and tested to provide graduates with the job skills required for employment in the clean energy economy.

Federal and state programs have emerged to support workforce development efforts, from incentive programs, on-the-job-training programs, ridership programs, to environmentally sound economy programs, and information about these programs is vital to local communities.

Enhancing Local Benefits While Meeting the Demand

There is growing need for energy in residential, commercial, and industrial applications. Stimulated by consumer appetite for energy choices, economic inducements, and regulatory requirements, the demand for alternative energy goods and services has been increasing steadily for the past 10 years and is likely to continue. The border region exhibits opportunities for export from existing renewable energy sectors and the development of businesses in construction, manufacturing, and service sectors to meet local needs in the border states at large. Energy production should have low environmental impact, in the manufacture of equipment, siting and generation, and be high value added with a significant benefit accruing to local communities in the form of revenues and employment.

Easily, the most available activity with short-term impact is the adoption of conservation and energy efficiency technologies. Unlike some of the more expensive residential systems devoted to generation of electricity, conservation techniques can benefit low-income families currently paying high prices for energy, and often can result in rebates to those families.

Beyond job growth, key benefits that can accrue to local economies from growth in the renewable energy sector include savings in municipal energy costs; increased revenues from sales taxes, permitting fees, and payroll taxes; and investment in operating capital, infrastructure, and equipment. Some of the larger municipalities use input-output analysis to project the effects of increased economic activity, although forecasting return on investment generally does not occur at the local level.

In addition, savings to local communities are a sometimes-overlooked economic benefit from alternatives to conventional electricity production and supply. Some examples include:

- In the arid Southwest, a large part of the typical municipal utility budget is devoted to the pumping of potable water and wastewater treatment—in some cases as high as 80 percent. Silver City, New Mexico, expects to break ground in September 2011 on a 1 MW facility that is expected to save the town $2 million during the next 20 years in pumping costs for wastewater through a PPA modeled on a successful program in Santa Fe.

- Hatch Valley public schools have inaugurated a 100 kW PV solar energy system under ARRA. The Ruben Torres Elementary School in Deming, New Mexico, in a county chronically characterized by high unemployment, already has received a check for $78,000 from the local electric cooperative representing savings from its geothermal energy system.

- Municipal lighting of buildings, traffic signals, and streetlights are other sources of considerable expense for small town and large city budgets alike. Programs to retrofit conventional lighting sources have resulted in savings of well over $100,000 a year for 20 years in some smaller cities.

What Drives the Growth of the Renewable Energy Economy

Although the border population is a relatively small proportion of each of the U.S.-Mexico border states, averaging about 10 percent of the total population of these states, this nevertheless represents more than 7 million people in a rapidly growing geographic area. In the four border states, renewable energy economic activity is concentrated in utilities and construction, followed by wholesale trade. The potentially more lucrative manufacturing activities are relatively few. This section examines the factors that affect economic activity.

Policy

Federal, tribal, state, and local policies all have been fundamental drivers of current infrastructure devoted to renewable energy development. The continuation or expansion of these policies will affect ongoing and future developments, while a change away from existing financial incentives and mandates could negatively impact development on the border.

Major State Policies

In the U.S. border states, the fundamental state policy that has led to the development of utility-scale renewables has been the renewable portfolio standard (RPS). RPS policies require a percentage of electric demand to be met by renewables but let the markets determine the price for renewable electricity. Although RPS policy designs vary among the four states, it can be argued that the past and current development would not have been possible without these policies. The quick installment of wind generation in West and East Texas between 2005 and 2010 was conducted to meet Texas' RPS and the current development of solar resources in southeastern California was done to meet that state's RPS.

Although several bills have been introduced at the federal level to create a national RPS, there currently is no federal law mandating that a certain percentage of renewable resources serve the United States.

States also differ in how they approach the development of onsite renewable resources, sometimes known as distributed generation. New Mexico has a specific set-aside for onsite renewables as part of the RPS, while California has created a multi-billion dollar incentive program for onsite solar. New Mexico offers no specific state or local rebates for solar or other onsite renewables, while Texas and Arizona only offer them through local and utility programs, and there is no specific mandate to do so. In Arizona, several of the local electric cooperatives along the border offer solar rebate programs, in part to help meet their RPS requirements. In New Mexico, although there is no rebate program, in an effort to meet their RPS requirements, the three major investor-owned utilities all offer performance-based incentives to those installing solar capacity.

Other important policies for the development of onsite renewables include grid interconnection requirements and how surplus electricity generated back into the electric grid is treated and paid for, a policy commonly known as net-metering. These state and/or local utility policies can have a direct impact on the economics and development of onsite solar. Policies that make the installation of small-scale solar and wind cheaper and easier generally will lead to more installed capacity. Arizona, New Mexico, and California all have established statewide net-metering policies, but Texas has not, though some individual utilities have done so.

Federal Policies

Federal Financing and Tax Incentives

Although the state RPS, energy efficiency standards, and onsite renewable policy and incentives have been important tools in the development of renewables, federal rules and incentives, such as production and investment tax credits, have played a vital role. The development of wind energy in Texas closely tracked Congressional reauthorization of the Production Tax Credits. Similarly, the Investment Tax Credit has been a crucial factor in the development of solar energy.

A key issue for the development of renewables will be the continuation of these incentives at the federal level for a defined period of time, which allows these nascent industries to reach cost parity with previously incentivized fossil and nuclear energy. Many of these programs are scheduled to expire between 2012 and 2016, or are subject to budget allocations, meaning their continuation may come into question.

As part of the federal stimulus package, the government allowed projects to choose an upfront grant to help cover up to 30 percent of the cost of renewable energy projects rather than utilizing a 10-year tax incentive. This section 1603 program has facilitated more than $30 billion in manufacturing and construction since 2008. A further financial incentive provided for some public utility providers was the use of CREBs, or Clean Renewable Energy Bonds, in which the federal government lowers the cost of debt financing by providing a tax credit to bondholders in place of interest payments from the bond issuer. Tax-Exempt Private Activity Bonds are another source of funding that can be used by state and local governments to finance certain types of energy and infrastructure projects. The interest paid to holders of these bonds is not included in gross income calculations for federal income tax purposes.

Through ARRA and another piece of legislation, $2.4 billion was allocated to develop renewable energy projects throughout the United States. The federal government has been investing directly in programs through federal loan guarantees. Thus, several of the large solar installations occurring in California are being backed by the approximately $10 billion available for such projects. The DOE's Loan Program has committed more than $30 billion to support 42 renewable energy projects. These include several solar projects in the border area in Arizona, including Sempra's Mesquite Solar 1 in Maricopa County, Arizona; Abengoa Solar in Gila Bend, Arizona; and Agua Caliente in Dateland, Arizona.

Siting and Transmission

The siting of the renewable energy projects themselves as well as the siting of transmission can create an opportunity for development in the border region as well. Given the great potential for wind and solar power generation in the U.S. states that border Mexico, the federal government has the opportunity to support installation of renewable energy projects at its facilities or on federal lands. Where sufficient land exists and environmental considerations are addressed, larger renewable energy generation projects could be installed on federal lands, particularly those located near transmission lines. These projects could power any federal buildings at the site and potentially could feed power to the grid.

The federal policy to encourage the use of federal BLM lands to be used for siting large-scale renewable energy projects has led to several being developed in the border areas in California and Arizona. Importantly, this policy has included a programmatic Environmental Impact Study to try to predetermine the appropriate location of such large-scale renewable projects. The Department of Defense (DoD) is the single largest energy consumer in the United States, accounting for about 90 percent of the federal government's energy use, and in 2002 Congress set aside funding to assess the renewable energy potential of U.S. military installations. The DoD formed a Renewable Energy Assessment Team to explore solar, wind and geothermal energy resources at military installations. By mid-2009, the resulting Energy Conservation Investment Program generated plans for more than a dozen projects in the Air Force alone, with expected savings of more than $4 million per year. [100] In 2011, an Energy Initiatives Task Force for Large-scale Renewable Energy Projects was created with the explicit goal of getting 25 percent of the U.S. Army's power from renewable sources by 2025. Within the border region, for example, Fort Bliss, in El Paso, Texas, has a goal of being energy independent by 2015 and of reducing its water consumption and using some of El Paso's waste to produce electricity by 2018.[101]

Efforts to identify and address transmission needs and challenges are occurring at many levels. The Western Governors Association (WGA) began its own process to identify transmission needed to take advantage of renewable resources. During the past several years, the WGA has undertaken an initiative to determine where large-scale electrical generation from renewable sources might be possible in the western states. The 2009 *Western Renewable Energy Zones (WREZ)—Phase 1 Report* explains the methodology used to identify sites capable of producing sufficient power for distribution on a regional basis and established population density and transmission proximity criteria for the designation of locations as potential production sites.[102]

In June 2009, DOE announced the availability of stimulus funds to analyze transmission requirements under a broad range of alternative energy futures and to develop long-term, interconnection-wide transmission expansion plans. In December, DOE announced that a combined total of $26.5 million would be given to the WGA and the Western Electricity Coordinating Council to complete this work. WGA and its affiliate, the Western Interstate Energy Board, are concentrating their efforts in two major areas: continuation of activities initiated under the WREZ project and the development of alternative energy futures that can be modeled into transmission plans that will open up high-quality renewable resource areas.

The Western Area Power Administration (Western) is a federal agency under DOE that markets and transmits wholesale hydroelectric power across 15 western states, including the four U.S. states along the border with Mexico—California, Arizona, New Mexico, and Texas. Western's transmission system carries electricity from 57 power plants operated by the Bureau of Reclamation, U.S. Army Corps of Engineers, and the U.S. Section of the International Boundary and Water Commission (IBWC). Two-thirds of the power is sold to state agencies, cooperatives, and municipalities.

In 2009, under the American Recovery and Reinvestment Act (ARRA), Congress expanded Western's role to include the Transmission Infrastructure Program (TIP). The program provides authority to borrow up to $3.25 billion from the U.S. Treasury to develop transmission infrastructure that delivers renewable energy across the West. Project beneficiaries will repay project costs. Projects considered for funding under this authority will be evaluated against the following criteria. The project:

- Facilitates delivery to market of power generated by renewable resources constructed or reasonably expected to be constructed
- Is in the public interest
- Will not adversely impact system reliability or operations, or other statutory obligations
- Is reasonably expected to generate enough transmission service revenue to repay the principal investment; all operating costs, including overhead; and accrued interest
- Has at least one terminus within Western's service territory
- Provides economic development benefits, including job creation
- Satisfies Western's Open Access Transmission Tariff
- Has technical merits and feasibility

- Has financial stability and capability of potential project partners
- Has project readiness
- Participates in region-wide or interconnection-wide planning groups or forums

The Sonoran-Mojave Renewable Transmission (SMRT) Project,[103] which involves nine public and private power firms or entities, is aimed at taking a regional look at the feasibility of: (1) providing transmission capacity for renewable resources, (2) providing wholesale and retail markets in Arizona and California access to those renewable resources, and (3) providing a more robust transmission grid in the southwestern United States.

To date, insufficient attention has been paid to opportunities to co-locate facilities that take advantage of different renewable resources in a single geographic area. Given the large land requirements of both wind and solar projects, as well as the need for transmission, co-location of projects that use wind (which generally blows more at night) and solar (which has its greatest impact in the middle of the day) has the potential to lower costs and potential impacts. Future analysis of these and similar potentials could help foster appropriate renewable energy development in the border region.

The Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADB)

When the NADB and its sister institution, the BECC, were created in 1993 as part of a side agreement to the North American Free Trade Agreement (NAFTA), their primary focus was on the creation of environmental infrastructure on both sides of the U.S.-Mexico border to help alleviate the scarcity of proper systems to provide potable water, wastewater treatment, flood control, and solid waste management. The focus of these binational agencies has expanded in recent years, during which the BECC and NADB have been examining the potential to move into financing renewable energy projects.

The BECC and NADB are authorized to provide grants for project development and loans for implementation of renewable and efficient energy infrastructure projects. The NADB recently provided a contract for a loan credit of $77.4 million to Imperial Valley Solar Company for a solar PV utility plant in Imperial County. It previously has helped finance a biofuels plant in El Paso, Texas. In addition, the EPA and NADB financed the construction of a wastewater treatment plant for Nogales, Sonora. In an example of positive synergy, EPA and Mexican federal and state commissions have agreed to finance the construction of a solar array to supply 100 percent of electrical energy needs to the Nogales project.[104] Moreover, NADB currently is involved in financing the development of a 54 MW wind farm project in El Porvenir in the Municipality of Reynosa, Tamaulipas, that, when completed, would supply electricity for Soriana, a supermarket chain store in Mexico.[105] In addition to renewable energy, the NADB also is authorized to provide grants for project development and loans for implementation of clean and efficient energy infrastructure projects. In addition to these large initiatives, there are many opportunities to promote small-scale renewable energy projects along the border.

Energy Demand and Electricity Growth

The success of existing renewable resources already installed along the U.S.-Mexico border and the potential for much greater development in wind, solar, geothermal, and biomass depend on a number of factors, including the growth in energy demand and the actual price of energy. With some exceptions, such as the current recessionary period, electricity demand has risen throughout the Southwest, even as new appliances and buildings become more efficient.

Within the part of Texas it serves, the Electric Reliability Council of Texas (ERCOT) predicts that both resource capacity and demand are expected to rise slightly, but then supplies may not be able to meet all load demands, in part because of older plant retirement. Although projections of demand have varied, the most recent predictions continue to indicate that demand will continue to grow and that by 2014 capacity will not meet demand, and still maintain the required reserve, which is 13.75 percent under ERCOT protocols. This energy demand—measured in summer peak demand—is expected to rise by 21 percent during the next 10 years or between 2 and 2.5 percent per year.[27] Border cities such as Brownsville and El Paso have among the highest population growth rates in the state, and their energy needs are likewise expected to continue to grow.

A recent long-term study by ERCOT specifically highlights the growing demand for electricity in the South Zone, which includes the Rio Grande Valley, and the lack of transmission as an impediment to a reliable electricity system. Electric demand in the three-county Rio Grande Valley—Starr, Hidalgo, and Cameron Counties—is expected to grow from 3,300 MWs of peak demand in 2015 to 3,900 MWs of peak demand in 2020, or more than 3 percent per year.[106]

Similarly, according to a report on its Integrated Resource Planning process, El Paso Electric (EPE), which serves three counties in Texas–Culberson, Hudspeth, and El Paso, and much of Doña Ana and Luna counties in New Mexico, is facing severe growth in demand in the coming years.[107] The required renewable portfolio standard (RPS) in New Mexico, along with the growth in demand, is likely to require even more investments in renewable energy in southern New Mexico. EPE is reacting by investing in utility-scale solar and paying customers who invest in roof-top solar and has established some contracts with a wind provider in eastern New Mexico.

In the Western Interconnection, which oversees reserves and supply projections in the California, New Mexico, and Arizona markets, as well as other states, there is a similar tale of an increasing demand, and while supply currently is sufficient, the potential for shortages in upcoming years is real.

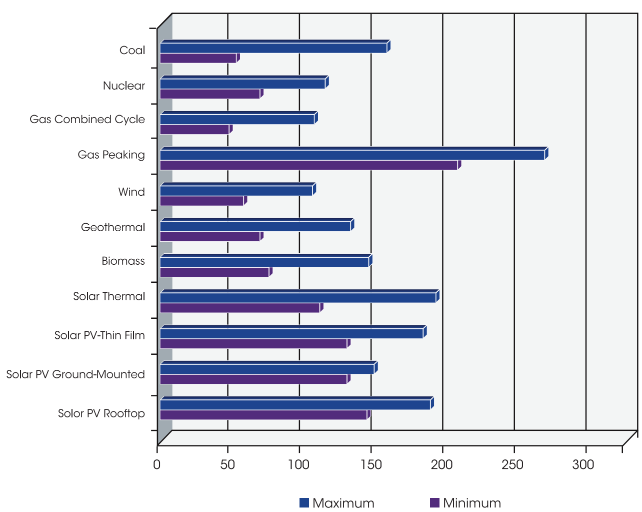
In sum, three specific areas—Southern California, the EPE service area, and the Lower Rio Grande Valley—are likely to need more energy resources, and the development of local border renewable resources coupled with efficiency is one option to meet these needs. According to EPE's most recent 2011 Load and Energy Forecast and Integrated Resource Reports, El Paso is expecting a deficiency in its energy supplies by 2016 and a deficiency in its reserve by 2014 if additional resources are not added.[107]

Electricity Price and Cost of New Generation

The ability of developers and financiers to develop renewable energy projects is dependent on the cost of those resources, the average price of electricity on the market, and any incentives that lower that cost. Although solar costs have been reduced significantly during the past 10 years—in particular, the installed cost of PV systems—in general the cost of renewables still is higher than depreciated aging of conventional sources. Nonetheless, the costs of new fossil fuel and nuclear resources are already, in some cases, as expensive or greater than renewable resources.

Several recent studies have indicated that continued declines in the price of renewables, and particularly solar, could favor the development of these resources in the future, although the price of natural gas will be an important factor in whether these resources can compete in the market. A frequently used concept to compare energy prices is the Levelized Cost of Electricity (LCOE), which includes both construction costs, sometimes called the overnight cost, and operations and maintenance, including the cost of fuel. Figure 11 shows a recent projection of LCOE by one firm that specializes in determining present and future costs of different electricity sources and suggests that wind already is competitive in the United States, and that solar is becoming competitive with the price of other resources.

Figure 11. Levelized Cost of Energy ($s/Megawatt Hour)



Average prices in the Texas electricity market have fallen in recent years, in part because of the discovery of new supplies of natural gas throughout the United States, lowering the cost of natural gas. This is true both in "competitive" areas and in those areas served by monopolies.

Even though average retail prices have decreased within ERCOT in the past 3 years, there has continued to be wind development, in part because of continued federal support for wind power. The reduced price of natural gas, however, has affected the development of wind power. The only solar development in Texas has been through power purchase agreements (PPAs) with municipal utilities and not through sales in the competitive market. There is significant concern that the present low price of electricity in Texas does not provide any market incentive for new generation of any type, and only forced retirement of older plants is likely to spur new development.

Average electricity prices in New Mexico and Arizona have been lower than those in Texas, meaning apart from the state RPS, there is little to suggest that market prices would lead generators to invest in renewable technology. In California, on the other hand, the higher average electricity prices have led many investors to see renewables like solar and wind to be a competitive investment, particularly because there is no fuel charge. The higher average cost of electricity in California in part has been responsible for the greater development of renewable power, along with state policies designed to support its use.

Transition Toward Renewable Energy and Impact of Environmental Regulation

A number of recent studies have pointed to the impact that current and upcoming environmental regulations related to clean air, clean water, and management of waste will have on existing fossil fuel plants, particularly older coal plants. These studies all come to the conclusion that some older coal plants likely will retire, because the cost of adding the additional pollution controls is not economically viable. An October 2010 study by the North American Electric Reliability Corporation found that under a moderate scenario of EPA regulations, some 5,241 MWs in Texas, 5,285 MWs in California, and 2,407 MWs in Arizona, New Mexico, and Southern Nevada could be subject to de-rating or retirement by 2018.[108]

Most recently, EPA announced its final "Transport" rule, which affects coal and natural gas plants in all eastern states, as well as Texas, by forcing major reductions in sulfur dioxide and nitrogen oxides. The July announcement was immediately met by a letter from ERCOT suggesting that Texas might face severe electricity supply issues because several plants may have economic difficulty meeting the new rules.[109]

Studies suggest that coal plants and even older gas plants in the border states could be affected by recent EPA rulemakings. A number of states have put in place transition plans to move away from coal and toward natural gas and renewable technologies because they are less affected by these regulations.

Cooperation With the Mexican Market

During the past few years, there has been increasing interest in the role that U.S. electricity providers could play in the Mexican market, as well as the role that renewable and other energy sources in Mexico could play in the U.S. market, particularly in Texas and southern California. Mexico's Federal Electricity Commission (CFE) has been interested in increasing the amount of electricity it obtains from renewable resources and has been interested, for example, in obtaining energy from the Texas market.

A number of high-profile studies have been conducted in recent years, and the U.S. and Mexican governments recently have committed to promote regional renewable energy markets and ways to ease the transmission of electricity between the two countries through the Cross-Border Electricity Task Force.

A recent U.S.-Mexico Cross-Border Electricity Stakeholders Forum in San Diego, California, brought together more than 70 stakeholders to discuss issues pertinent to the fostering of increased electricity trade between the two countries with an emphasis on renewable energy.[110] Arizona State University's North American Center for Transborder Studies has held similar forums and recently released a Transborder Renewable Energy Framing Paper and a Transborder Renewable Energy Exchange. These point to the potential to create a transborder renewable energy market with the potential for jobs and economic development.[111]

A recent study produced by the Woodrow Wilson International Center for Scholars suggests a number of policy options, and the potential for the U.S. government and private industry to assist in the development of Mexico's renewable energy projects, including those designed to serve the U.S. market. Significant transmission constraints to moving power across the border exist, and there

San Diego's Participation in the Renewable Energy Economy

According to California's Public Utility Commission data, Northern California is by far the largest solar market in the state. San Diego County, however, makes up less than 10 percent of the state's energy consumption, yet the city of San Diego surpasses all other cities, including Los Angeles, in the number of PV systems installed.

Of the 49,335 California residential installations completed in July 2009, 2,262 were installed in the City of San Diego, which was equivalent to 19.4 MWs of installed capacity. The California Solar Initiative (CSI) program started with a residential rebate of $2.50 per AC watt installed in 2006, with a MW trigger mechanism to reduce said rebate to zero over a period of no longer than 10 years. As of July 2010, the rebate was reduced to $0.25 per AC watt. In addition, the San Diego region has 140 PV installer companies out of 231 renewable energy vendors, according to the California Center for Sustainable Energy.[114]

In addition to residential PV projects, the San Diego region has an active and growing clean technology sector. According to Clean Tech San Diego, a nonprofit organization that works with clean technology companies to help them grow and expand in the region, San Diego is home to more than 800 companies doing business in the renewable energy space. These include research and development for biofuels, solar PV and thermal, energy efficiency, and small to large wind energy. In addition, San Diego has a very active university, University of California, San Diego (UCSD), which works with private companies on research and development projects and on deploying and using renewable technologies to reduce their energy costs.

The high activity in renewable energy in San Diego is a result of a successful CSI program implementation, a strong state commitment to renewable energy through the 33 percent RPS, and the emissions reduction efforts under AB32. Strong state policy followed by smart local implementation has made San Diego a hub for renewable energy businesses.

are only a few interconnections. The most recently built interconnection was added in south Texas, where Sharyland Utilities owns and operates a 150 MW high voltage direct current (DC) interconnection with Mexico. Completed in October 2007, the DC interconnection provides reliability benefits to both sides of the border.

Some wind and geothermal developments in Mexico already are serving the California markets. The Los Angeles Department of Water and Power has a contract with Cerro Prieto, a geothermal development near Mexicali, to import some 50 MWs of power through a PPA.[112] Most recently, Sempra, which owns San Diego Gas and Electric (SDG&E), has proposed a new cross-border transmission line to bring wind from the Sierra Juárez Wind Project into the California market. The more recent wind energy project, La Rumorosa in Baja California, is being developed in part to serve the Southern California market, although significant transmission constraints remain to fully develop these resources.[113] The development of renewable energy in Mexico to provide power to the U.S. market has sparked concern over potential job displacement and the loss of economic development opportunities in the United States.

Moving Forward

As the border region progresses toward a more robust renewable energy future, many questions remain unanswered. Information needs include a more specific understanding of the economic opportunities for business development serving local markets in the region and a determination of the impact of such business development, including both the required inputs and the costs of securing them, as well as the outputs and the means of delivering them to consumers. In addition, the costs and benefits of renewable energy to the ambient environment have not been assessed fully and adequately. Finally, it is important to determine the likely cost-effectiveness of renewable energy enterprises and related investment on job creation, revenue forecasts, and increases in the local tax base.

3 | Economic Impacts of Renewable Energy Development in the U.S.-Mexico Border Region

Recommendations

4 Chapter

Renewable energy production is expected to increase sharply in the United States, and the U.S.-Mexico border region is likely to play a significant role in that production. This production can be positive for the nation, the border region, and the specific communities within which it is taking place. Yet, the border region should not become merely an exporter of energy to other parts of the United States. Existing and potential impacts of renewable energy development have led to conflicts with communities and natural resource conservationists, and these will continue unabated unless more attention is paid to the scale and form of this development and to pre-development analysis of natural resource and human community conditions and needs. GNEB believes in an approach that identifies priority areas for potential energy development and emphasizes coordination of local, state, tribal, and federal partners. These recommendations are provided to help promote a careful approach to renewable energy development along the U.S.-Mexico border.

I. Planning and Resource Protection

GNEB recommends that the federal government encourage the careful planning and execution of projects and regional initiatives to ensure that any negative impacts are identified and avoided to the greatest extent possible and that any remaining unavoidable impacts are minimized or mitigated.

A. The federal government should encourage the implementation of energy efficiency projects and initiatives as a partial or complete alternative prior to and in conjunction with the development of new renewable energy projects.

B. To facilitate sound renewable energy development, the federal government should:
  - Continue to build on initiatives such as EPA's Re-Powering America's Land, efforts aimed at developing a comprehensive inventory of mechanically disturbed lands (including marginal agricultural lands) in the region that may be candidates for renewable energy development;
  - Develop and make publicly available a list of siting and environmental screening criteria that could be used to prioritize projects. These include proximity to existing transmission infrastructure with sufficient current or approved capacity and to urban areas, use of disturbed or marginal agricultural lands, avoidance of culturally significant tribal sites, and avoidance of threatened and endangered species and of United States and state waters;
  - Establish regular consultation and collaboration with tribal officials to inform project and programmatic level efforts and to address how any impact to tribal or cultural resources will be avoided or mitigated, consistent with federal laws and executive orders; and
  - Identify incentives that can be used to motivate developers to site and design in an environmentally responsible manner and reward examples of superior environmental stewardship.

C. At its facilities and properties in and near the border region, the federal government should:

- Produce and purchase renewable energy. The Department of Defense (DoD) should give priority to facilities in the border region as it shifts its emphasis to increased use of renewable energy. Consistent with their missions, other federal agencies should follow the lead of the DoD and increase the use of renewable energy in their ongoing operations;

- Install solar generation as part of overall energy efficient design when constructing new buildings or renovating old buildings in the border region or, at a minimum, construct buildings on which solar generation systems readily can be added in the future;

- Improve federal interagency coordination to increase the border region's ability to take advantage of renewable energy capabilities;

- Continue to explore opportunities to coordinate with local, state, tribal, and federal partners to accelerate evaluation and permitting of wind farms and solar arrays on federal lands adjacent to transmission lines; and

- Continue to upgrade existing federal hydroelectric power plants:
  - Support installation of additional low-head power generation at federal hydroelectric power plants, taking into consideration costs and benefits;
  - Support or expand projects to uprate existing federal hydropower plants to ensure the efficient, reliable, and cost-effective generation of hydropower.

D. All renewable energy planning and land use initiatives should:

- Optimize the use of rooftops, greyfields,[1] brownfields, underutilized federal properties,[2] and disturbed sites, recognizing that some degraded areas may be restored to become key components of the conservation landscape, and provide adequate incentives and assurances to encourage developers and landowners to take full advantage of opportunities to site renewable energy facilities at these environmentally preferable locations;

- Involve all stakeholders as early as possible in planning and maintain that involvement throughout project design and development;

- Identify multi-jurisdictional land management and conservation efforts, such as Landscape Conservation Cooperatives and solar energy zones, and work to ensure compatibility of objectives and actions and to take advantage of synergies to avoid duplication of efforts, optimize learning, and increase efficiency;

- Use best available data, including those generated by conservation, habitat connectivity,

---

[1]Greyfields are underused or declining urban properties, such as shopping malls, which usually have parking lots.

[2]An underutilized property is defined in Title 41 of the Code of Federal Regulations as "an entire property or portion thereof, with or without improvements, which is used only at irregular periods or intermittently by the accountable landholding agency for current program purposes of that agency, or which is used for current program purposes that can be satisfied with only a portion of the property."

and wildlife movement research to identify project areas and transmission routes that do not negatively impact rare or threatened species, rare or sensitive biological communities and ecosystems, cultural resources and landscapes, or Protected Areas, such as designated wilderness, National Park Service units, or U.S. Fish and Wildlife Refuges. Ensure that gaps in knowledge concerning the location of such resources are addressed prior to the start of development activities;

- Optimize the use and upgrading of the existing electric transmission network wherever possible; and
- Optimize benefits to border communities, including tribal areas, through efforts such as local hiring, job training, new manufacturing investments, discounting power rates, and providing solar panels, solar water heating systems, small wind turbines, and small biomass projects for nearby residents at affordable prices to reduce their energy costs.

E. To promote a high level of environmental stewardship and good project planning, all proposed renewable energy project developers should:

- Conduct early, in-depth resource analyses (e.g., hydrological and biological) through a due diligence process, project application submittal, or project Plan of Development, to determine a project's viability and to avoid potential project delays later in the process;
- Ensure applicants, during the early stages of a project application process, fully consider environmentally preferable alternatives, including alternate sizes and/or siting locations, and including the use of private lands as well as neighboring disturbed sites;
- Develop and incorporate specific design criteria for each renewable energy technology, including requirements to maintain natural hydrologic flow, minimize soil disturbance, protect critical habitat and wildlife movement corridors, and demonstrate maximum water use conservation;
- Compare and contrast different technologies to determine "best fit" given different environmental and site characteristics. Consider key parameters such as design flexibility (e.g., to avoid drainages), water use, and megawatts per acre;
- Ensure adequate lands are available for compensatory mitigation of affected areas and that these will be protected into perpetuity;
- Evaluate environmental and socioeconomic cumulative impacts of individual projects and facilities in the vicinity of any proposed project. Mitigate impacts on threatened and endangered species, hydrology, groundwater, and air quality; and
- Incorporate systematic monitoring for each project to evaluate the effectiveness of key avoidance and mitigation measures. Require biannual reporting of such evaluation to ensure a constant feedback cycle.

II. Education and Outreach

GNEB recommends that increased efforts be made by the federal government, in partnership with state and local governments, councils of government, tribal officials, and chambers of commerce in border communities, to communicate with and inform border populations about the development and use of renewable energy resources in the border region.

A. To improve communication with border communities and especially local and tribal governments, businesses, homeowners, and lenders about renewable energy resources and opportunities, the federal government should:
   - Conduct outreach to border communities on renewable energy technologies and best practices, costs and benefits, and the use of data and analyses in determining the potential impacts of project development;
   - Provide guidance for shepherding proposals through the public process to ensure informed decision-making about the use of public lands; and
   - Develop an education campaign for local banks and credit unions to encourage them to offer lending products in border regions, which could easily spread to the rest of the country.

B. To identify opportunities to reduce energy use and identify the most appropriate forms of renewable energy development, the federal government should:
   - Encourage and assist municipalities and businesses to conduct energy audits on an ongoing basis. The Border Environment Cooperation Commission (BECC) should continue to help border cities to conduct such audits, to the extent that it does not detract from other important core mission work;
   - Cooperate closely with U.S. border states to provide technical assistance for renewable energy projects; and
   - Create a baseline of renewable energy resources in the border region to measure increases and impacts over time.

III. Financing

GNEB recommends that the federal government provide greater certainty regarding renewable energy production and energy-saving technologies to help drive investment into these important sectors.

A. To reduce uncertainty, the federal government should:
   - Through the Property Assessed Clean Energy (PACE) program or another mechanism, establish national rules whereby localities can move forward on financing mechanisms to allow individuals to invest in renewable and water and energy savings technologies over the long term;

- Extend and expand tax incentives for energy efficiency and the production of renewable energy, including wind, biomass, geothermal energy, landfill gas, and hydroelectricity for several years, to provide more certainty to the industry;

- Support performance-based financial incentives such as through conversion of the Business Energy Investment Tax Credit (ITC) to a production tax credit or incentive to encourage the actual production of renewable energy as opposed to simple investment, and the use of the NPS-administered Historic Preservation Tax Credit program to provide incentives for sustainability, including renewable energy, in historic preservation activities;

- Continue to provide financing tools such as the Clean Renewable Energy Bonds (CREBs) for governmental entities and rural electric cooperatives and consider allocating a portion to the North American Development Bank (NADB) for the border area;

- Allow public/private partnerships and quasi-governmental initiatives to access Private Activity Bonds.

B. The Border Environment Cooperation Commission (BECC) and the NADB have emerged as a "green" financing mechanism for the border area and have successfully certified several renewable energy/energy efficiency projects in the past few years. The BECC and NADB should continue to make protection and preservation of the border environment their primary mission. While continuing to fund and prioritize technical assistance for their core programs for water supply, wastewater treatment and solid waste management, the BECC and NADB should:

- Update their criteria to incorporate energy efficiency and renewable energy;

- Continue to make financing available for renewable energy projects that meet their criteria, and expand technical assistance for medium and small-sized renewable energy projects, especially those that combine electric generation with energy savings and efficiency, so that implementation funds can be leveraged;

- Identify opportunities in energy efficiency during project development, which could include water conservation, improved operations of the existing systems, and the use of renewable energy sources;

- Undertake a regional assessment of the opportunities to promote small-scale renewable projects along the border, including the identification of projects, resources, and efforts that currently exist at the federal, state and local levels to promote coordination and shared learning; and

- Encourage project developers of renewable systems to utilize the BECC certification process as a way to ensure that their projects meet important criteria regarding public participation, community development, environmental protection, and financial integrity.

IV. Coordination and Collaboration

GNEB recommends that the federal government develop better collaboration and coordination among the various levels of government and different sectors. Key elements are:

- Increase coordination among federal agencies with regard to permitting procedures for renewable energy projects.
- Evaluate costs associated with licenses needed to feed back into the power grid for low-head power generation on irrigation canals.
- Carefully evaluate the environmental, social, and economic benefits, as well as challenges, related to cross-border generation and transmission of electricity from renewable energy sources.

Glossary of Acronyms

AD	anaerobic digester
AEP	American Electric Power
ARRA	American Recovery and Reinvestment Act
BECC	Border Environment Cooperation Commission
BLM	U.S. Bureau of Land Management
CFE	Mexico's Federal Electricity Commission
CO_2	carbon dioxide
CONUEE	Mexico's National Commission for Energy Efficiency
CRE	Mexico's Energy Regulatory Commission
CREB	Clean Renewable Energy Bond
CSI	California Solar Initiative
CSP	concentrated solar power
DC	direct current
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EBID	Elephant Butte Irrigation District
EGS	enhanced geothermal systems
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPE	El Paso Electric
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
FHA	Federal Housing Authority
GAO	U.S. Government Accountability Office
GHG	greenhouse gas
GLO	Texas General Land Office
GMI	Global Methane Initiative
GNEB	Good Neighbor Environmental Board
H_2S	hydrogen sulfide
HHS	U.S. Department of Health and Human Services
IBWC	International Boundary and Water Commission
IIE	Mexico's Institute for Electricity Research
IOU	investor-owned utility
ITC	investment tax credit
LAERFTE	Mexico's Renewable Energy Development and Financing for Energy Transition Law
LCOE	Levelized Cost of Electricity
LEDS	Low-Emission Development Strategy
LFG	landfill gas
LIHI	Low Impact Hydropower Institute
MBC	Metro Biosolids Center
MIT	Massachusetts Institute of Technology
MSW	municipal solid waste
MW	megawatt
MWh	megawatt hour
NADB	North American Development Bank
NAFTA	North American Free Trade Agreement
NCCF	North City Cogeneration Facility
NCG	non-condensable gas
NCWRP	North City Water Reclamation Plant
NEPA	National Environmental Policy Act
NOx	nitrogen oxides
NREL	National Renewable Energy Laboratory
PACE	Property Assessed Clean Energy
PAH	polycyclic aromatic hydrocarbon
PG&E	Pacific Gas and Electric
PPA	power-purchase agreement
PTC	production tax credit
PUCT	Public Utility Commission of Texas
PV	photovoltaic
QECB	qualified energy conservation bond
REAP	Rural Energy for America Program
REC	Renewable Energy Certificate
REPI	renewable energy production incentive
RES	renewable electricity standard
RFP	request for proposals
ROW	right-of-way
RPS	Renewable Portfolio Standards
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SEMARNAT	Mexican Secretariat of Environment and Natural Resources
SENER	Mexico's Secretariat of Energy
SMRT	Sonoran-Mojave Renewable Transmission
SO_2	sulfur dioxide
TEP	Tucson Electric Power
TIP	Transmission Infrastructure Program
UCSD	University of California, San Diego
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WGA	Western Governors' Association
WREZ	Western Renewable Energy Zones

Summary of **Federal Incentives** and Rules for **Renewable Energy** and **Energy Efficiency**

Financial Incentives	Rules, Regulations & Policies
Corporate Depreciation • Modified Accelerated Cost-Recovery System (MACRS) + Bonus Depreciation (2008-2012) **Corporate Exemption** • Residential Energy Conservation Subsidy Exclusion (Corporate) **Corporate Tax Credit** • Business Energy Investment Tax Credit (ITC) • Renewable Electricity Production Tax Credit (PTC) **Federal Grant Program** • Tribal Energy Program Grant • U.S. Department of Treasury - Renewable Energy Grants • USDA - High Energy Cost Grant Program • USDA - Rural Energy for America Program (REAP) Grants **Federal Loan Program** • Clean Renewable Energy Bonds (CREBs) • Energy-Efficient Mortgages • Qualified Energy Conservation Bonds (QECBs) • U.S. Department of Energy - Loan Guarantee Program • USDA - Rural Energy for America Program (REAP) Loan Guarantees **Industry Recruitment/Support** • Qualifying Advanced Energy Manufacturing Investment Tax Credit **Performance-Based Incentive** • Renewable Energy Production Incentive (REPI) **Personal Exemption** • Residential Energy Conservation Subsidy Exclusion (Personal) **Personal Tax Credit** • Residential Energy Efficiency Tax Credit • Residential Renewable Energy Tax Credit	**Energy Standards for Public Buildings** • Energy Goals and Standards for Federal Government **Green Power Purchasing** • U.S. Federal Government - Green Power Purchasing Goal **Interconnection** • Interconnection Standards for Small Generators

Source: U.S. Department of Energy, Database of State Incentives for Renewable and Efficiency

2011 Members of the Good Neighbor Environmental Board

Diane Austin, Ph.D., Chair
Associate Research Anthropologist, Bureau of Applied Research in Anthropology
University of Arizona

Cecilia E. Aguillon
Director, Market Development and Government Relations
KYOCERA Solar, Inc.

Jose Angel
Assistant Executive Officer
Colorado River Basin Region Water Quality Control Board

Evaristo Cruz
Director, Environmental Management Office
Ysleta del Sur Pueblo

Gary Gallegos
Executive Director
San Diego Association of Governments

Veronica Garcia
Deputy Director, Waste Programs Division
Arizona Department of Environmental Quality

Gary Gillen
President
Gillen Pest Control

David Henkel, Ph.D.
Professor Emeritus, Community and Regional Planning Program
University of New Mexico

Patti Krebs
Executive Director
Industrial Environmental Association

Stephen M. Niemeyer, P.E.
Border Affairs Manager and Colonias Coordinator
Texas Commission on Environmental Quality

Luis Olmedo
Executive Director
Comite Civico Del Valle, Inc.

Michael J. Ortega, P.E.
County Administrator
Cochise County Arizona

Luis E. Ramírez Thomas, MSFS
President
Ramirez Advisors Inter-National, LLC

Cyrus B.H. Reed, Ph.D.
Conservation Director, Lone Star Chapter
Sierra Club

Thomas Ruiz, M.S.
Border/Environmental Justice Liaison
New Mexico Environment Department

Nathan P. Small
Conservation Director
New Mexico Wilderness Alliance

Ann Marie A. Wolf
President
Sonora Environmental Research Institute, Inc

John Wood
Representative
Cameron County Regional Mobility Authority

Antonio Noé Zavaleta, Ph.D.
Director, Texas Center for Border and Transnational Studies
University of Texas at Brownsville

Federal Members

Department of Agriculture/Natural Resources Conservation Service
Robert M. Apodaca
Assistant Chief - West

Department of Commerce
David Kennedy
Assistant Administrator, National Ocean Service, National Oceanic and Atmospheric Administration

Department of Energy
Gilbert C. Bindewald, III
Acting Deputy Assistant Secretary, Office of Electricity Delivery and Energy Reliability

Department of Homeland Security
Dr. Teresa R. Pohlman, LEED AP
Director, Occupational Safety & Environmental Programs

Department of Housing & Urban Development
Yolanda Chavez
Deputy Assistant Secretary, Grant Programs

Department of Health and Human Services
Dan Reyna
General Manager, U.S. Section, Office of Global Health Affairs

Department of Interior
Gregory E. Eckert, Ph.D.
Restoration Ecologist, National Park Service

Department of State
Rachel Poynter
U.S.-Mexico Border Coordinator, Office of Mexican Affairs

Department of Transportation
Linda L. Lawson
Director, Safety, Energy and the Environment

Environmental Protection Agency
Lawrence Starfield
Deputy Regional Administrator (Region 6)

International Boundary and Water Commission
Edward Drusina
Commissioner

Designated Federal Officer

Mark Joyce
Associate Director
U.S. EPA Office of Federal Advisory Committee Management and Outreach

Resource Specialists

Department of Energy
Christopher Lawrence, Electricity Industry Specialist

Department of State
Georgina Scarlata, Border Affairs Officer
Angela Palazzolo, Border Affairs Officer

Department of Transportation
Sylvia Grijalva, U.S.-Mexico Border Planning Coordinator, Federal Highway Administration

Environmental Protection Agency
William Luthans, Deputy Director of Multimedia Planning and Permitting Division, Region 6
Carlos Rincon, El Paso Border Office Director, Region 6
Maria Sisneros, Environmental Engineer, Region 6
Debra Tellez, El Paso Border Office, Region 6
Enrique Manzanilla, Communities and Ecosystems Division Director, Region 9
Tomas Torres, U.S.-Mexico Border Program Coordinator, Region 9
José Garcia, U.S.-Mexico Border Program Specialist, Region 9
Alheli Banos, U.S.-Mexico Border Program Environmental Health and Outreach Coordinator, Region 9

International Boundary and Water Commission
Sally Spener, Public Affairs Officer

National Oceanic and Atmospheric Administration
Laurie McGilvray, Division Chief, Estuarine Reserves Division
Donna Wieting, Acting Director, Office of Ocean and Coastal Resource Management
Alison Krepp, Estuarine Reserves Division

Acknowledgments

Thanks to the following individuals and organizations for their assistance with this report.

Michelle Alexander, Program Assistant, National Climate Change and Wildlife Science Center, **USGS**

Michael Armistead, Chief Security Officer, **U.S. Section, IBWC**

Valentin Arzola, Civil Engineer, **U.S. Section, IBWC**

Lisa Bicker, President and CEO, **Clean TECH San Diego**

Ofelia Bolaños, General Engineer (Planning), **U.S. Section, IBWC**

David P. Brown, Ph.D., Regional Climate Services Director, Southern Region, **NOAA**

Nicole Capretz, Director, Green Energy/Green Jobs Campaign, **Environmental Health Coalition, California**

Matt Clouse, Acting Chief, Energy Supply & Industry Branch, Office of Air and Radiation, **EPA**

John Dake, Power System Dispatcher, **Western Area Power Administration**

Bryn Davis, New Mexico Operations Manager, **Sapphire Energy**

Frank D'Erchia, Science Advisor, **USGS**

Clay Doyle, Vice President of Transmission and Distribution, **El Paso Electric Company**

Gabriel Duran, General Engineer (Planning), **U.S. Section, IBWC**

Gary Esslinger, Treasurer-Manager**, Elephant Butte Irrigation District, New Mexico**

Todd Foley, Senior Vice President on Policy and Government Relations, **American Council on Renewable Energy**

Maria Elena Giner, General Manager, **Border Environment Cooperation Commission**

Xavier Gonzalez, General Engineer, **Western Area Power Administration**

Lorri Gray-Lee, Regional Director for Reclamation, Lower Colorado Region, **U.S. Bureau of Reclamation**

Pablo Gutierrez, Geothermal Program Technical Lead, **California Energy Commission**

Patricia Harrington, Ph.D., Energy Program Analyst, **U.S. Department of Homeland Security**

Luis Hernandez, Civil Engineer, Operations and Management Division, **U.S. Section, IBWC**

Rebecca Higgins, Office of Safety, Energy and Environment, **U.S. Department of Transportation**

Alberto Hinojosa, Power Productions Manager, **U.S. Section, IBWC**

Andy Horne, Deputy County Executive Officer, **Natural Resources Development, Imperial County**

Edward Hoyt, Principal Clean Energy Specialist, Energy and Carbon Management, **Nexant, Inc**.

Lesley Hunter, Research Program Specialist, **American Council on Renewable Energy**

Eric Lantz, Energy Analyst, Market and Policy Impact Analysis Group, **NREL**

Rob Lawrence, Senior Policy Advisor, Multimedia Planning and Permitting Division, Region 6, **EPA**

Priscilla C. Lucero, Executive Director, **Southwest New Mexico Council of Governments**

Kathy MacDougall, Director of Human Resources, **Independent Energy Solutions, Inc.**

Andrew McAllister, Director of Policy and Strategy, **California Center for Sustainable Energy**

Kerry McCalman, Program Manager (Power Resources), **U.S. Bureau of Reclamation**

Lauren Oertel, Graduate Research Assistant, **Texas Commission on Environmental Quality**

Robin O'Malley, Policy and Partnership Coordinator, National Climate Change and Wildlife Science Center, **USGS**

Diana Papoulias, Research Biologist, **USGS**

Thomas Plenys, Environmental Scientist, Environmental Review Office, Region 9, **EPA**

Bill Powers, Owner, **Powers Engineering**

Michael Pulskamp, Program Analyst, **U.S. Bureau of Reclamation**

Ross Pumfrey, Senior Program Coordinator, **Texas Commission on Environmental Quality**

Billy Roberts, Strategic Energy Analysis Center, **NREL**

Richard D. Rosen, Ph.D., Senior Advisor for Climate Research, **NOAA**

Paul Royalty, Manager of Energy Efficiency, **El Paso Electric Company**

Christian P. Sarason, Product Manager, **3TIER**

Jo Anne Shelby, Plant Manager, **Compass Manufacturing Services**

Linda Smrkovsky, Executive Director, **Deming Luna County Economic Development, Inc.**

Max Spiker, Program Manager (Power Resources), **U.S. Bureau of Reclamation**

Sue Stendebach, Senior Advisor on International Air Quality, Office of Air and Radiation, **EPA**

Karyn Stockdale, Vice President and Executive Director, **New Mexico Audubon Society**

Tom Stoffel, Manager, Resource Information and Forecasting Group, Electricity, Resources, and Building Systems Integration Center, **NREL**

Pascal Storck, Ph.D, Chief Operating Officer, **3TIER**

Soll Sussman, Alternative Fuels Program Coordinator, Renewable Energy Division, **Texas General Land Office**

Dub Taylor, Director, **State Energy Conservation Office, Texas**

Suzanne Tegen, Energy Analyst, Market and Policy Impact Analysis Group, **NREL**

Sharon Thomas, Mayor Pro Tem, **Las Cruces, New Mexico**

Donna Tisdale, Secretary, **Protect Our Communities Foundation**

Jeremy Turner, Executive Director, **New Mexico Renewable Energy Transmission Authority**

Randall G. Updike, Regional Executive for the Rocky Mountain Area, **USGS**

Rick Van Schoik, Director, North American Center for Transborder Studies, **Arizona State University**

Andrea Watson, Project Leader, Integrative Applications Center, **NREL**

Steven White, C.E.M., Energy Program Manager, **U.S. Department of Homeland Security**

Duncan Wood, Professor, **Instituto Tecnológico Autónomo de México**, Senior Advisor for the Renewable Energy Initiative, **Mexico Institute of the Woodrow Wilson International Center for Scholars**

James Yarbrough, Climate Advisor, Multimedia Planning and Permitting Division, Region 6, **EPA**

Amy Zimpfer, Associate Director, Management Lead for Energy and Climate Change, Region 9, **EPA**

Endnotes

1 | U.S. Environmental Protection Agency, Sulfur Dioxide, Health, 2011, http://www.epa.gov/air/sulfurdioxide/health.html.

2 | U.S. Energy Information Administration, "U.S. Energy Facts Explained," 2011, http://www.eia.gov/energyexplained/index.cfm?page=us_energy_home.

3 | Kate Galbraith, "California and Texas: Renewable Energy's Odd Couple," *New York Times*, October 17, 2009, http://www.nytimes.com/2009/10/18/weekinreview/18galbraith.html.

4 | The United States-Mexico Border Health Commission, "The United States-Mexico Border at a Glance," http://www.nmsu.edu/~bec/BEC/Readings/10.USMBHC-TheBorderAtAGlance.pdf.

5 | Campo Kumeyaay Nation, "Muht Hei, Inc.," http://www.campo-nsn.gov/windfarm.html.

6 | University of Arizona, "Tohono O'odham Nation Collaborate on Land-Use Plan," UANews, August 9, 2011, http://uanews.org/node/41050.

7 | U.S. Department of Energy, Efficiency and Renewable Energy Program, Tribal Energy Program, http://apps1.eere.energy.gov/tribalenergy/.

8 | U.S. Department of Energy, Efficiency and Renewable Energy Program, Tribal Energy Program, "Projects on Tribal Lands," http://apps1.eere.energy.gov/tribalenergy/projects.cfm.

9 | U.S. Energy Information Administration, "Solar Energy Explained, Your Guide to Understanding Energy," accessed October 2011, http://www.eia.gov/energyexplained/index.cfm?page=solar_home.

10 | Solar Energy Industries Association, "US Solar Market Insight, 2010 Year in Review," 2010, p. 4, http://www.seia.org/galleries/pdf/SMI-YIR-2010-ES.pdf.

11 | Damon Franz, Mona Dzvova, James Loewen, Amy Reardon, Neal Reardon and Melicia Charles, California Public Utilities Commission, "California Solar Initiative, 2011 Annual Program Assessment – Legislative Report," June 2011, http://www.cpuc.ca.gov/NR/rdonlyres/9BC1AC3A-020C-4E85-99F0-D6CF42D34B03/0/2011_APA_FINAL_PRINT.pdf

12 | Jennifer Ramp and Holley Salmi. San Diego Gas and Electric, "SDG&E Signs Renewable Power Contract With Tenaska Project That Will Use Locally Produced Solar Modules," March 10, 2011, http://www.tenaska.com/newsItem.aspx?id=94.

13 | California Energy Commission, "Solar Thermal Projects under Review As of December 15, 2010," www.energy.ca.gov/siting/solar/index.html.

14 | BrightSource, www.brightsourceenergy.com.

15 | Duncan Wood, "Environment, Development and Growth: U.S.-Mexico Cooperation in Renewable Energies," May 2010, p. 38, http://www.statealliancepartnership.org/resources_files/USMexico_Cooperation_Renewable_Energies.pdf.

16 | Pew Center on Global Climate Change, "Renewable and Alternative Energy Portfolio Standards," http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm.

17 | U.S. Energy Information Administration, "EIA Renewable Energy-Arizona Renewable Electricity Profile," http://www.eia.gov/cneaf/solar.renewables/page/state_profiles/arizona.html.

18 | U.S. Department of the Interior, Bureau of Land Management, "Pending Arizona BLM Solar Projects," http://www.blm.gov/az/st/en/prog/energy/solar/pend-solar.html.

19 | David Wichner, "Solar Projects in AZ Get OK for Guarantees," *Arizona Daily Star*, October 9, 2011, http://azstarnet.com/business/local/article_d8d0f170-15e5-5a8d-af30-833b0957797b.html?mode=story.

20 | U.S. Department of Energy, Abengoa Solar Inc. (Solana), https://lpo.energy.gov/?projects=abengoa-solar-inc.

21 | Kathy Pedrick, Bureau of Land Management, "Arizona Restoration Design Energy Project PowerPoint Presentation, http://azgovernor.gov/renewable/documents/April2010/BLMRestorationDesignProjectPresentation.pdf.

22 | Shayle Kann, Solar Research, GTM Research, "The U.S. Utility PV Market: Demand, Players, Strategy and Project Economics Through 2015," Figure: Estimated Capacity Required to Meet 2015 RPS Target by State, http://www.greentechmedia.com/research/report/us-utility-pv-market-2015

23 | Allie Gardner, "Governor Richardson Pleased with News of Solar Plant," Clean Energy Authority, December 17, 2010, www.cleanenergyauthority.com.

24 | El Paso Electric Company, "El Paso Electric Company's Application for 2010 Annual Procurement Plan," 2011, http://www.epelectric.com/tx/business/2010-renewable-energy-procurement-plan.

25 | Laylan Copelin, "Green Energy is Dealt a Setback: Utility Commission Drops Plan for Renewable Energy Mandate", Austin American Statesman, July 6, 2011, http://www.statesman.com/business/utility-commission-drops-plan-for-renewable-energy-mandate-1584351.html?printArticle=y.

26 | Tracy Idell Hamilton, "CPS Energy Ratchets up Investment in Solar; Utility Notifies Its Bidders That Project Will Be Eight Times Larger," *San Antonio Express-News*, July 7, 2011, http://www.mysanantonio.com/news/energy/article/CPS-Energy-ratchets-up-investment-in-solar-1455605.php.

27 | Electric Reliability Council of Texas, "ERCOT: the Texas Connection," Report on Capacity, Demand and Reserves in the ERCOT Region, May 2011, http://www.ercot.com/content/news/presentations/2011/ERCOT_2011_%20Capacity,_Demand_and%20Reserves_Report.pdf.

28 | Jerry Patterson, "Texas General Land Office Renewable Energy Program," PowerPoint Presentation, February 25, 2011.

29 | U.S. Department of Energy, "Concentrating Solar Power Commercial Application Study: Reducing Water Consumption of Concentrating Solar Power Electricity Generation," http://www1.eere.energy.gov/solar/pdfs/csp_water_study.pdf.

30 | U.S. Energy Information Administration, Solar Photovoltaic Cell/Module Manufacturing Activities 2008, Table 3.16, December 2009, ftp://ftp.eia.doe.gov/renewables/solarpv08.pdf.

31 | Nicole T. Carter and Richard J. Campbell, Congressional Research Service, "Water Issues of Concentrating Solar Power (CSP) Electricity in the U.S. Southwest," June 8, 2009, 7-5700, R40631, http://www.circleofblue.org/waternews/wp-content/uploads/2010/08/Solar-Water-Use-Issues-in-Southwest.pdf.

32 | Joan F. Kenny, Nancy L. Barber, Susan S. Hutson, Kristin S. Linsey, John K. Lovelace, and Molly A. Maupin, U.S. Geological Survey, "Estimated Use of Water in the United States in 2005," October 27, 2009, http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf.

33 | Vasilis Fthemakis and Hyung Chul Kim, "Land Use and Electricity Generation: A Life-Cycle Analysis," *Renewable and Sustainable Energy Reviews*, Vol. 13 (2009): 1465-1474.

34 | U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, "The Ecological and Hydrological Significance of Ephemeral and Intermittent Streams in the Arid and Semi-arid American Southwest," EPA/600/R-08/134, ARS/233046, 116 pp., http://azriparian.org/docs/arc/publications/EphemeralStreamsReport.pdf.

35 | Vasilis Fthenakis, Hyung Chul Kim and Erik Alsema, "Emissions from Photovoltaic Life Cycles," *Environmental Science & Technology,* Vol. 42 (2008): 2168-2174.

36 | National Renewable Energy Laboratory, Concentrating Solar Power, Troughnet, http://www.nrel.gov/csp/troughnet/faqs.html.

37 | Sarah Pizzo. "Note & Comment: When Saving the Environment Hurts the Environment: Balancing Solar Energy Development with Land and Wildlife Conservation in a Warming Climate," *Colorado Journal of International Environmental Law*, Vol. 22 (2011): 123-157.

38 | Solar Energy Development Programmatic EIS Information Center, http://solareis.anl.gov/guide/environment/index.cfm.

39 | The Wilderness Society, "Natural Dividends: Wildland Protection and the Changing Economy of the Rocky Mountain West," 2007, www.wilderness.org.

40 | Silicon Valley Toxics Coalition, "Toward a Just and Sustainable Solar Energy Industry," January 14, 2009, http://www.greencollar.org/UserFiles/ads-media/12526955654aaa9e0d799db.pdf.

41 | Electric Power Research Institute, "Potential Health and Environmental Impacts Associated with the Manufacture and Use of Photovoltaic Cells," Report to the California Energy Commission, Palo Alto, CA, 2003, http://www.energy.ca.gov/reports/500-04-053.PDF.

42 | Robert Glennon and Andrew M. Reeves, "Solar energy's cloudy future," *Arizona Journal of Environmental Law & Policy*. Vol. 1, No. 1 (2010), http://www.ajelp.com/2010/GlennonFinal.pdf.

43 | U.S. Department of Energy, "80-Meter Wind Maps and Resource Potential," http://www.windpoweringamerica.gov/wind_maps.asp.

44 | U.S. Government Accountability Office, "Federal Electricity Subsidies: Information on Research Funding, Tax Expenditures, and Other Activities That Support Electricity Production," October 2007, http://www.gao.gov/new.items/d08102.pdf.

45 | Global Wind Energy Council, "Global Cumulative Installed Wind Capacity," http://www.gwec.net/fileadmin/images/Publications/5Global_cumulative_installed_wind_capacity_1996-2010.jpg.

46 | California Energy Commission, "Total Electricity System Power," http://energyalmanac.ca.gov/electricity/total_system_power.html.

47 | California Energy Commission, "Overview of Wind Energy in California," http://www.energy.ca.gov/wind/overview.html.

48 | Katherine Tweed, "Tehachapi Renewable Transmission Project Completes Phase One," *greentechgrid*, May 5, 2010, http://www.greentechmedia.com/articles/read/phase-one-completed-in-tehachapi-renewable-transmission-project/.

49 | Ross Pumfrey, Texas Commission on Environmental Quality, telephone conversation with Karin Wadsack of Northern Arizona University, September 26, 2011.

50 | American Wind Energy Association, "Wind Energy Facts: New Mexico," http://www.awea.org/learnabout/publications/upload/New-Mexico.pdf.

51 | Jeremy Lewis, New Mexico Energy, Minerals, and Natural Resources Department, e-mail to Ross Pumfrey, Texas Commission on Environmental Quality, September 26, 2011.

52 | Western Governors' Association and U.S. Department of Energy, "Western Renewable Energy Zones-Phase 1 Report," June 2009, p. 12, http://www.westgov.org/component/joomdoc/cat_view/95-reports/96-2009.

53 | Ross Pumfrey, Texas Commission on Environmental Quality, telephone conversation with Michael McDermott, New Mexico Energy, Minerals, and Natural Resources Department, September 26, 2011.

54 | New Mexico Energy, Minerals, and Natural Resources Department, "Annual Report 2010", p. 34, http://www.emnrd.state.nm.us/main/documents/EMNRD-2010-Annual-Report.pdf.

55 | RS&H Engineering, prepared for the Public Utility Commission of Texas, "CREZ Progress Report No. 3," April 2011, p. 1, http://www.texascrezprojects.com/page29601131.aspx.

56 | National Renewable Energy Laboratory, "Utility-Scale Energy Technology Capacity Factors," http://www.nrel.gov/analysis/tech_cap_factor.html.

57 | Utility Wind Interest Group, "Wind Power Impacts on Electric-Power-System Operating Costs, Summary and Perspective on Work Done to Date," November 2003, http://www.uwig.org/windpower2004.pdf.

58 | The National Academies, "Environmental Impacts of Wind-Energy Projects," 2007, http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/wind_energy_final.pdf.

59 | Somnath Baidya Roy and Justin J. Traiteur, "Impacts of Wind Farms on Surface Air Temperatures," *Proceedings of the National Academy of Sciences*, Vol. 107, No. 42 (2010): 17899-17904, http://www.pnas.org/content/early/2010/10/12/1000493107.full.pdf.

60 | C. Wang and R.G. Prinn, "Potential Climatic Impacts and Reliability of Very Large-Scale Wind Farms," *Atmospheric Chemistry and Physics*, Vol. 10 (2010): 2053-2061, http://www.atmos-chem-phys.org/10/2053/2010/acp-10-2053-2010.pdf.

61 | Vestas, Life Cycle Assessment (LCA), http://www.vestas.com/en/about-vestas/sustainability/wind-turbines-and-the-environment/life-cycle-assessment-%28lca%29.aspx.

62 | California Energy Commission, "Overview of Wind Energy in California," http://www.energy.ca.gov/wind/overview.html.

63 | U.S. Fish and Wildlife Service, "Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines", May 8, 2003, http://www.fws.gov/habitatconservation/wind.pdf.

64 | George C. Ledec, Kennan W. Rapp, and Roberto G. Aiello, The World Bank, Latin America and Caribbean Region, "Greening the Wind: Environmental and Social Considerations for Wind Power Development in Latin America and Beyond", Energy Sector Management Assistance Program Report, June 2011, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/07/26/000333038_20110726003613/Rendered/PDF/634800v10WP0Gr00BOX361518B00PUBLIC0.pdf.

65 | "Wind Power in View: Wind Turbines, Aesthetics, & Public Acceptance," Martin J. Pasqualetti, Paul Gipe, and Robert W. Righter, eds., San Diego: Academic Press, 2002.

66 | American Wind Energy Association, "Air Space, Radar, and Wind Energy" http://www.awea.org/learnabout/publications/upload/04-10_Radar_factsheet.pdf.

67 | National Academy of Sciences, National Research Council, "Environmental Impacts of Wind-Energy Projects," 2007, pp. 157-160, http://www.nap.edu/catalog.php?record_id=11935.

68 | City of El Paso "'Carbon Footprint'" Report: Municipal Operations Baseline Greenhouse Gas Emissions Inventory Report," December 2010, http://www.elpasotexas.gov/sustainability/_documents/City%20of%20El%20Paso%20Carbon%20Footprint%20Report.pdf.

69 | U.S. Department of Agriculture, "An Analysis of Energy Production Costs from Anaerobic Digestion Systems in U.S. Livestock Production Facilities," October 2007, p.1, http://policy.nrcs.usda.gov/OpenNonWebContent.aspx?content=18476.wba.

70 | Ayhan Dermibas, "Importance of Biodiesel As Transportation Fuel," *Energy Policy,* Vol. 35 (2007): 4661-4670.

71 | R.E. Morris, A.K. Pollack, G.E. Mansell, C. Lindhjem, Y Jia, and G. Wilson, National Renewable Energy Laboratory, "Impact of Biodiesel Fuels on Air Quality and Human Health," May 2003, http://www.afdc.energy.gov/afdc/pdfs/33793.pdf.

72 | Biocom Institute, "Algae Grown in Pecos for Fuel," January 1, 2011, http://biocominstitute.org/news/277/.

73 | Ayhan Demirbas and M. Fatih Demirbas, "Importance of algae oil as a source of biodiesel". *Energy Conversion and Management,* Vol 52 (2011): 153-170.

74 | Sierra Club, "Sierra Club Conservation Policies: Biomass Guidance," 2000, http://www.sierraclub.org/policy/conservation/biomass.aspx.

75 | Resource Dynamics Corporation, U.S. Department of Energy, "Combined Heat and Power Market Potential for Opportunity Fuel," Distributed Energy Program Report, 2004, pp. 2-7, http://www1.eere.energy.gov/industry/distributedenergy/pdfs/chp_opportunityfuels.pdf.

76 | Ingvar Fridleifsson, Ruggero Bertani, Ernst Huenges, John W. Lund, Arni Ragnarsson and Ladislaus Rybach, The Possible Role and Contribution of Geothermal Energy to the Mitigation of Climate Change. In: O. Hohmeyer and T. Trittin (Eds.), IPCC Scoping Meeting on Renewable Energy Sources, Proceedings, Luebeck, Germany, January 2008, pp. 59-80, http://www.iea-gia.org/documents/FridleifssonetalIPCCGeothermalpaper2008FinalRybach20May08_000.pdf.

77 | Jerry Patterson, Texas General Land Office Renewable Energy Program Powerpoint Presentation, February 25, 2011.

78 | Geothermal Energy Association, "U.S. Geothermal Power Production and Development Update," 2010, http://www.geo-energy.org/pdf/reports/April_2010_US_Geothermal_Industry_Update_Final.pdf.

79 | Massachusetts Institute of Technology, "The Future of Geothermal Energy - Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century," http://www1.eere.energy.gov/geothermal/pdfs/future_geo_energy.pdf.

80 | Alyssa Kagel, Diana Bates and Karl Gawell, Geothermal Energy Association, "A Guide to Geothermal Energy and The Environment," 2007, http://www.geo-energy.org/reports/Environmental%20Guide.pdf.

81 | Bruce Squires, "Case Study in Removal of Hydrogen Sulfide, Mercury and Benzene from Geothermal Non-Condensable Gas," *Geothermal Resources Council Transactions*, Vol. 26 (2002).

82 | Gary J. Nagl. "15 Years of Successful H_2S Emission Abatement," Merichem Chemicals & Refinery Services, LLC, 2009, http://www.geothermal.org/09NovDec21.pdf.

83 | Kristín V Matthíasdóttir, Department of Chemical Engineering, Lund Institute of Technology, Lund, Sweden, "Removal of Hydrogen Sulfide from Non-Condensable Geothermal Gas at Nesjavellir Power Plant," 2006, http://www.chemeng.lth.se/exjobb/E251.pdf.

84 | Northern Arizona University, Geothermal Sustainable Energy Solutions, "Geothermal Energy and the Environment," http://geothermal.nau.edu/about/enviroment.shtml.

85 | John W. Lund, Karl Gawell, Tonya L. Boyd, and Dan Jennejohn, "The United States of America Country Update 2010," Proceedings, Thirty-Fifth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, http://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2010/lund.pdf.

86 | Western Area Power Administration, www.wapa.gov/about/power.htm and "Roadmap for Renewable Energy, Western Area Power Administration Annual Report 2010," http://www.wapa.gov/newsroom/pdf/annrep10.pdf/.

87 | U.S. Bureau of Reclamation records.

88 | U.S. Section, International Boundary and Water Commission records.

89 | Bureau of Reclamation, U.S. Department of Interior, "Hydropower Resource Assessment at Existing Reclamation Facilities," March 2011, http://www.usbr.gov/power/AssessmentReport/USBRHydroAssessmentFinalReportMarch2011.pdf.

90 | Bureau of Reclamation, "Hydropower Report Announces Clean Energy Improvements," ETA, Spring 2011, http://www.usbr.gov/eta/docs/spring2011ETA.pdf.

91 | U.S. Environmental Protection Agency, Clean Energy, Hydroelectrity, http://www.epa.gov/cleanenergy/energy-and-you/affect/hydro.html.

92 | Richard J. Campbell, Congressional Research Service, "Small Hydro and Low-Head Hydro Power Technologies and Prospects," March 1, 2010, http://nepinstitute.org/get/CRS_Reports/CRS_Energy/Renewable_Fuels/Small_hydro_and_Low-head_hydro_power.pdf.

93 | Low Impact Hydropower Institute, "Low Impact Hydropower Certification Criteria, Summary of Goals and Standards," http://www.lowimpacthydro.org/assets/files/CriteriaSummary11-08.pdf.

94 | The Pew Charitable Trust, "The Clean Energy Economy: Repowering Jobs, Businesses and Investments through Investments Across America," 2009, http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/Clean%20Energy%20Economy.pdf.

95 | The Brookings Institute, "Sizing the Clean Economy: A National and Regional Green Jobs Assessment," 2011, http://www.brookings.edu/~/media/Files/Programs/Metro/clean_economy/0713_clean_economy.pdf.

96 | Union of Concerned Scientists, "Clean Power, Green Jobs," 2009, http://www.ucsusa.org/assets/documents/clean_energy/Clean-Power-Green-Jobs-25-RES.pdf.

97 | Blue-Green Alliance, "How to Revitalize America's Middle Class with the Green Energy Economy," http://www.bluegreenalliance.org/admin/publications/files/0012.4.pdf.

98 | John A. Laitner, American Council for an Energy-Efficiency Economy, "Energy Efficiency Investments as an Economic Productivity Strategy for Texas," March 2011, http://www.aceee.org/research-report/e112.

99 | S. Tegen, M. Goldberg and M. Milligan, National Renewable Energy Laboratory, "User-Friendly Tool to Calculate Economic Impacts from Coal, Natural Gas, and Wind: The Expanded Jobs and Economic Development Impact Model (JEDI II)," Conference Paper NREL/CP-500-40085, June 2006, http://www.nrel.gov/wind/pdfs/40085.pdf.

100 | U.S. Department of Defense, "Investing in Energy Conservation Expected to Save Millions," http://www.af.mil/news/story.asp?id=123161632.

101 | El Paso Times Editorial Board, "Energy Independence: Fort Bliss Leads the Way," *El Paso Times*, October 28, 2011, http://www.elpasotimes.com/opinion/ci_19208885.

102 | Western Governors' Association, "Western Renewable Energy Zone Phase I Report," June 2009, http://www.westgov.org/wga/publicat/WREZ09.pdf.

103 | SMRT, Sonoran-Mojave Renewable Transmission Project Preliminary Feasibility Study November 2010, http://ww2.wapa.gov/sites/western/recovery/Documents/SMRTProjectFinalReport12-7.pdf.

104 | BECC, Border Environment Flash, "Significant Environmental Infrastructure Work Done by BECC in Nogales," http://www.cocef.org/news/archivo/2011/08/EN/125/Significant_Environmental_Infrastructure_Work_Done_by_BECC_in_Nogales.html.

105 | NADB, "NADB Projects To Be Featured at U.S.-Mexico Border Energy Forum XVIII in El Paso, Texas," October 26, 2011, Press Release, http://www.nadb.org/pdfs/pastnadbnews/volume_15/35.pdf.

106 | Electric Reliability Council of Texas, Long-Term Study Task Force, "Long-Term Transmission Analysis 2010-2030," Interim Report, Vol. 1, June 2011. http://www.ercot.com/content/committees/other/lts/keydocs/2011/LONG_TERM_STUDY__INTERIM_REPORT_Volume_1.pdf.

107 | El Paso Electric Company Integrated Resource Planning Public Advisory Group, "Resource Planning Process," presentation, June 15, 2011, http://www.epelectric.com/files/html/IRP_2011/Resource_Planning_Presentation_6-15-11.pdf.

108 | North American Electric Reliability Corporation (NERC), "2010 Special Reliability Scenario Assessment: Resource Adequacy Impacts of Potential U.S. Environmental Regulations," October 2010, p. 24. http://www.nerc.com/files/EPA_Scenario_Final.pdf.

109 | H.B. "Trip" Doggett, Electric Reliability Council of Texas, CEO Statement Regarding EPA Cross-State Rule, July 19, 2011, http://www.ercot.com/news/press_releases/show/354.

110 | Institute of the Americas, "Summary Report: U.S.-Mexico Cross-Border Electricity Stakeholder Forum," 2011, http://azmc.org/amc_downloads/amcdownload1361.pdf.

111 | D. Rick Van Schoik. Arizona State University, North American Center for Transborder Studies, "Transborder Renewable Energy Framing Paper," 2011, http://nacts.asu.edu/sites/default/files/NACTS%20Renewable%20Energy%20WORKshop%20Framing%20Paper.pdf.

112 | Duncan Wood, Mexico Institute, Woodrow Wilson International Center for Scholars, "Environment, Development and Growth: U.S.-Mexico Cooperation in Renewable Energies," May 2010, page 22, http://www.statealliancepartnership.org/resources_files/USMexico_Cooperation_Renewable_Energies.pdf.

113 | Duncan Wood, Mexico Institute, Woodrow Wilson International Center for Scholars, "Environment, Development and Growth: U.S.-Mexico Cooperation in Renewable Energies," May 2010, page 33, http://www.statealliancepartnership.org/resources_files/USMexico_Cooperation_Renewable_Energies.pdf.

114 | Environment California, "California's Solar Cities Leading the Way to a Clean Energy Future," 2009, http://sandiegohealth.org/environment/californiasolarcities.pdf.

Photo Credits
BrightSource, Page 16

The Scientific Consulting Group, Inc.
Editor: Mary Spock
Art Director: Eric Doty
Senior Creative Artist: Charles Wallace