Clearing California's Coal Shadow from the American West

CENTER FOR ENERGY EFFICIENCY
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Cover image
The Navajo Generating Station in the heart of the American Southwest supplies coal-fired electricity to the Los Angeles Department of Water and Power, and is one of the nation's single largest sources of global warming pollution. Photo courtesy of the Grand Canyon Trust.

The Center for Energy Efficiency and Renewable Technologies is a nonprofit coalition of the nation's leading environmental and public interest groups, renewable energy and energy efficiency providers. CEERT's mission is to expand the use of conservation, energy efficiency and renewable technologies, in order to reduce over-reliance on fossil fuels, and to advance sustainability and to improve air and water quality.

Environmental Defense is dedicated to protecting the environmental rights of all people, including the right to clean air, clean water, healthy food and flourishing ecosystems. Guided by science, we work to create practical solutions that win lasting political, economic and social support because they are nonpartisan, cost-effective and fair.

Western Resource Advocates is a non-profit environmental law and policy organization dedicated to restoring and protecting the natural environment of the Interior American West. Our team of lawyers, scientists and economists works to promote a clean energy future that reduces pollution and the threat of global warming; to restore degraded river systems and encourage urban water providers to use existing water supplies more efficiently, so we can meet human needs while protecting rivers, streams, and aquifers; and to protect public lands from the twin threats of energy development and unauthorized off-road vehicle travel.

The complete report is available online at www.environmentaldefense.org.

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Executive summary

Far from the southern California beaches, the movie studios of Hollywood, and the Golden Gate Bridge, a fleet of coal plants in distant western states churns out power for the California market. These coal plants discharge vast quantities of air pollution, consume huge amounts of water and emit destructive global warming gases. Some of the largest mining operations in the United States tear up the land to provide the coal they burn. While the power from these coal plants is transmitted many miles to customers in California, the pollution and environmental disturbances stay behind, sending a cascade of human health and environmental impacts across the American West and the globe. Although coal-fired electricity production accounts for a smaller share of California's power mix than it does in other western states, the sheer size of the California market means that the Golden State's consumption of coal-based power casts a long shadow over the American West.

Critical choices

Today California is at a crossroads. Policymakers have an opportunity to confront the state's coal dependence and lead the way to a new energy future for the entire region. Thousands of megawatts of new coal-fired power generation are being promoted across the interior West, with a sharp focus on the growing California market. At the same time, progressive policymakers at the California Public Utilities Commission and the California Energy Commission have proposed protective new emissions standards for imported power. Their actions, coupled with deliberations over how to meet Governor Schwarzenegger's historic June 2005 directive to reduce global warming pollution, have spawned a vigorous debate about the future of coal in meeting California's electricity needs. This report seeks to inform that debate and to ensure California addresses its reliance on distant coal plants. It documents California's long dependence on high-polluting coal plants in the interior West and describes the environmental threat posed by new coal projects in the region. It also lays out policy recommendations for California and for states in the interior West to chart a new path to a cleaner electricity supply throughout the western United States.

California has a long tradition of leading the way to cleaner air. It has been bold in harnessing the forces of American ingenuity to combat urban air pollution and in adopting the nation's first law to regulate global warming pollution from motor vehicle tailpipes. Industry opponents have repeatedly met California's initiatives with arguments that the technological and economic obstacles to progress were insurmountable. But California has pushed forward, and viable solutions have repeatedly been found.

California's dirty coal legacy

In 2004, coal plants located in the interior West supplied an estimated 20% of all electricity in California, which is twice the share that comes from renewables. Large quantities of air pollution are discharged from these coal plants.

- The harmful sulfur dioxide emitted from California's share of out-of-state coal plants exceeds the quantity of sulfur dioxide released from *all* pollution sources within the state of California.
- *Ten times more* smog-forming oxides of nitrogen are released by California's

share of distant coal plants than the total amount of nitrogen oxides emitted from all power plants within the state.

- California's share of the mercury produced from western coal plants is more than 200 times the total amount emitted from *all power plants* within the state of California, which the EPA reported was 9 pounds in 1999.

- Each year, California's share of distant coal plants releases a staggering 67 million tons of global-warming carbon dioxide. The global warming pollution emanating from these smokestacks is equivalent to the emissions from more than 11 million cars and *cancels out* the reductions to be achieved by California's landmark global-warming standards for motor vehicles and its current renewable portfolio standard.

California buys power from coal plants across the West. In addition, major California electric utilities and municipalities have a dedicated ownership stake in some of the most-polluting coal plants in the western United States.

Southern California Edison, the Los Angeles Department of Water and Power, the California Department of Water Resources, the MSR Public Power Agency, the Southern California Public Power Authority, and the cities of Anaheim, Riverside, Pasadena, Burbank, and Glendale have various ownership interests in the Four Corners and San Juan power plants in New Mexico, the Intermountain Power Project in Utah, the Mohave and Reid Gardner generating stations in Nevada, and the Navajo Generating Station in Arizona.

These California-owned coal-fired power plants are clustered in the heart of the American Southwest, near the renowned "golden circle" of national parks and wilderness areas that includes the Grand Canyon, Canyonlands, Bryce Canyon, Arches, Capitol Reef, Mesa Verde, and Zion national parks. This is the great canyon country that inspired John Wesley Powell, Wallace Stegner, and millions of American families who travel here from across the nation.

It also is a region hard hit by air pollution, including unhealthy ozone levels, haze that obscures scenic vistas, and advisories against consuming mercury-contaminated fish. The Navajo, Hopi, Zuni, and many other native peoples live, work, and raise families in this area.

Air quality in the areas around these plants would not pass muster in California. Over the past three years, San Juan County in northern New Mexico has monitored some 51 violations of California's health standard for ozone. In addition, pollution levels at the Grand Canyon have violated California's ozone health standard 40 times over the same period, and 21 violations have been recorded at Canyonlands National Park. National Park Service data show that ozone concentrations have significantly worsened over the past decade at the Grand Canyon, Mesa Verde, and Canyonlands national parks.

A number of the region's lakes and reservoirs also suffer from mercury fish consumption advisories. The water bodies with protective warnings range from Lake Mary in northern Arizona to the McPhee, Narranguinnep, and Navajo reservoirs in southwestern Colorado.

California's appetite for coal-based electricity has a major role in the air pollution in the American West and the global atmosphere.

- The Los Angeles Department of Water and Power has a 21% ownership interest in the Navajo Generating Station located on the Navajo Indian Reservation near Page, Arizona. The facility is one of the nation's single largest sources of global-warming pollution, discharging 20 million tons of heat-trapping carbon dioxide each year.

- The Mohave power plant is a 1640 megawatt coal plant positioned in the far southern tip of Nevada immediately adjacent to the common border with California and Arizona. Mohave is one of the West's largest sources of haze-forming sulfur dioxide and releases about 10 million tons of heat-trapping carbon dioxide annually. Each year, 4.8 million tons of coal are extracted from Peabody Coal Company's Black Mesa Mine on the Navajo and Hopi reservations in northeastern Arizona, mixed with ground water retrieved 3,000 feet below the reservations from the depleted Navajo Sandstone Aquifer, and carried by pipeline 273 miles across the high desert to the Mohave power plant. The slurry process alone uses over 1 billion gallons of ground water each year, more than the collective annual water needs of the entire Navajo and Hopi tribes. While the facility is located in Nevada, most of its power is delivered to southern California. Southern California Edison has a 56% ownership interest in the plant and the Los Angeles Department of Water and Power holds a 10% ownership interest. Since 1999, the owners have been under a court-supervised consent decree to clean up the plant but to date have made no effort to meet any of the pollution control design and construction deadlines in the decree. The owners agreed that if they did not install the pollution control equipment they would shut down the plant by December 31, 2005.

- Southern California Edison also owns 48% of Units 4 and 5 at the Four Corners Power Plant located on the Navajo Indian Reservation near Farmington, New Mexico. The Four Corners plant discharges more than 40,000 tons of smog-forming oxides of nitrogen annually, more than any other power plant in the entire United States.

- The Four Corners Power Plant and the San Juan Generating Station, which is partly owned by the Southern California Public Power Authority, the city of Anaheim, the Imperial Irrigation District and the MSR Public Power Agency, have the unfortunate distinction of being the top two mercury-emitting power plants in the American West.

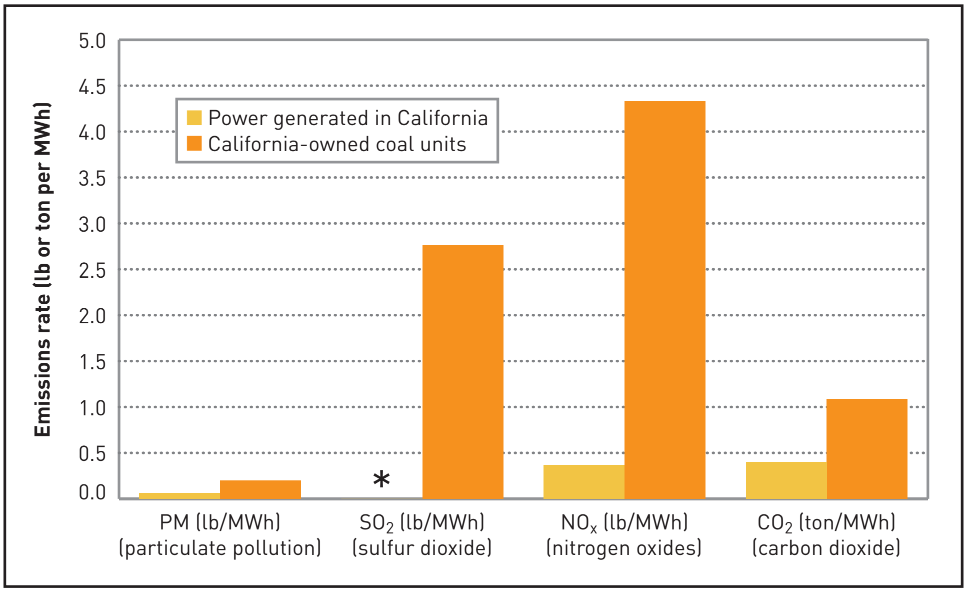
- The California Department of Water Resources has a thirty percent ownership interest in the Reid Gardner coal plant, located near the Moapa Indian Reservation in southern Nevada. The plant is a significant source of smog-forming oxides of nitrogen and airborne lead. The plant's ponds and landfills are also suspected of contaminating groundwater in the area.

- The coal plants dedicated to the California market also are significant sources of toxic lead, chromium, and arsenic.

California's in-state power generation resources are much cleaner than the out–of-state coal plants in the interior West that deliver power to the California market. As Figure ES-1 shows, the out-of-state coal units in which California utilities share ownership emit about three times more global-warming carbon dioxide and particulate pollution and 12 times more smog-forming oxides of nitrogen per megawatt-hour of electricity generated than do the non-coal-fired power generation sources located inside California. While California's out-of-state coal plants also discharge large quantities of harmful sulfur dioxide and toxic mercury, its in-state power plants are virtually free of these contaminants.

FIGURE ES.1

Comparison of emissions rates of electric power generation sources located in California and California's coal-fired generation in the interior West



*Electric power sources located in California have negligible sulfur dioxide emissions.

Source: Generation-weighted average emissions rates for California-owned units are computed based on data from Energy Information Administration Form 767 for 2002-2003 generation, coal burned, and PM emission rates, and the U.S. Environmental Protection Agency's Clean Air Markets Database for 2002-2003 heat input, SO_2, NO_x, and CO_2 emissions. Estimates of emissions rates for in-state California power generation sources are from the California Energy Commission's "A Preliminary Environmental Profile of California's Imported Electricity," June 2005.

Coal-fired power plants owned by California utilities also consume precious water in the Southwest. The Navajo Generating Station and the Four Corners Power Plant each consume more than 8 billion gallons of water every year. The environmental footprint of coal-fired power plants further extends to the coal-mining operations that supply them. The Black Mesa-Kayenta mining complex, which supplies the Mohave and Navajo generating stations, is one of the largest strip-mining operations in the United States.

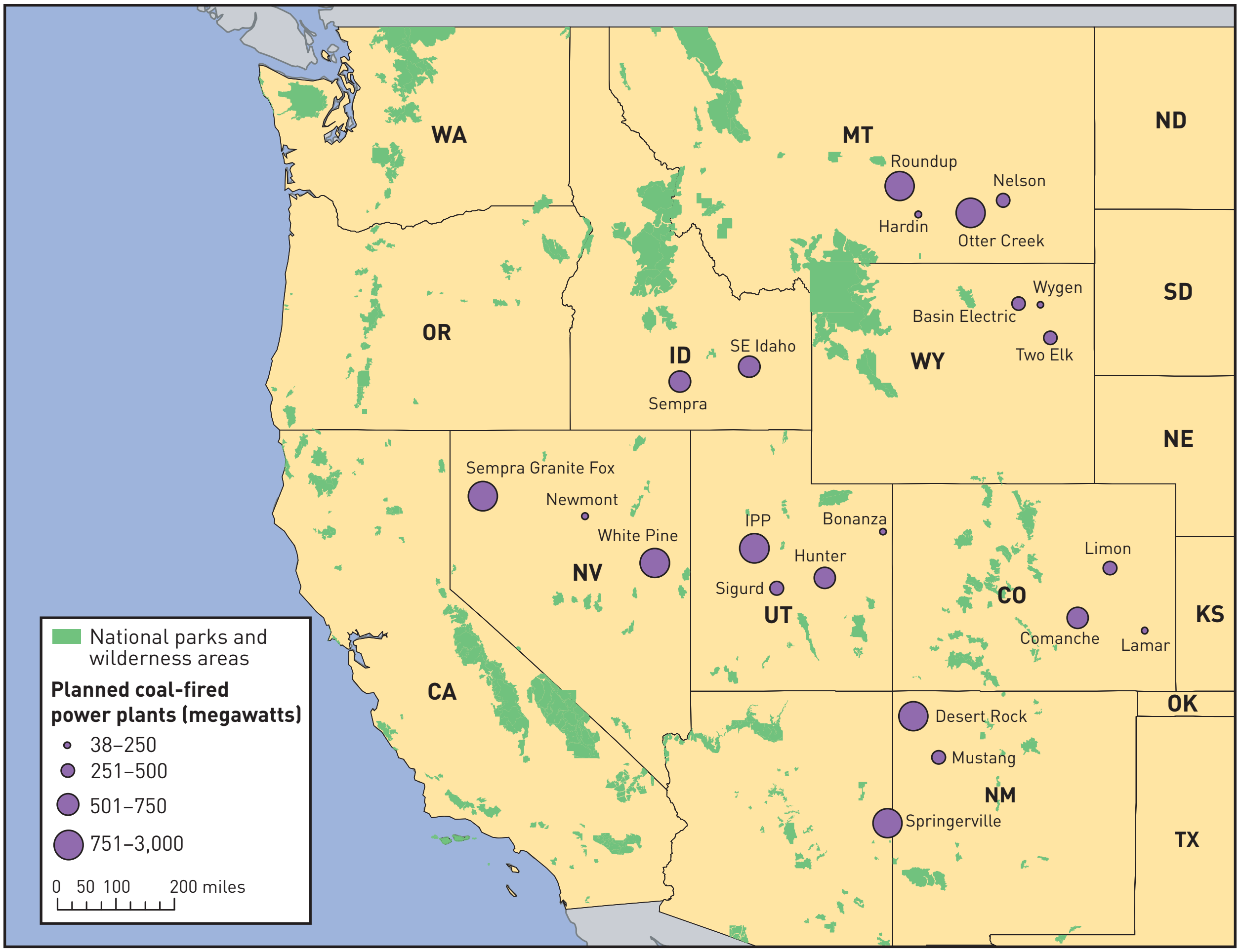
The push for more coal-fired power plants in the interior West

The interior West faces an unprecedented resurgence in coal-fired power plants, with more than 14,000 megawatts of new coal-fired generating capacity in various stages of development. Without new energy efficiency or renewable energy initiatives, California could consume all of the electricity produced by these new plants in 2025 if its demand for electricity grows over the next two decades as projected. The map in Figure ES-2 depicts the numerous new coal plants proposed for the region. As proposed, these would all be pulverized coal plants that produce large quantities of air pollution, not pollution-minimizing advanced coal combustion technologies such as coal gasification.

The coal-fired power plants proposed for the interior West will be situated in communities whose residents' health already is threatened by rising ozone levels, near rivers and lakes with advisories against consuming fish contaminated with mercury, and close to the region's treasured parks and wilderness areas, where haze obscures otherwise stunning

FIGURE ES.2

Proposed new coal-fired power plants in the western United States



Source: Compiled from PSD permits, permit applications, or company-issued information.

views and nitrogen deposition threatens alpine wildflowers and native trout. The staggering amounts of global-warming pollution released from these plants would nullify California's in-state investments in lowering greenhouse gases and thwart the nation's progress in addressing the immediate problem of global warming.

Unless action is taken to apply more protective environmental standards across the region, coal plant developers in the interior West stand to benefit from the opportunity to sell power to the California electricity market, without having to meet the state's own clean air and global-warming standards.

Sempra Energy's proposed 1200-megawatt Granite Fox coal plant is a case in point. Sempra is a San Diego-based independent power producer that has long served the California market. Its new Granite Fox coal plant would be located in Gerlach, Nevada, just outside the California border, within easy reach of a major transmission line into California but avoiding the state's clean-air standards. The proposed plant's local impacts would include consuming 4 billion gallons of water a year, exhausting the annual groundwater recharge in the surrounding Smoke Creek Basin. As planned, the Sempra facility would release some 10 million tons of global-warming pollution each year, which is equivalent to the emissions from 1.8 million cars.

Harnessing clean energy to achieve clean air

Earlier this year, the governors of California, Nevada, Utah, and Wyoming announced a joint venture to build a massive high-voltage transmission line that would carry coal-fired electricity from the interior West to California. Paradoxically dubbed the "Frontier Line" by its promoters, the multibillion-dollar project would help expand the development of coal plants in the interior West to serve California markets. New transmission lines should be used to carry to market the power produced from the West's abundant renewable resources, not from high-polluting coal plants.

In the face of proposals like the Frontier Line, policymakers in California and the interior West must move swiftly to harness clean energy alternatives. Instead of building thousands of megawatts of new coal-fired electricity generation, policymakers must deploy cost-effective energy efficiency measures that will both save consumers money and protect the environment. Instead of saddling the interior West with high-polluting coal plants, western policymakers should spur development of the region's clean, abundant renewable energy resources—wind, geothermal, biomass and solar. Instead of building more conventional coal plants with their health and global-warming burdens, policymakers should unleash the forces of new technology and demand coal plants that maximize thermal efficiencies, use state-of-the-art pollution controls, and meet emission standards for global-warming pollution that are set at or below those achieved by today's new combined cycle natural gas plants.

More fully tapping the renewable energy and energy efficiency resources available across the West could eliminate the need for all the new coal-fired power plants being proposed for the region.

- Taking advantage of all achievable cost-effective energy efficiency opportunities in California would avoid the need to construct eight new 500-megawatt coal plants.
- Fully tapping energy efficiency opportunities in the states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming would avoid the need to construct 26 new 500-megawatt coal plants.
- Tapping just 3% of the West's renewable energy potential would avoid the need for over 30 new 500-megawatt coal plants.

The Frontier Line and other similar multi-billion dollar transmission projects to carry high-polluting coal-fired power across the American West are drawn directly from Twentieth Century blueprints. The West's future is not repeating the past but boldly using the region's resources to maximize energy efficiency and multiply renewable energy resources. If new coal plants are necessary, the region must deploy genuinely cleaner coal systems that meet California's own clean air and global-warming standards. The new frontier is addressing the region's growing energy needs while effectively lassoing today's urgent global-warming and air pollution challenges.

CHAPTER 1

Introduction

Across the western United States, developers are proposing dozens of new coal-fired power plants. If they are built as proposed, these power plants will operate for decades, adding to the region's burden of health-damaging air pollution, casting a haze over the West's grand vistas, consuming scarce western water, and discharging huge amounts of global-warming pollutants. Many of the proposals are driven not by local power needs but by the growing demand in California. This state has long imported coal-fired electricity, leaving the pollution that comes with it behind in the states where the electricity is generated.

The coal-fired power plants proposed for the interior West will be situated in communities whose residents' health already is threatened by rising ozone levels, near rivers and lakes with advisories against consuming fish contaminated with mercury, and close to the region's treasured parks and wilderness areas, where haze obscures otherwise stunning views and nitrogen deposition threatens alpine wildflowers and native trout. These coal plants would use technology that will emit local and regional air pollutants and global-warming contaminants at levels far higher than would be allowed in California. The staggering amounts of global-warming pollution released from these plants would nullify California's in-state investments in lowering greenhouse gases and frustrate the nation's progress in addressing the urgent problem of global warming.

California has a proud legacy of leadership on clean-air issues. It has boldly led the nation in the fight against smog and the urgent problem of global warming. In 1947, California Governor Earl Warren signed one of the nation's first state air pollution control laws, approving historic legislation to establish air pollution control districts in every county. Also half a century ago, Dr. Arie Haagen-Smit uncovered the connection between ground-level ozone in Los Angeles and emissions from motor vehicles and industrial factories, a landmark breakthrough in atmospheric science. In 1966, California adopted the nation's first automotive tailpipe emission standards for smog-forming pollution. Thanks to the state's commitment to energy efficiency, per-capita electricity use in California held steady over the last 30 years while it rose nearly 50% nationwide. In 2002, Assemblywoman Fran Pavley led the California legislature in adopting the nation's first law to regulate global-warming pollution from motor vehicles. That same year, the legislature passed an ambitious renewable portfolio standard, which the California Public Utilities Commission has aggressively moved to implement and expand. And in June 2005, Governor Schwarzenegger announced a historic executive order committing California to meet crucial milestones for reducing global-warming pollution.

As a result of these ground-breaking efforts, California's in-state electricity portfolio is among the cleanest anywhere, based on demand-side energy efficiency and electricity generation from renewable energy and natural gas. But even though California has fruitfully exported innovative tools and technologies for air quality management, it also exports air pollution. Nearly 20% of California's electricity needs are met by high-polluting coal-fired power plants operating outside its borders. Although coal-fired electricity production accounts for a smaller share of California's power mix than it does in other western states, the sheer size of the California market means that the Golden State's consumption of coal-based power casts a long shadow over the region.

More power will be sought in California and across the West over the coming decades as the region's population grows. Viable, clean alternatives for meeting this demand are available now. The first is energy efficiency, and in this regard the states of the interior West need to follow California's example of reducing demand for electricity as the first "source" of new supplies. The second alternative is to develop and market the West's abundant renewable resources of wind, geothermal, and solar power. Finally, a variety of technologies exist to burn coal more efficiently and cleanly and to address the daunting global-warming pollution that coal combustion produces. California must end its double standards for in-state power and imported power. The state must require the coal-fired electricity that it imports from other states to meet the same protective clean-air and global-warming standards it demands of in-state power producers.

The lifetime of a coal-fired power plant can extend to 60 years. Therefore, before new power plants are approved, transmission lines are built, or long-term power contracts are signed, California must harmonize the environmental performance standards for out-of-state suppliers with the protective standards for in-state power. All the states of the interior West must demand clean-energy solutions that take full advantage of cost-effective energy efficiency and renewable energy resources. And if the region must use more coal, western states must draw the line on old-style high-polluting coal plants and require advanced coal power technologies, such as coal gasification, that truly minimize air pollution while safely and reliably capturing and sequestering global warming gases.

CHAPTER 2
California's connection to coal in the interior West

Although there are no large coal-fired power plants in California,[1] this does not mean that its electricity is clean. In recent years, Californians have received an estimated one-fifth of their electricity supplies from coal-fired power plants located across the interior West, which is twice as much electricity as they get from renewables.[2] In fact, California utilities *own* more than 4,500 megawatts (MW)[3] of coal-fired power generation capacity located out of state. These coal-fired units provided about 27 terawatt-hours (TWh)[4] of electric energy to California in 2003.[5] That same year, an additional 32 TWh of electricity generated by other coal plants in the interior West was estimated to have been sold across the grid into California.[6] The coal-fired power plants that supply electricity to California emit large quantities of air pollution that damage human health, harm ecosystems, and obscure scenic vistas across the region.

California's dedicated out-of-state coal fleet

The out-of-state coal plants owned by California utilities are as old and polluting as any in the interior West. They all use decades-old pulverized coal technology. Table 2.1 lists the plants and the quantity of sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM_{10}), and carbon dioxide (CO_2) emitted from the units that are at least partly owned by California utilities. Sulfur dioxide, NO_x, and PM_{10} contribute to fine-particle air pollution that impairs visibility and damages human health. NO_x also forms health-damaging ozone and harms sensitive, high-elevation ecosystems. The fourth pollutant listed, CO_2, is the main air pollutant that causes global warming. California's out-of-state coal plants also emit toxic contaminants, such as arsenic, chromium, lead, mercury, and dioxin. Table 2.2 shows the plantwide levels of toxic contaminants discharged from facilities with California-owned units. On a plantwide basis, the Four Corners Power Plant, which is partly owned by Southern California Edison, and the San Juan Generating Station, which is partly owned by several California municipalities, the Imperial Irrigation District, and the MSR Public Power Agency,[7] have the unfortunate distinc-

TABLE 2.1
Emissions of air pollutants from coal-fired units partly owned by California utilities

Plant	Location	CA-owned units	Nameplate capacity MW	Average generation, 2002–2003 TWh	Average emissions from units partly owned by California utilities, 2002–2003 PM_{10} tpy*	SO_2 tpy	CO_2 1,000 tpy	NO_x tpy	CA share of capacity MW
Navajo	Page, AZ	1,2,3	2,410	17	1,900	3,690	19,640	33,600	510
Reid Gardner	Moapa, NV	4	270	1.8	560	2,780	2,390	4,630	183
Mohave	Laughlin, NV	1,2	1,640	10	1,920	39,100	9,860	19,200	1,082
Four Corners	Farmington, NM	4,5	1,640	11	670	23,600	10,700	27,500	786
San Juan	Waterflow, NM	3,4	1,110	7.6	410	10,600	8,300	17,200	447
Intermountain	Delta, UT	1, 2	1,640	13	730	3,520	14,950	28,720	1,574
Total			**8,700**	**60**	**6,200**	**83,350**	**65,820**	**130,840**	**4,582**

Note: Nameplate capacity, average generation, and emissions reflect totals for units at least partly owned by California utilities.

Sources: Generation and PM_{10} emission rates are from Energy Information Administration, Form 767. Heat input, SO_2, NO_x, and CO_2 emissions are from the U.S. EPA Clean Air Markets Database. Nameplate capacity is from California Energy Commission, A Preliminary Environmental Profile of California's Imported Electricity, June 2005. Output emission rates are calculated based on net generation.

*tpy = tons per year; CO_2 emissions are presented in 1,000 tons per year.

TABLE 2.2

Plantwide emissions of hazardous air pollutants from coal-fired power plants partly owned by California utilities (average, 2002–2003)

Plant	State	Arsenic lb/yr	Lead lb/yr	Chromium lb/yr	Mercury lb/yr	Dioxin gram/yr
Navajo	AZ	nd[a]	290	440	330	3.6
Reid Gardner	NV	110	830	nd	96	3.0
Mohave	NV	780[b]	1,490	1,470	190	2.1
Four Corners	NM	nd	360	270	610	1.1
San Juan	NM	150	140	220	640	1.0
Intermountain	UT	260	140	260	220	1.9
Total		**1,290**	**3,250**	**2,650**	**2,080**	**12.7**

Notes: Emissions of hazardous air pollutants reflect plantwide totals, including but not limited to units at least partly owned by California utilities.

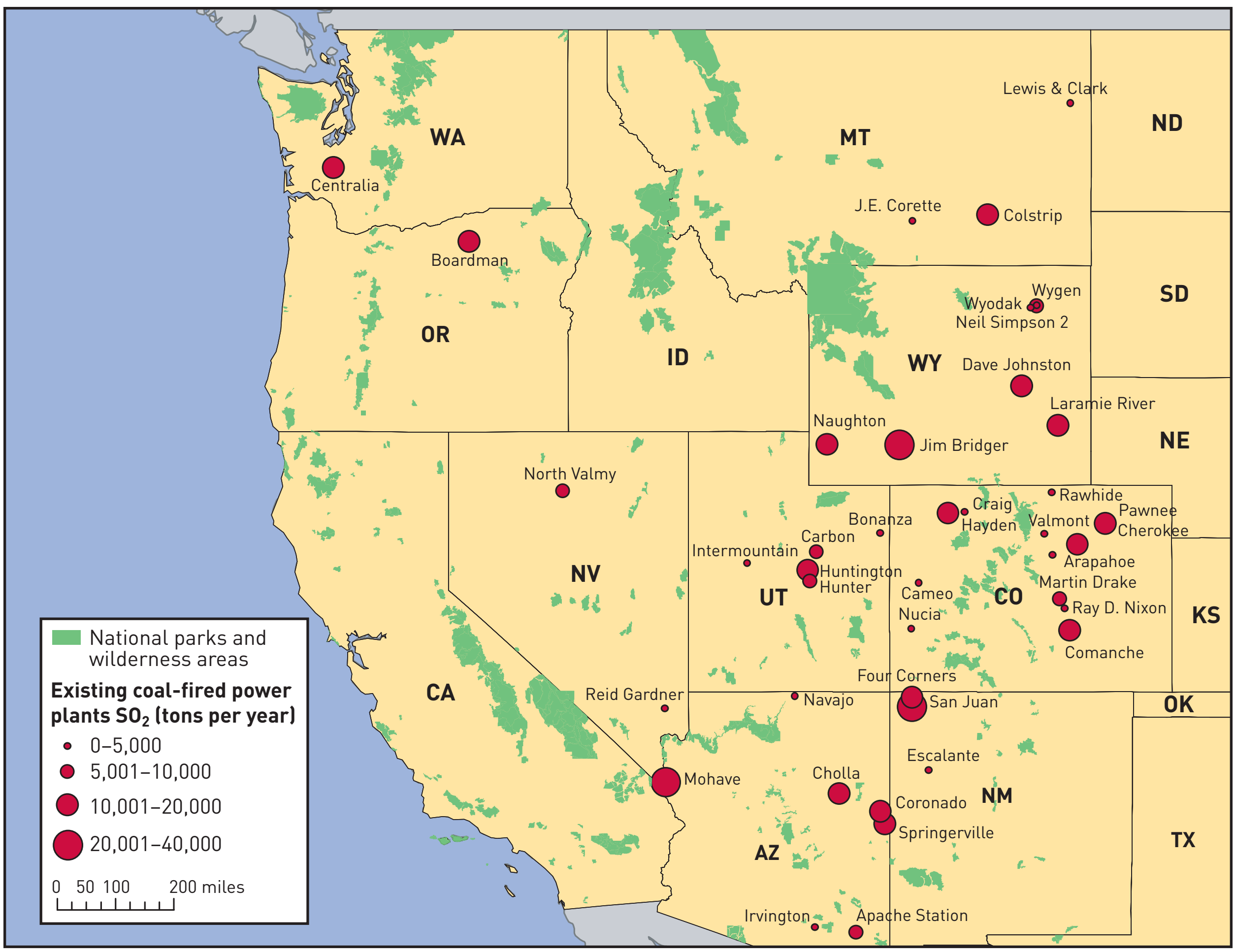
[a] nd = no data.

[b] Only 2002 emissions data were available in the Toxic Release Inventory System.

Sources: Generation is from Energy Information Administration, Form 767. Emissions of hazardous air pollutants are from U.S. EPA, Toxic Release Inventory System, Envirofacts Warehouse, available at http://www.epa.gov/enviro/html/ef_overview.html. Emissions data are generally reported as totals of all compounds of the named elements.

FIGURE 2.1

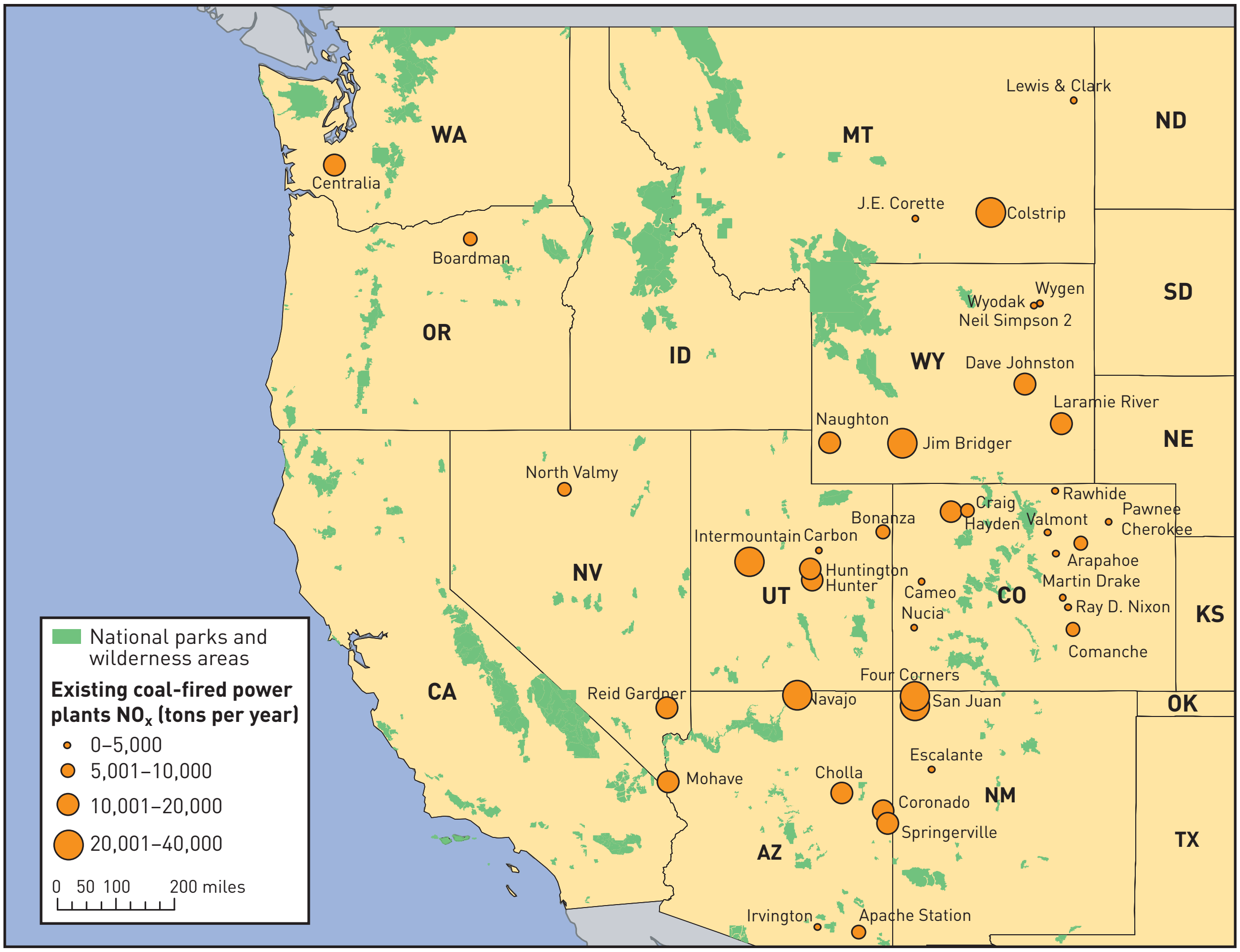
Average sulfur dioxide (SO_2) emissions from existing coal-fired power plants in the western United States, 2002–2003



Sources: Annual emissions data are from U.S. EPA, Clean Air Markets Database.

FIGURE 2.2

Average nitrogen oxides (NO_x) emissions from existing coal-fired power plants in the western United States



Sources: Annual emissions data are from U.S. EPA, Clean Air Markets Database.

tion of being the top two mercury-emitting power plants in the West.

California's additional imports from the western coal fleet

The full fleet of coal-fired power plants in the interior West (including plants that are owned by California utilities and other plants that sell power onto the grid) generates about 230 TWh of electricity,[8] of which more than a quarter is estimated to go to California. Figure 2.1 shows the locations of these western coal plants and the magnitude of the SO_2 emissions from each facility. Figure 2.2 shows the NO_x emissions from the same facilities. Coal plants that supply power to California emit large quantities of pollution that threaten human health and are situated close to national parks and wilderness areas across the interior West, where they contribute to haze and damage ecosystems.

The emissions from California's estimated share of the power generation from all western coal plants are shown in Table 2.3. These plants create a huge amount of air pollution compared to sources in California.

TABLE 2.3

Annual emissions from California's share of coal-fired electricity generation in the West

Pollutant	CO_2 tpy*	PM tpy	SO_2 tpy	NO_x tpy	Mercury lb/yr
Emissions	67,000,000	7,000	107,000	125,000	2,100

Sources: Figures for electricity from coal imported to California are from California Energy Commission, 2003 Net System Power Calculation, May 2004. Emissions are estimated based on generation-weighted average emissions from existing western coal plants, using generation and PM emissions rate data from Energy Information Administration, Form 767. Heat input, SO_2, NO_x, and CO_2 emissions data are from U.S. EPA, Clean Air Markets Database.

*tpy = tons per year

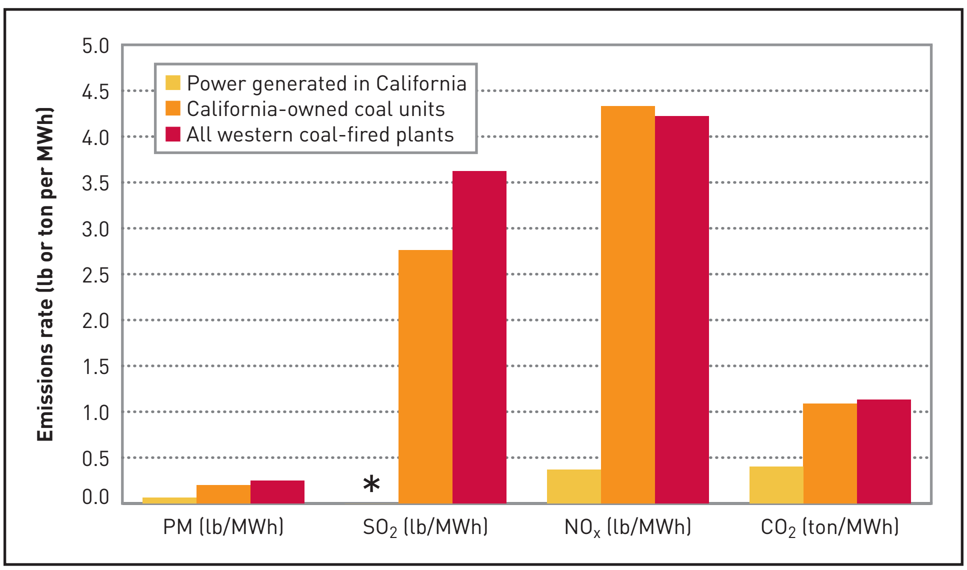
- The quantity of SO_2 emitted from California's share of western coal-fired electricity generation exceeds the total amount of SO_2 emitted from *all sources* in California, which the California Air Resources Board (CARB) reported was 93,000 tons in 2004.[9]
- The amount of NO_x emitted from California's share of western coal is *more than ten times* the total amount of NO_x emitted from all electric utilities in California, which CARB reported was 11,400 tons in 2004.

The amount of NO_x emitted from California's share of western coal is almost as great as the amount of NO_x emitted from all on-road motor vehicles in Los Angeles County, which CARB reported was 140,000 tons in 2004.[10]

- California's share of the mercury produced from western coal plants is more than 200 times the total amount emitted from *all power plants* within the state of California, which the EPA reported was 9 pounds in 1999.[11]

FIGURE 2.3

Comparison of emissions rates of electric power generation sources located in California and coal-fired power generation in the interior West



Sources: Generation-weighted average emission rates for western coal-fired power plants and California-owned units are computed based on data for 2002–2003 generation, coal burned, and PM emission rates reported on Energy Information Administration, Form 767 and 2002–2003 heat input, SO_2, NO_x, and CO_2 emissions from U.S. EPA's Clean Air Markets Database. Estimates of emission rates for California power generation sources are from California Energy Commission, A Preliminary Environmental Profile of California's Imported Electricity, June 2005.

*Emissions of sulfur dioxide from power generation in California are negligible.

- The CO_2 produced is about half the total amount of CO_2-equivalent emissions from all motor vehicles in California, which CARB reported was 140 million tons in 2004.[12]

California enjoys the benefits of relatively clean electricity production within the state while the burden of pollution from the coal plants serving the state falls elsewhere. As Figure 2.3 shows, along with other coal plants in the interior West, the out-of-state coal plants owned by California utilities emit almost three times as much CO_2 and PM and 12 times as much NO_x per megawatt-hour of electricity

Back to the drawing board to find alternatives to coal

California's appetite for out-of-state coal is not new. By the mid-1970s, state utilities considering new investments in coal supply turned their attention beyond the state borders. In the states of the interior West, where regulations were less strict, relatively small utilities were planning large expansions, with the expectation that excess electricity could be readily sold to the hungry California utilities.

In 1979, PG&E and Southern California Edison tried to circumvent the California Energy Commission's jurisdiction by investing in a shared 2,500-MW coal project in Utah. The $5 billion Henry Allen-Warner Valley Energy System contained five power plant units, an open strip mine, and a slurry pipeline to carry coal from one unit to another. Even though the project threatened both Bryce Canyon and Zion National Parks, it remained the number one construction priority for both of California's biggest utilities.

Although the California authorities were barred from considering environmental impacts outside the state in their review of the proposal, they were required to take account of alternative investment options. Zach Willey, a senior economist in Environmental Defense's Oakland office, prepared to argue that material investments in conservation were a far more cost-effective means of meeting growing energy demands than were investments in construction of new generation facilities. He already had presented a sound and detailed argument in a PG&E rate case, in which he demonstrated, relying on basic financial analysis, that investments in conservation could lead to more growth and higher profits without the problems of coal and nuclear power.

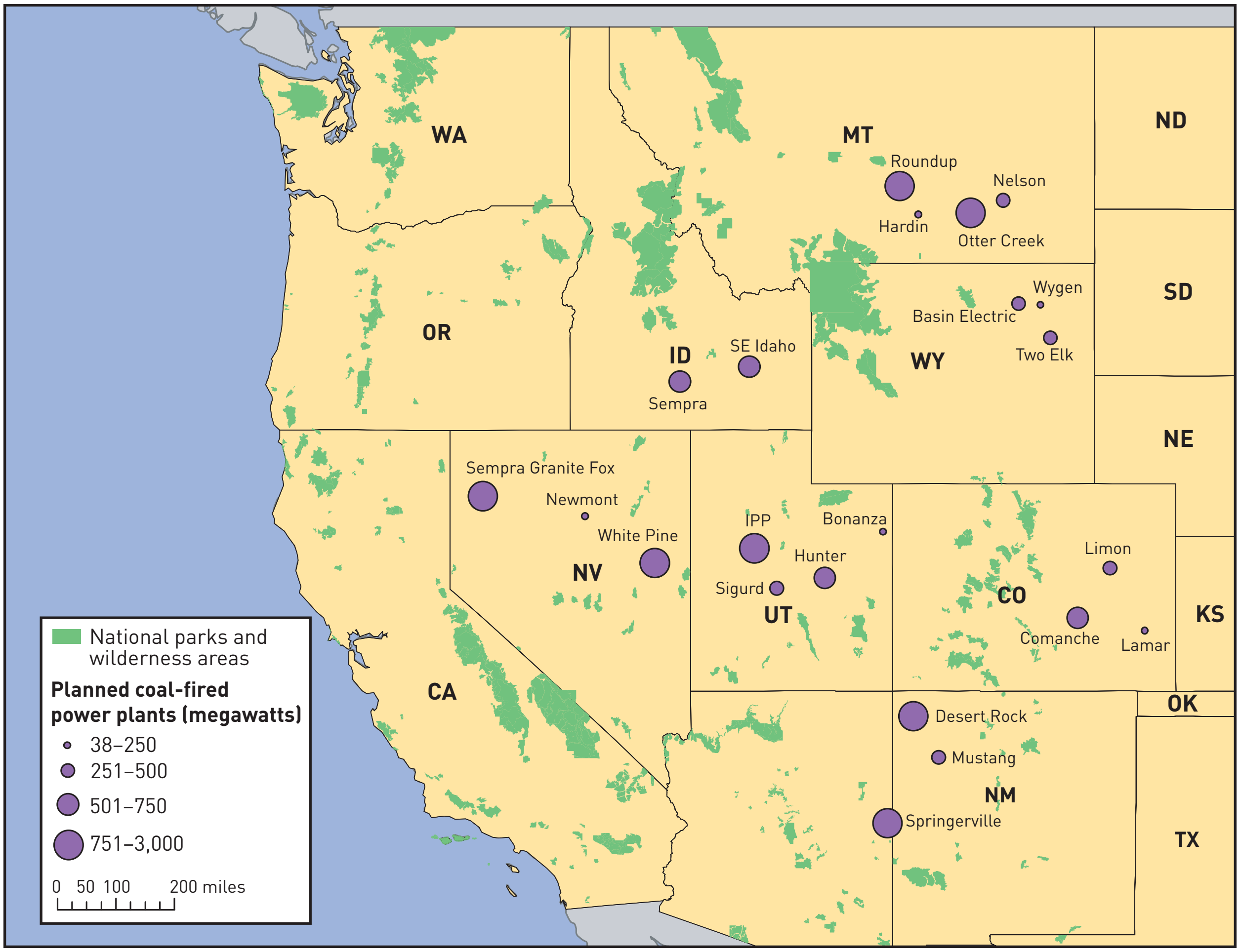
Willey's analysis showed a half-billion-dollar economic advantage to investing in conservation alternatives instead of Allen-Warner. Added to information about the environmental effects of strip mining, smokestack emissions, and aquifer depletion, the economic analysis proved that the Allen-Warner project was, as the study put it, "clearly an inferior choice" for both economic and environmental reasons.

As the case progressed following the submission of Willey's analysis, it became clear that the commission would conclude that Willey was right: Allen-Warner Valley did not need to be built because alternatives could do the entire job at a lower cost. PG&E and Edison withdrew their plans to proceed with Allen-Warner. The utilities went back to their drawing boards and figured out how to meet all their electricity needs through the end of the 1980s without ordering a single new monolith. Allen-Warner, lacking the guarantee of California's demand, was never pursued.

An article in the *New York Times* on the case concluded that "inertia and lack of imagination, not cost advantage, now drive utilities toward conventional solutions to energy needs."[13]

FIGURE 2.4

Proposed new coal-fired power plants in the western United States



Source: Compiled from PSD permits, permit applications, or company-issued information.

generated as do the non-coal-fired power generation sources located inside California.

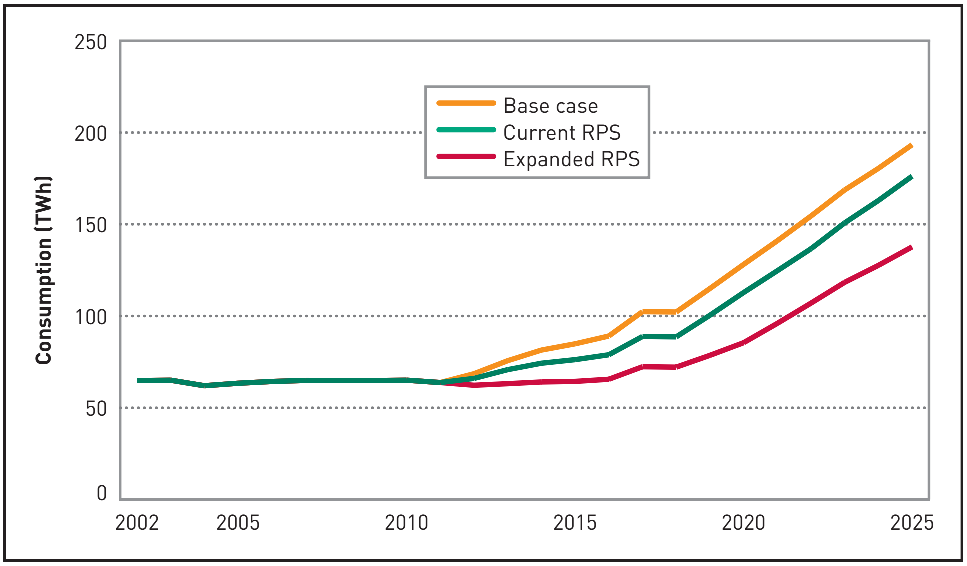
California's growing demand for electricity

In addition to California's contribution to the existing pollution in the interior West, its growing demand for electricity is feeding a surge of proposals for new coal-fired power plants across the region. Over the last several years, most of the generation capacity added in the West has been fired by natural gas. But rising gas prices are spurring an unprecedented number of proposals for new coal plants. According to the California Energy Commission (CEC), "Coal appears to be the preferred resource for future development."[14]

More than 20 proposals for new pulverized coal-fired power plants, corresponding to nearly 14,000 MW of new generating capacity, are in various stages of development across the interior West.[15] Figure 2.4 shows the size and location of these new projects, indicating what is in store if the generation of electricity from coal escalates in the West as predicted. As proposed, these would all be conventional pulverized coal plants, not pollution-minimizing coal gasification facilities that safely capture and sequester global warming

FIGURE 2.5

Influence of renewable portfolio standards on projected growth in California's demand for coal-generated electricity from the interior West



Sources: Underlying data and analyses are described in Appendix A.

pollution. As are the plants in the existing fleet, the new coal plants would be located close to national parks, wilderness areas, and communities across the interior West that are already suffering from the health, visibility, and ecological impacts of air pollution.

Although new coal plants would satisfy other states' demand, too, California's demand for coal-generated electricity is projected to grow dramatically, beginning early in the next decade. The U.S. Department of Energy (DOE) predicts that coal-fired electricity generation in the West will rise steeply, beginning around 2012 and continuing through 2025.[16] Based on the DOE's forecast, we estimated the amount of electricity from coal that California will import from both dedicated and nondedicated sources. Projections were developed with and without factoring in California's renewable portfolio standard (RPS).[17] As originally designed, California's RPS would have committed retail sellers of electricity to a sales portfolio including at least 20% renewable sources by 2017 (the current RPS). The governor of California, Arnold Schwarzenegger, and the state's energy commission have endorsed an acceleration of the 20% RPS compliance date to 2010, with an additional goal of 33% renewables by 2020 (the expanded RPS).

As Figure 2.5 indicates, in the DOE base case, which ignores California's RPS, the state's demand for electricity from coal is projected to more than triple by 2025. That demand could be reduced somewhat by a RPS, although the increase in coal-fired power over current levels still will be dramatic. With the current RPS, California's annual demand for coal-fired electricity is projected to increase by 111 TWh by 2025. Thirty new 500-MW plants operating at 85% capacity would be needed to generate this energy. Twenty-two new 500-MW plants would be required if an expanded RPS limited the growth in yearly demand for coal-generated electricty to 81 TWh. The expanded RPS forestalls any significant increase in coal consumption until 2017

TABLE 2.4

Projected additional emissions from western coal plants in 2025 due to California's increased demand for electricity

Scenario	Added California demand (TWh)	SO_2 (tpy)*	NO_x (tpy)	PM (tpy)	CO_2 (tpy)
Base case	129	65,400	52,100	9,800	145,000,000
Current RPS	111	56,400	44,900	8,500	125,000,000
Expanded RPS	81	41,300	32,800	6,200	91,700,000

Sources: Estimates are based on the projected growth of California's demand for coal-generated electricity and average emission rates for SO_2, NO_x, and PM for new and proposed power plant projects in the interior West. Emission rates for CO_2 were assumed to be equal to those from the existing western coal-fired power plant fleet.

*tpy = tons per year

or so—five years later than the base case and the current RPS scenario. By 2025, the expanded RPS would prevent a cumulative total of 430 TWh of coal-fired electricity generation, compared to the base case forecast. Though not factored into our analysis, California could also slow the projected growth in its electricity consumption and reliance on coal if it expands its groundbreaking energy efficiency policies.

Even under the expanded RPS, California is predicted to consume much more coal-generated electricity in 2025 than it does today. And although the new coal plants will be cleaner than most of the existing ones, if built as proposed using pulverized coal combustion technology they nevertheless will add to the burden of pollution in the interior West. Table 2.4 shows the additional CO_2, NO_x, SO_2, and PM emissions expected in the interior West if conventional pulverized coal plants are built to supply the forecast demand in California in 2025. These estimates are based on the average emission rate limits proposed or adopted for the facilities shown in Figure 2.4, excluding those units being built at existing facilities where offsetting reductions are planned to avoid net emissions increases.

Depending on whether or not the RPS is expanded, SO_2 emissions from coal-fired electricity generation for California could increase by 40% to 60% over the next 20 years, compared with current levels (see Table 2.3), and NO_x emissions could increase by 30% to 40%. The percentage increases for these pollutants are relatively modest, because new power plants are likely to have more stringent SO_2 and NO_x controls than those employed by the coal fleet that serves California now. The worst projections are for CO_2, a key global-warming pollutant. Unless new policies are implemented or new technologies are adopted to improve the efficiency of electricity generated from coal and to capture and sequester CO_2, the emissions of CO_2 from coal-fired electricity generation for California could double or triple over the next 20 years.

The global-warming pollution discharged under any scenario in which the CO_2 from coal is not seriously limited will more than cancel out the global-warming reductions projected under the greenhouse gas standards for California's automobiles. In 2020, California's motor vehicle emissions standards are forecast to reduce greenhouse gases by some 32 million to 36 million tons each year. But California's expanded reliance on coal-based electricity during the same time will increase its annual global-warming pollution by 90 million to 145 million tons, some three to four times more than the predicted reductions from motor vehicles.

CHAPTER 3

Air pollution in the western skies

California's reliance on imported coal-based electricity has real consequences in rural and urban areas of the interior West. Pollutants discharged from the smokestacks of western coal-fired power plants have serious local, regional, and global effects, casting a shadow across western skies, western communities, and some of the most treasured natural areas in the world.

Monitoring data from the National Park Service show that ground-level ozone, haze, and nitrate concentrations are worsening at national parks and monuments across the interior West, from Yellowstone in the north to Grand Canyon and Bandelier in the south. These contaminants obscure vistas and threaten the vitality of high-elevation lakes, streams, and forests. At the same time, a number of urban and rural communities in the interior West are struggling to restore or maintain their compliance with the federal health standard for ground-level ozone and are affected by both local pollution sources and pollution from distant smokestacks. Coal plants supplying power to California also are responsible for a large volume of mercury pollution in the interior West, where bodies of water from Montana to Arizona are under fish consumption advisories for mercury contamination.

New coal plants in the interior West will only compound these serious and growing air quality challenges.

Unhealthy ozone pollution is all too common across the interior West

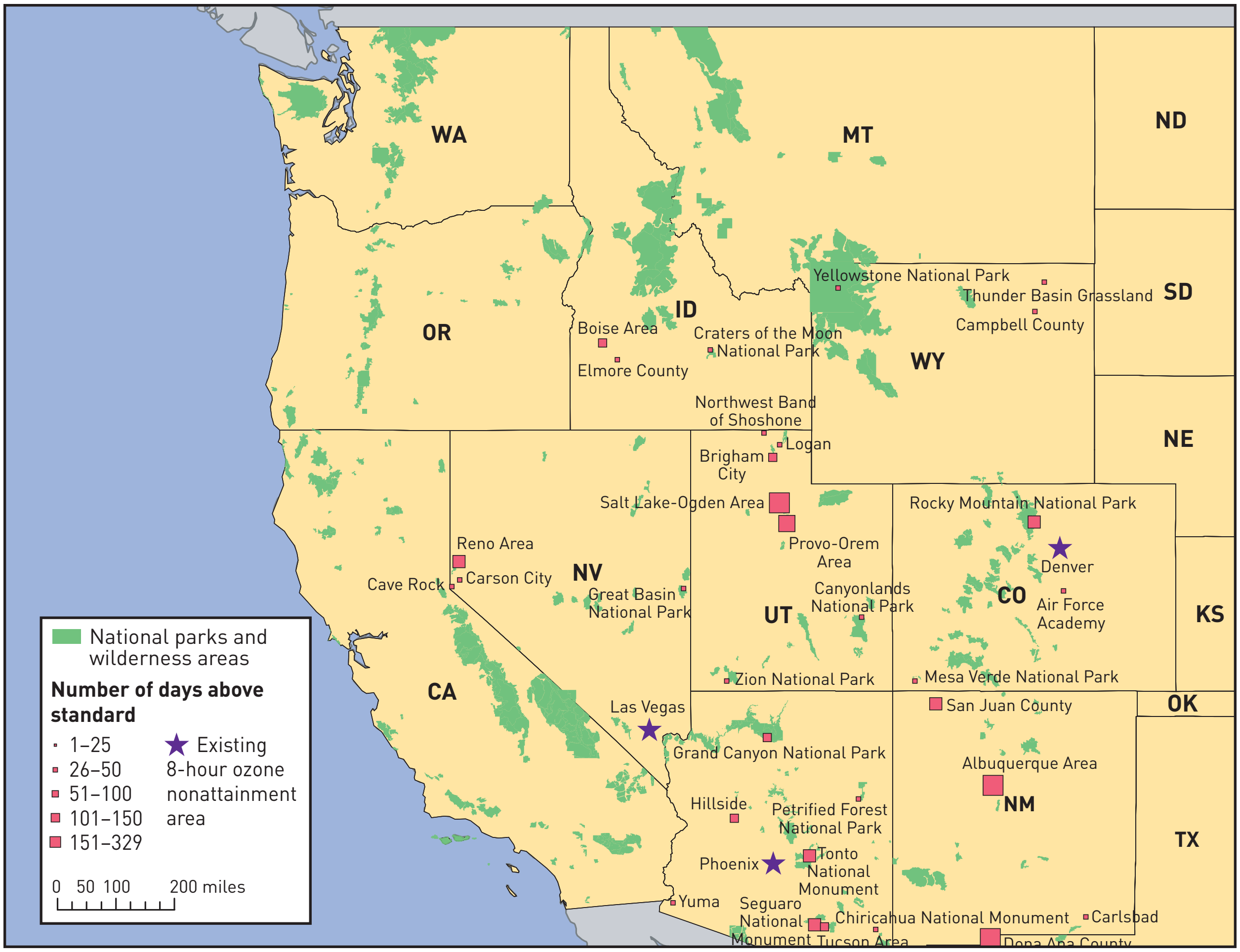
Ozone, the main component of photochemical smog, forms in the lower atmosphere when oxides of nitrogen (NO_x) and various volatile organic compounds (VOCs) react in the presence of sunlight. Elevated ozone concentrations cause a suite of adverse health effects, including decreased lung function, particularly in children active outdoors; hospital admissions and emergency room visits for respiratory problems in children and adults with preexisting respiratory diseases such as asthma; inflammation of the lungs; and possible long-term lung damage.[18] Children are particularly at risk because their lungs are not fully developed and so their airways are narrow, and their respiration rates are relatively high for their size.[19] Numerous studies conducted in recent years have linked ozone with school absences resulting from sore throats, coughs, and asthma attacks; decreased lung function in girls with asthma; long-term lung damage in children; and premature death.[20]

In April 2005, the California Air Resources Board (CARB) responded to the new science concerning the health effects of ozone, particularly on children's health, by adopting a more protective ozone standard. California's new state ozone standard is set at 0.070 parts per million (ppm) for an eight-hour averaging period, not to be exceeded. The federal health-based eight-hour ozone standard is 0.08 ppm and therefore is less protective. Furthermore, the form of the federal standard allows for more exceedances before a violation of the health standard is declared. Compliance with the federal standard is based on the three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area.[21]

A close look at the available monitoring data shows that the interior West

FIGURE 3.1

Western areas outside California where its eight-hour ozone health standard is violated



Note: Exceedance data are not shown for the following eight-hour ozone nonattainment areas: Las Vegas, Phoenix, and the urban portion of the Denver nonattainment area. Analysis based on data at 144 federal, state, and tribal ozone monitors in the western states.

has high ozone pollution levels extending from its urban centers to rural communities to remote national parks. The major urban centers of the interior West face many of the same air quality challenges as do the major metropolitan areas in California. Indeed, the EPA has declared Denver, Las Vegas, and Phoenix to be out of compliance with the federal ozone health standard, and officials are working to restore and maintain healthy air. High ozone concentrations are not confined to these urbanized areas but are all too common across the interior West and, in many instances, are growing worse. We analyzed volumes of government data to compare ozone concentrations in the interior West directly with California's own protective ozone health standard. The results are striking.

According to air-monitoring data reported to the EPA for 2002 through 2004 and as shown in Figure 3.1, numerous areas of the West outside California, including 14 national parks and monuments, would not meet the state's ozone health standard. In fact, the levels of ozone pollution at places like Yellowstone, Canyonlands, Zion, Rocky Mountain, Mesa Verde, and Grand Canyon national parks would violate the California health standard. Similarly, rural communities such as Campbell County, Wyoming, the heart of the West's coal-mining country, and San Juan County, New Mexico, violate California's health standard for ozone.

Moreover, in many places, the California standard is frequently violated. Most of the areas shown in Figure 3.1 exceeded California's ozone standard multiple times between 2002 and 2004. For example, Rocky Mountain National Park would have violated the California health standard on 79 days during this three-year period. In addition, this standard was repeatedly violated in moderately populated areas across the West, such as Albuquerque, the Salt Lake City region, Tucson, Reno, and Boise. In all, ozone levels in 32 areas in the West for which monitoring data are reported exceeded California's health standard an alarming total of 1,616 times between 2002 and 2004.[22]

The complex air quality modeling necessary to quantify how much power plants contribute to ozone pollution across the West has not been performed. But there is ample evidence to indicate that coal-fired power plants are a significant contributor, as they discharge more than 20% of the smog-forming NO_x pollution in the region.[23] This pollution may increase as new facilities are built and as existing plants increase their operation. The NO_x discharged from power plant smokestacks can travel hundreds of miles downwind to form ozone, contributing to both high local pollution levels and elevated background concentrations across the interior West.

Particulate pollution endangers health in the interior West

Coal-fired power plants are a major contributor to fine-particulate pollution, which threatens human health and also impairs visibility. Sulfur dioxide and oxides of nitrogen are transformed in the atmosphere into the solid and liquid aerosols that are a major component of harmful fine-particulate pollution. The smokestacks at coal-fired power plants discharge nearly two-thirds of all sulfur dioxide and one-fifth of all oxides of nitrogen pollution in the interior West.[24]

The EPA has just completed an extensive review of the science on particulate pollution, which indicates that serious health effects, including premature death, can occur from exposure to particulate pollution in areas meeting the current federal standards. In fact, the EPA found no strong evidence of a clear threshold below which serious health effects do not occur.[25] Risk estimates for breathing particulate pollution[26] applied to current pollution levels in Salt Lake City, Denver, Las Vegas, Phoenix, and Albuquerque indicate that serious health effects, including premature death, may be occurring due to particulate air pollution in these cities.[27]

Based on the body of evidence documenting adverse health effects from particulate pollution that falls below the current federal standard, EPA staff recently recommended tightening the National Ambient Air Quality Standards for particulate pollution.[28] They recommended that the agency tighten both the annual average and the 24-hour average standards. At the midpoint of the range of concentrations being considered, the EPA staff estimate that 45 of the counties with monitors in the Northwest and Southwest outside California would violate a more protective 24-hour standard for fine-particulate pollution.[29]

Coal-fired power plants contribute to elevated mercury levels across the West

Mercury is a toxic heavy metal that threatens the development of fetuses and children and contributes to the risk of heart disease. A senior EPA scientist estimates that 630,000 newborns in the United States each year have unsafe mercury levels in their blood.[30] Coal-fired power plants account for about 40% of mercury air pollution in the United States and are the nation's largest source of human-produced mercury air pollution.[31] Power plants in the interior West emit about 10,000 pounds of mercury per year.

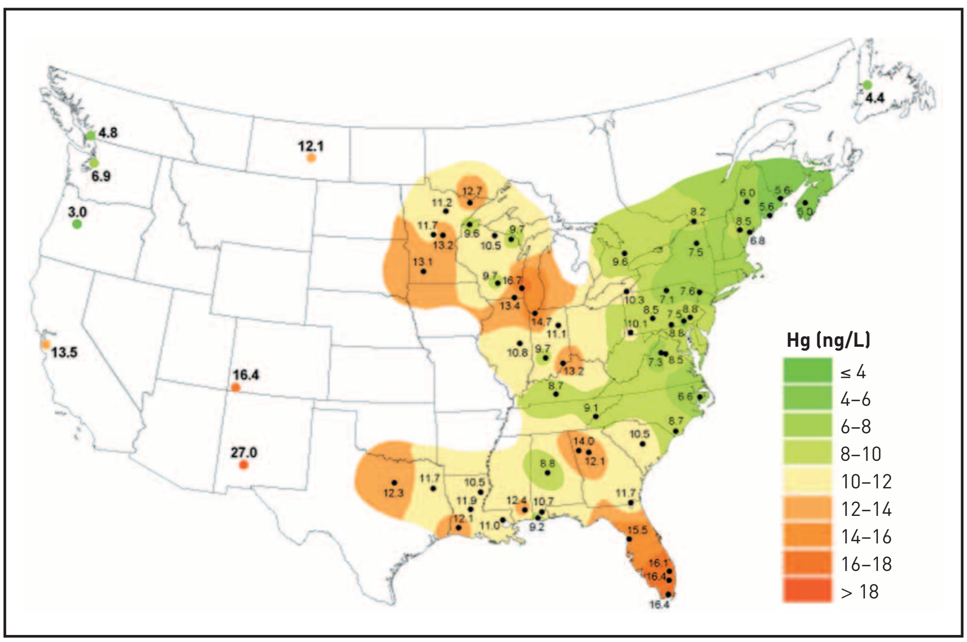
Although part of the mercury emitted from power plants is transported globally in the atmosphere to be deposited across the Northern Hemisphere, some of it is deposited close to its source. Through either direct deposition or runoff, mercury from power plant smokestacks ends up in lakes, rivers, and oceans. Bacteria in the sediments of water bodies transform mercury into its most toxic form, methylmercury, which readily accumulates in the aquatic food chain. Thus, by eating contaminated fish, hundreds of thousands of Americans are exposed to unsafe levels of methylmercury. Western states from New Mexico to Montana have active fish consumption advisories for mercury, covering hundreds of lakes and streams.[32]

Although mercury emissions from coal-fired power plants are higher in the eastern United States than in the West, because of the larger number of power plants in the East,[33] elevated mercury levels still are common in the West. Although sparse,[34] the available data show that the concentrations of atmospheric mercury in precipitation (see Figure 3.2) and the levels of wet deposition in the interior West are similar to those in the East. In fact, in 2003, the highest annual precipitation mercury concentration in the nation was a value of 27 nanograms per liter (ng/L) observed in New Mexico. The Colorado monitoring site at Mesa Verde National Park recorded the third highest concentration in the country.[35]

The EPA recently issued new rules governing mercury emissions from

FIGURE 3.2

Annual average concentrations of mercury in precipitation, 2003



Source: National Atmospheric Deposition Program/Mercury Deposition Network.

power plants. But these rules fail an elementary test of good public policy by allowing this toxic pollutant to increase in much of the West over the next decade, even though cost-effective control technology is available. The current clean-air rules therefore provide scant protection for westerners hard hit by mercury pollution from coal-fired power plants in the region.

Other toxins from coal-fired power plants

Besides discharging the toxic pollutant mercury, coal-fired power plants also are a significant source of arsenic, lead, chromium, and dioxin. In 1999, coal-fired power plants in Arizona, Colorado, Montana, Nevada, New Mexico, North Dakota, Oregon, Utah, South Dakota, Washington, and Wyoming contributed 33% of the arsenic, 24% of the lead, and 15% of the total chromium emissions in these 11 states.[36]

The EPA's 1998 Report to Congress on the toxic pollution from power plants raised important health concerns about all these contaminants.[37] The report outlined the severe cancer risk associated with arsenic, finding that

inhalation exposure to inorganic arsenic has been strongly associated with lung cancer in humans. Human exposure to inorganic arsenic, via ingestion, has been associated with an increased risk of several types of cancer, including skin, bladder, liver, and lung cancers. Oral exposure to inorganic arsenic has also been associated with noncancer effects, including effects to the central nervous system, cardiovascular system, liver, kidney, and blood.[38]

This report also examined the health effects of dioxins discharged from power plants.[39] Dioxins are classified as a probable human carcinogen and are associated with soft-tissue sarcomas, lymphomas, and stomach carcinomas. They also are known to be a developmental toxicant in animals, causing skeletal deformities, kidney defects, and weakened immune responses in the offspring of animals exposed during pregnancy.[40]

The United States has made great strides in eliminating a major source of lead in the environment through the EPA's landmark program to phase out lead in gasoline. Although levels of lead in the air have declined dramatically, lead pollution associated with coal-fired power plants remains largely unregulated and is still a significant concern. Children are particularly sensitive to the chronic effects of lead, including slowed cognitive development and reduced growth.[41]

Long-term exposure to chromium compounds can cause respiratory tract problems like shortness of breath, coughing, and wheezing from acute exposure; and perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects from chronic exposure. Inhaled chromium in its most toxic form is a human carcinogen, resulting in an increased risk of lung cancer.[42]

In its controversial mercury rules issued earlier this year, the EPA refused to regulate arsenic, lead, chromium, or dioxins from coal-fired power plants. If the region continues to rely on conventional coal plants for power generation, westerners will be exposed to more of these harmful contaminants.

Haze obscures many of the West's treasured vistas

The western United States is renowned for its inspiring vistas and piercing blue skies, but they are threatened by air pollution. The same fine-particulate pollution that has adverse health effects also cloaks western vistas in haze. At many national parks and wilderness areas across the interior West, visibility is often only half of what it would be under natural conditions. As with harmful particulate pollution, coal-fired power plants are a major contributor to haze-forming sulfur dioxide and oxides of nitrogen.

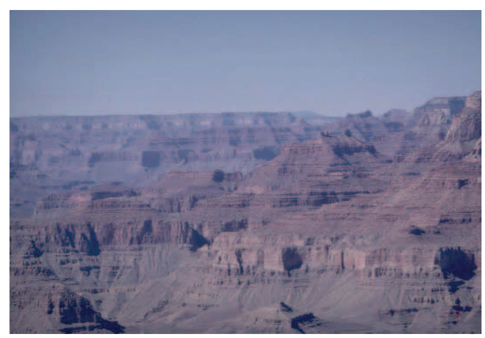
The photos in Figure 3.3 contrast clear and hazy days in two "crown jewels" of the interior West, the Grand Canyon and Rocky Mountain national parks. On the clearest days, when pollution levels are close to the natural background, the visibility is as good as it gets. On hazy days, air pollution dramatically clouds distant features of the landscape and obscures nearby features and colors.

Not only do the scenic vistas of the West suffer from excessive air pollution, but National Park Service data indicate that in many areas, visibility on the haziest days is deteriorating. Over the past ten years, from 1994 to 2003, the haziest days have worsened at Mesa Verde, Guadalupe Mountains, Petrified Forest, Crater Lake, Glacier, Rocky Mountain, and Great Sand Dunes national parks, and at Bandelier and Tonto national monuments.[43] At Great Sand Dunes National Park in Colorado, visibility has also deteriorated on the clearest days, making it the only

FIGURE 3.3
Contrast between very hazy and very clear days at the Grand Canyon and Rocky Mountain National Parks

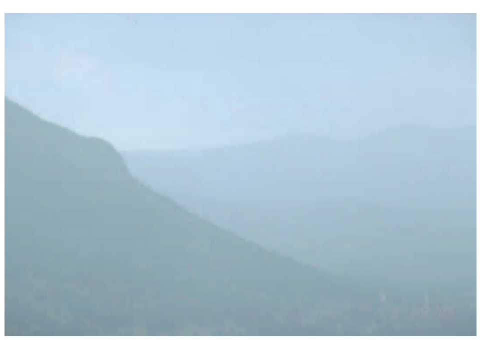
GRAND CANYON NATIONAL PARK

Visual range: ~75 miles



Visual range ~150 miles

ROCKY MOUNTAIN NATIONAL PARK



Visual range: ~13 miles

Visual range: ~130 miles

Source: Visibility Information Exchange Web System, available at http://vista.cira.colostate.edu/views/Web/General/Data.htm.

national park in the country with worsening visibility conditions on both hazy and clear days.[44]

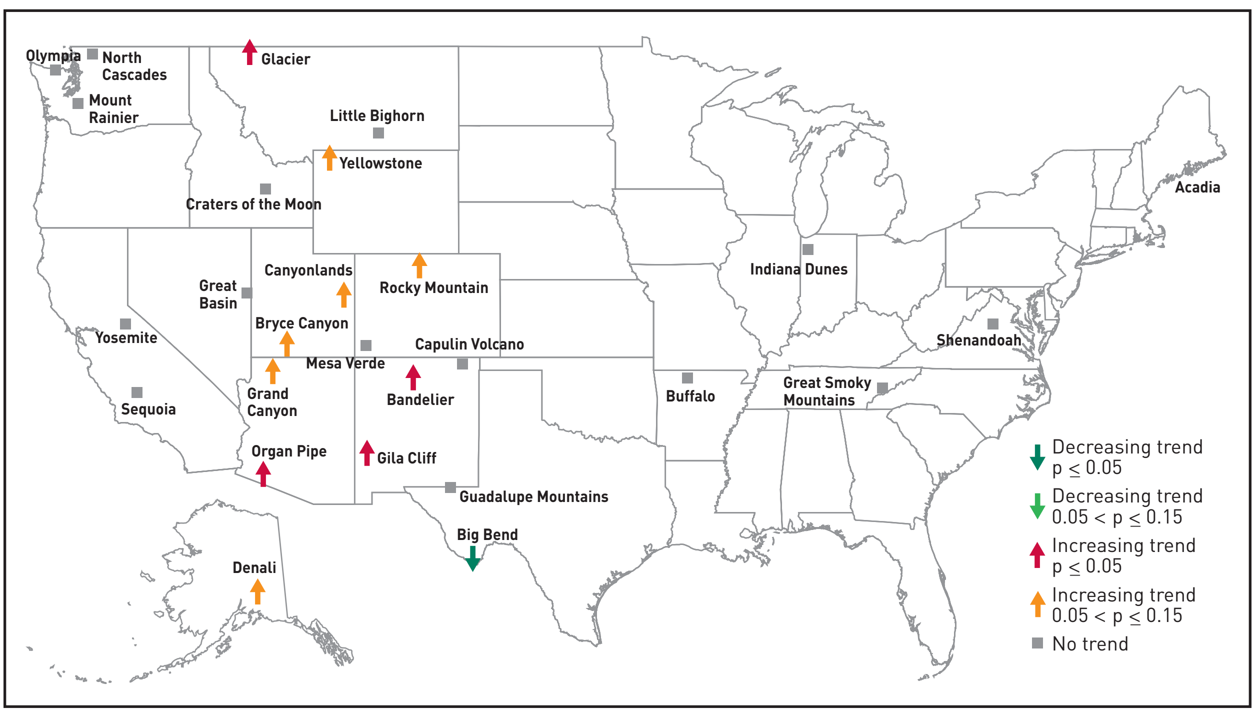
The national parks are icons of the American West. They also sustain a vibrant tourist economy, attracting millions of visitors each year. California's long shadow reaches well outside its border to contribute to the pall over these scenic areas.

Nitrogen deposition threatens western ecosystems

As a major source of nitrogen oxides, coal-fired power plants are an important contributor to the growing problem of reactive nitrogen deposition. Reactive nitrogen is released into the atmosphere in the form of ammonia (primarily from agriculture) or NO_x (from combustion sources) and then is deposited in gas, particle, or aqueous form. The deposition of reactive nitrogen can lead to the overfertilization of sensitive ecosystems and to acidification of lakes and streams. High-mountain ecosystems and water bodies across the West, from the Sierras and Cascades to the Colorado Rockies, are susceptible to this damage.

Nitrogen deposition affects soils and soil microorganisms and plants and can reduce tree growth and change the composition of plant communities.[45] Numerous ecological impacts caused by nitrogen deposition have been documented in the western United States, including shifts in species composition and loss of diversity.[46] For example, the National Park Service has concluded that critical loads for nitrogen deposition (the loads that can be sustained without damaging sensitive features of the ecosystem) are being exceeded at Rocky Mountain National Park. Nitrogen deposition is changing the chemical composition of streams and lakes, foliage, and soils, along with the phytoplankton population

FIGURE 3.4
Annual nitrate concentrations in precipitation, 1994–2003



Sources: National Park Service, GPRA Air Quality Trends Reports, 2004, available at www2.nature.nps.gov/air.

of the park's alpine lakes. If this increase in nitrogen deposition continues, alpine wildflowers may be displaced, and some of the park's high-altitude waters could acidify to the point that they will be unable to support Colorado's state fish, the greenback cutthroat trout.

In the last decade, nitrate (NO_3^-) concentrations in precipitation, a major vector for reactive nitrogen deposition, rose at many parks across the country, with national parks in the interior West showing especially large increases.[47] The National Park Service's most recent reporting for 1994 through 2003 (Figure 3.4, page 17) shows that nitrate concentrations in precipitation rose at nine western parks and monuments: Bandelier, Bryce Canyon, Canyonlands, Gila Cliff Dwellings, Glacier, Grand Canyon, Organ Pipe, Rocky Mountain, and Yellowstone.[48]

CHAPTER 4

Global warming impacts on the West

The West's reliance on coal-based electricity has global consequences with a very long time horizon. With the rising levels of carbon dioxide, methane, and other global-warming pollutants in the atmosphere, the world's climate is changing and will change even more dramatically in the decades to come. Thus business-as-usual reliance on coal to meet increased electricity demands will lead to devastating consequences for many parts of the globe, including the western United States, where a precariously balanced water supply system and precious natural ecosystems are under threat.

In 2003, coal combustion contributed 36% of the United States' total heat-trapping carbon dioxide (CO_2) emissions,[49] and coal mining produced 11% of its methane emissions.[50] The United States is the largest emitter of energy-related CO_2 emissions in the world, accounting for nearly one-quarter of the world total.[51] Although currently employed technologies can substantially reduce emissions of nitrogen oxides, sulfur dioxide, particulate matter, and hazardous air pollutants from coal-fired power plants, CO_2 emissions from this sector will increase in lockstep with power generation unless policy and innovative technologies are changed very quickly.

Californians have recognized the folly of continuing business-as-usual and have broken ground for the rest of the country to follow with new emission standards to limit global-warming pollution from motor vehicles. These standards are forecast to reduce greenhouse gases from California vehicles by some 32 million to 36 million tons each year by 2020. As discussed in earlier chapters, this pioneering effort could be canceled out if California expands its reliance on coal-based electricity from other western states. Likewise, California's reliance on imported coal power without protective global-warming limits would nullify the historic commitment made by Governor Schwarzenegger in June, when he established landmark targets to reduce global-warming pollution statewide in California.[52]

Climate change threatens the West's irreplaceable ecosystems and precious water supplies

From the vibrant desert of Saguaro National Park to the emerald tundra of Glacier National Park, the American West is a region of amazing colors, landforms and ecological diversity. The region is home to more than 200 mountain ranges, with elevations reaching over 14,000 feet. The West's natural climate, flora and fauna vary dramatically with altitude and moving from south to north over a distance of 1200 miles. Eighty-five percent of the water used in the region is surface water, most of which originates as mountain snow pack.[53] This most precious resource is carried east and west to more arid regions by great river systems including the Colorado, Rio Grande and Missouri. Most of the water that originates in the West is fully allocated, primarily to agricultural uses, and demand is increasing with rapid population growth in the region. The impacts of climate change on water resources, agriculture, recreation, and tourism in this region will be significant. If climate change proceeds as predicted, the consequences for the West's fragile alpine ecosystems will be nothing short of tragic.

HISTORICAL TRENDS AND PROJECTIONS OF CHANGING TEMPERATURES AND PRECIPITATION

Most of the interior West experienced increased temperatures over the last century, with changes in annual average temperatures across the region estimated to range from 0.5 to 1.2ºF.[54] The most pronounced changes occurred in the northern Rockies; in contrast little or no change occurred in the southeastern Rockies and central Great Basin parts of the region.[55] Significant variations would have occurred within these sub-regions due to the range of elevations, terrain features, and urbanization that influence the West's more localized climate patterns.

Precipitation in much of the interior West is estimated to have increased by about 10% over the last century.[56] Most of the precipitation increase was seen in the late spring and early summer months. In contrast, and significantly for western water supplies, a recent study that analyzed data for 1925–2000 concluded that the West experienced widespread declines in early spring snow pack[57] over that period, with most of the decline occurring since mid-century.[58] This is a troubling trend, because the region's water supply systems depend heavily on storage of water as mountain snow pack.

The Rocky Mountain/Great Basin Regional Climate Change Assessment performed for the U.S. Global Change Research Program applied two climate models, the Canadian Global Climate Model and the British Hadley Model, to predict climate changes over the next century, assuming that atmospheric concentrations of CO_2 double during that period.[59] Predictions from these models are uncertain, especially at the regional scale, but they provide insight into what to expect from climate changes due to global warming pollution. For the Rocky Mountain/Great Basin region, the Hadley Model predicts average warming across the four seasons of 6.5˚F by 2100, while the Canadian Model predicts even more dramatic warming of about 11.5˚F.[60]

Both of the models used in the Regional Climate Change Assessment predict significantly increased precipitation for the Rocky Mountain/Great Basin region as a whole, especially in fall and winter.[61] But other climate models disagree with this prediction. Climate models essentially all predict warming over the next century, but commonly disagree on precipitation trends.[62] For example, a recent study using the National Center for Atmospheric Research Parallel Climate Model[63] predicts that slightly decreased precipitation will accompany warming in the Colorado River Basin if current emissions trends for global warming pollutants continue over the next century.[64] Regardless of net precipitation changes, higher temperatures are expected to delay snow pack formation in western mountains until later in the fall or winter, and advance spring snow melt and runoff.[65] One climate forecast predicts that snow pack will disappear from the northern Rockies by 2070.[66]

IMPACTS ON WATER RESOURCES, AGRICULTURE, FIRE, AND TOURISM

As mentioned above, 85% of the water used in the interior West is surface water, most of which is fed by snow melt. Most of the surface water in the West is fully appropriated, and growing population in the region will exacerbate water scarcity. As noted above, regional-scale predictions of changes in precipitation due to global-warming pollution are uncertain, and it is far from clear whether precipitation in the interior West will increase or decline as temperatures warm. If precipitation decreases as

If climate change proceeds as predicted, the consequences for the West's fragile alpine ecosystems will be nothing short of tragic.

ISTOCKPHOTO

temperatures warm, however, the result could be severe water supply shortages, especially in the Southwest.[67]

Climate change scenarios examined for the Regional Climate Change Assessment predict increased precipitation, but mostly in the fall and winter, rather than during the growing season. If warming reduces the amount of precipitation stored in snow pack, as expected, flood risks would increase[68] and reservoir storage capacity could prove inadequate to store water for summer use.[69]

Increased temperatures without increased precipitation in parts of the West would contribute to the decline of both agriculture and ranching, due to increased aridity and declining water availability. On the other hand, if climate change produces increased temperatures and increased precipitation, crop yields and forage for livestock could increase in some areas.[70]

The risk of wildland fire in the western United States is expected to increase significantly over the next century if current emissions trends continue. A recent study conducted using the Parallel Climate Model found a significant increase in the number of days with high fire danger in the northern Rockies, Great Basin and Southwest, due to warming and corresponding reductions in relative humidity.[71]

Any adverse or positive impacts to outdoor recreation and tourism in the interior West would be felt most profoundly in the local communities that serve these sectors. Resort areas and national park gateway communities across the West depend for their economic lifeblood on the millions of visitors who hike, ski, fish, hunt, raft and view western wildlife and scenery. Increased temperatures could benefit some of these local economies, but climate change would devastate others, especially those that rely heavily on income from skiing. Ski towns would be severely impacted by reduced snow pack and shortened ski seasons due to warmer temperatures.[72]

HEALTH

Higher temperatures could elevate the number of heat-stress deaths and outbreaks of infectious diseases.[73] For example, Arizona could expect to see increases in viral, parasitic, and bacterial infections from water supplies; rodent-borne diseases such as plague and hanta virus; mosquito-carried diseases; and fungal diseases like valley fever.[74] An example of climate change in Washington State would be more extreme weather events, a greater risk of Lyme disease, more bacterial outbreaks in shellfish, and worse air pollution.[75] The high levels of ground-level ozone associated with many adverse health effects also are likely to become more prevalent as a result of climate change.

NATURAL ECOSYSTEMS

While the West may be able to adapt to some water supply disruptions and economic impacts from climate change, albeit at great cost, natural ecosystems in the region could be changed irrevocably. Natural diversity could be diminished by increased invasion of exotic weed species that thrive on elevated CO_2 levels.[76] Stream organisms, riparian areas, and lake and stream communities could be altered, with warmer water temperatures favoring non-native species over trout and other native western fish.[77]

With its dramatic changes in elevation, the interior West is characterized by ecosystem zones, with grasslands or desert at the base, a range of forest types at intermediate elevations, and a cap of alpine tundra. Ecosystem zones would shift in elevation as a result of increased temperatures and changing precipitation. If the climate gets warmer and drier, all ecosystem zones are expected to shift upward in elevation. With warmer temperatures and more precipitation, forest zones are expected to expand in both directions. In either case, one devastating threat is that the West's spectacular and fragile alpine tundra could simply disappear.[78]

California's water supplies and natural systems are also at risk

Many of these effects are mirrored in California, where global warming will have direct impacts on the environment and the economy. Some of the most dramatic impacts will be on California's water resources. Water is already in short supply in California, and global warming is likely to make water management even more difficult, contentious, and expensive. Throughout the state, most precipitation falls in the winter, but demand for water is highest during the late spring and summer. Winter precipitation accumulates in the Sierra Nevada snow pack, which acts as an enormous natural reservoir. During the late spring and summer, snowmelt from the mountains provides drinking water for over 20 million Californians, as well as irrigation water for much of California's $30 billion agricultural industry.

As temperatures rise, more precipitation will fall as rain rather than as snow, the snow season will start later, and snow will melt earlier.[79] In fact, these trends are already visible: compared to 50 years ago, Sierra snow pack is 2% lower[80] and stream flow peaks three weeks earlier.[81] As these changes continue, runoff from the mountains will be heavier in the winter and early spring.[82] California has an elaborate system of man-made reservoirs used to store water and control flooding. Because this system was designed to handle historical levels of winter runoff, in many future years the larger amounts of winter water will overwhelm reservoirs, forcing managers to release and lose water that would otherwise be stored for summer use. With less snow in the mountains, there will be less water available in late spring and summer for drinking, irrigation, habitat protection, and other uses. In fact, state-of-the-art models forecast that, even in a best case scenario, spring and summer stream flow will be 40% lower by the end of the century.[83]

Global warming threatens California's highly productive agricultural industry not only through effects on the state's water supply, but also through direct impacts of warming. For example, dairy cows cannot tolerate high temperatures, so statewide milk production is likely to decline.[84] Similarly, higher temperatures and more extreme heat waves are expected to decrease grape quality in many of California's premier wine-producing regions.[85]

Heat waves are projected to become longer, hotter, and more frequent, with serious implications for public health and the economy. Heat-related deaths may increase. High temperatures are also associated with smog formation, so California's already-poor air quality is expected to decline further. Hot, dry weather also provides ideal conditions for wildfires, which threaten lives and property.

Warmer temperatures also have effects on California's coast. Sea levels are rising as warming waters expand and melting glaciers and ice sheets pour into the oceans. The effects are already apparent worldwide and the trend is certain to continue. Rising waters inundate land, destroy wetlands, increase coastal erosion and flooding, displace communities, and contaminate fresh water sources. In the Sacramento-San Joaquin Delta, fragile levees protect valuable farmland and residential neighborhoods that, in some places, are as much as 20 feet below sea level. El Niño storms in 1997 caused flooding that forced the evacuation of thousands of people and caused $1.8 billion in damage.[86] Future storms could cause even more damage as the average water level rises. Sea level rise also causes intrusion of saltwater into coastal freshwater aquifers.[87] This is already evident in Monterey County, where 16,000 acres of highly productive farmland sit above aquifers that have been contaminated with saltwater.[88] Advancing contamination threatens not only critical irrigation systems, but also the domestic water supply for the city of Salinas.[89]

Global warming will also impact the state's precious natural resources and ecosystems, some of which are found only in California. Just off the California coast, cold, nutrient-rich water rises from the ocean depths to the surface. The upwelling nutrients support tremendous productivity in California's near shore waters. However, warm surface waters can disrupt upwelling, and decrease nutrient availability and marine productivity off the California coast.[90] Along the shoreline, rising sea levels are slowly drowning the rich wetland ecosystems of the San Francisco Bay, which provide critical habitat for over a million migrating birds.[91]

Throughout the state, rising temperatures are also forcing species to move. Along the coast, southern warm water species have displaced many northern cold-water species.[92] On land, the checkerspot butterfly has died out in the southern part of its historical range.[93] California's alpine vegetation, shrublands, and woodlands are projected to decline as temperatures rise and fire frequency increases.[94] As they try to keep up with temperature changes, some species may not be able to move fast enough; others may have nowhere else to go. As a result, many of California's unique species and ecosystems may disappear forever.

The American West has a great deal to lose if global warming proceeds as predicted. The consequences will be far-reaching, as western mountain snows feed the great river systems of the United States and the region's landscapes and wild areas feed the country's spirit. All of the West has an outstanding opportunity to lead the country and to help itself by reducing global-warming pollution from the use of coal power.

CHAPTER 5

A closer look at California's coal plants

California's dependence on coal-fired power plants has imposed an especially heavy burden on the Four Corners region of the American Southwest. This area is home to one of the world's premier clusters of natural areas. It is also home to some of the largest, most-polluting coal plants in America, including several that are dedicated to delivering power to the California market.

The "golden circle" of national parks and wilderness areas in the Four Corners region includes the Grand Canyon, Arches, Canyonlands, Capitol Reef, Zion, Mesa Verde, and Bryce Canyon national parks. Over the past few decades this region has been hard hit by air pollution. The ozone concentrations at the Grand Canyon, Mesa Verde, Petrified Forest, Zion, and Canyonlands national parks now exceed California's ozone health standard, as do ozone levels in the communities in San Juan County in northern New Mexico. At the same time, the levels of mercury pollution detected at Mesa Verde National Park are among the highest in the nation. Numerous lakes and reservoirs throughout the Four Corners' region suffer under fish consumption advisories for mercury. The water bodies with protective warnings range from Lake Mary in northern Arizona to the McPhee, Narranguinnep, and Navajo reservoirs in southwestern Colorado.

The region is also home to several of the United States' largest sources of global-warming pollution due to the group of coal-fired power plants in the area that deliver power to California. Collectively, the Reid Gardner, Navajo, Mohave, Four Corners, Intermountain Power Project, and San Juan power plants discharge some 65 million tons of heat-trapping carbon dioxide each year.

The environmental footprint of these big coal plants extends beyond air pollution, burdening water resources in the arid Southwest and supporting vast mining operations. In this chapter we take a closer look at some of the coal plants in the Four Corners region that serve the California market. We also examine new proposals, such as the large coal plant that Sempra Energy wants to build in Gerlach, Nevada, which targets the California market but would be located just outside the California border, potentially avoiding the state's clean air and global-warming standards.

The Navajo Generating Station

The Navajo Generating Station, located in northern Arizona on the Navajo Indian Reservation near Page, Arizona, and adjacent to Lake Powell, began operation in 1974. The 2,410-MW plant,[95] run by the Salt River Project Agricultural Improvement and Power District, contains three coal-fired electric generating units that provide power to Arizona, Nevada, and California. The Los Angeles Department of Water and Power owns 21% of the power generated from this facility.[96]

Table 5.1 shows the power plant's average emissions for 2002 and 2003.

TABLE 5.1
Average emissions for Navajo power plant units 1, 2, and 3, 2002–2003

Pollutant	Emissions (tpy)*
Nitrogen oxides	33,600
Sulfur dioxide	3,690
Particulate matter	1,900
Carbon dioxide	19,640,000

Sources: Data are from Energy Information Administration, Form 767, and U.S. EPA, Clean Air Markets Database.

*tpy = tons per year

Right: Grand Canyon National Park is the crown jewel of the American Southwest and the national park system. It is encircled by large coal plants serving the California market.

COURTESY OF NATIONAL PARK SERVICE

Below: The Navajo Generating Station in northern Arizona supplies coal-fired electricity to the Los Angeles Department of Water and Power, and is one of the nation's largest sources of global warming pollution.

COURTESY OF THE GRAND CANYON TRUST

The plant discharges more than 19 million tons of carbon dioxide each year. In 2004, the Navajo Generating Station was the nation's fifth largest power plant emitter of heat-trapping carbon dioxide. It is the nation's 11th largest source of smog-forming oxides of nitrogen (NO_x) pollution from power plant smokestacks, discharging more than 33,000 tons of NO_x annually.[97]

The Navajo Generating Station is located about 25 kilometers from the Grand Canyon National Park boundary, and the impacts of this large power plant on air quality at the park have long been a concern. In 1987, the National Park Service conducted a study of the pollution from the plant and concluded that it contributed significantly to wintertime haze at the Grand Canyon.[98]

In 1991, the U.S. Environmental Protection Agency required a 90% reduction in the emissions of sulfur dioxide from the Navajo Generating Station, reflecting the culmination of years of litigation by environmental organizations and a negotiated settlement with the plant owners and operators.[99]

The Navajo plant uses up to 25,000 tons of coal per day if all units are running at full load.[100] Its coal comes from the Black Mesa-Kayenta mining complex, located on land leased from the Hopi and Navajo Indian tribes. Coal from the Kayenta mine, which produced 8.2 million tons in 2004,[101] is sent to the Navajo Generating Station, and coal from Black Mesa is sent to the Mohave Generating Station. This complex is one of the most extensive strip-mining operations in the United States.

In addition to coal, the power plant uses almost 8 billion gallons of water from Lake Powell each year for cooling.[102] Because of the recent drought conditions and large reductions in the amount of water stored in Lake Powell, the plant is undergoing an environmental review for a new water intake source.[103]

The Four Corners Power Plant

The Four Corners Power Plant is made up of five electric generating units with a total capacity of 2,270 MW.[104] It is operated by the Arizona Public Service Company and is located on the Navajo Indian Reservation near Farmington, New Mexico, which has a population of more than 40,000 people. The power plant also is located near Mesa Verde National Park in southwestern Colorado.

Even though it is situated in the distant landscape of the American Southwest, the facility has a strong connection to California, with Southern California Edison owning 48% of units 4 and 5. These are the two largest units at the facility, and each has 820 MW of nameplate generating capacity.[105] The facility first began operating in 1963; units 4 and 5 started up in 1969 and 1970, respectively.[106]

The Four Corners plant uses 28,000 tons of subbituminous coal per day when all units are running at full load.[107] The coal used at this plant comes from the Navajo mine, located on the Navajo reservation. This is an open pit mine, owned by BHP Billiton.[108] In 2004, the mine produced 8 million tons of coal.[109]

The Four Corners Power Plant is one of the United States' largest single sources of nitrogen oxides. In 2004, the Four Corners plant as a whole ranked first of all power plants in the nation for NO_x pollution and 24th for its carbon dioxide emissions.[110] Table 5.2 shows the 2002–2003 average emissions from units 4 and 5, the two large units in which

TABLE 5.2
Average emissions from units 4 and 5 of the Four Corners Power Plant, 2002–2003

Pollutant	Emissions (tpy)*
Nitrogen oxides	27,500
Sulfur dioxide	23,600
Particulate matter	670
Carbon dioxide	10,700,000

Sources: Data are from Energy Information Administration, Form 767, and U.S. EPA, Clean Air Markets Database.

*tpy = tons per year

COURTESY OF THE GRAND CANYON TRUST

Southern California Edison has a major ownership stake in the Four Corners Power Plant. Located on the Navajo Reservation in northern New Mexico, the coal-fired power plant releases more smog-forming oxides of nitrogen than any power plant in the nation.

Southern California Edison has a major ownership stake.

The Four Corners Power Plant also is a major consumer of water, using over 8 billion gallons of water each year from the adjacent Morgan Lake.[111]

The Mohave Power Plant

The Mohave power plant is a 1640 megawatt coal plant positioned in the far southern tip of Nevada immediately adjacent to the common border with California and Arizona. Mohave is one of the West's largest sources of haze-forming sulfur dioxide and releases about 10 million tons of heat-trapping carbon dioxide annually.

Each year, 4.8 million tons of coal are extracted from Peabody Coal Company's Black Mesa Mine on the Navajo and Hopi reservations in northeastern Arizona, mixed with ground water retrieved 3,000 feet below the reservations from the depleted Navajo Sandstone Aquifer, and carried by pipeline 273 miles across the high desert to the Mohave power plant. The slurry process alone uses over 1 billion gallons of ground water each year, more than the collective annual water needs of the entire Navajo and Hopi tribes.

Coal plants deplete the West's scarce water resources

The interior West is an arid region with a rapidly growing population that is straining available water supplies. Fossil fuel electricity generation adds to the stress on scarce water resources. As part of the cooling process, coal and natural gas-burning power plants in the interior West currently consume 355 million gallons of water every day, totaling more than 130 billion gallons each year.[112] That is enough water to meet the annual needs of nearly 2 million westerners. Coal plants are the power sector's primary users of water, consuming 94% of the water used for power production in the region.[113]

The new coal plants proposed across the West will place additional pressure on water resources. The new Sempra coal plant proposed in the Smoke Creek Desert in northern Nevada is a stark example of the heavy burden imposed on the West's limited water resources. According to Sempra, the company will need about 4 billion gallons of water each year to cool the 1,200-MW plant. This represents most of the groundwater recharge in the Smoke Creek Basin. In other words, this single coal plant alone would use almost all the water that is available without mining the water and drawing down the water table. Local residents are concerned that the Sempra plant would leave no water for ranching, farming, or wildlife in the region. California ranchers in neighboring valleys to the west and officials of the Pyramid Lake Indian Tribe to the south are concerned as well, fearing that the power plant will draw down wells on which they depend for their livelihood.

In contrast to conventional coal plants, many viable clean energy alternatives would not add huge quantities of global-warming pollution to the atmosphere and would not deplete scarce groundwater resources. The location of the proposed Sempra coal plant is rich in renewable wind and geothermal resources. In contrast to a new coal plant, wind farms do not discharge global-warming pollution or air toxics and do not consume any water. Most geothermal plants in the part of northern Nevada where Sempra plans to build its coal plant are binary cycle plants that consume little or no water, with geothermal fluids reinjected into the deep geothermal acquifer. These renewable resources offer a clean energy alternative to Sempra's proposed new coal plant that would not sacrifice the region's precious water resources or pollute the air.

While the facility is located in Nevada, most of its power is delivered to southern California. Southern California Edison has a 56% ownership interest in the plant and the Los Angeles Department of Water and Power holds a 10% ownership interest. Since 1999, the owners have been under a court-supervised consent decree to clean up the plant but to date they have made no effort to meet the pollution control design and construction deadlines in the decree. The owners agreed that if they did not install the pollution control equipment they would shut down the plant by December 31, 2005.

The Reid Garner Power Plant

The California Department of Water Resources has a thirty percent ownership interest in the 612 megawatt Reid Gardner coal plant, located near the Moapa Indian reservation in southern Nevada. The plant is a significant source of smog-forming oxides of nitrogen and airborne lead. The plant's ponds and landfills are also suspected of contaminating groundwater in the area.

Sempra Energy's proposed Granite Fox power plant

Sempra Energy, a California-based energy company, plans to build a new, 1,200-MW, coal-fired plant in the small town of Gerlach, Nevada (110 miles north of Reno). The plant's location would allow it to tap into a major transmission line serving the California market while avoiding California's relatively protective environmental standards. Sempra proposes to build a conventional pulverized coal plant using traditional coal combustion technology.[114] The proposed plant is currently undergoing an environmental review, with an air quality permit application anticipated in 2006. Because some of the auxiliary facilities and rights-of-way will be located on public land, the U.S. Bureau of Land Management is preparing an environmental impact statement and held a public comment scoping period that ended in June 2005.[115] If approved, the plant is projected to start up in 2010.[116]

The Sempra power plant would burn 6 million to 7 million tons of coal each year,[117] supplied primarily from the Powder River Basin in Wyoming. Because of its large size and its reliance on a conventional coal power system, the plant would be a major source of global-warming pollution. It is predicted to discharge some 10 million tons of heat-trapping carbon dioxide annually, comparable to the global warming pollution from almost 1.8 million cars.

The proposed Sempra facility would also draw vast quantities of limited groundwater resources in this arid desert location. The plant would use more than 10 million gallons of desert groundwater each day, amounting to about 4 billion gallons per year.[118]

The proposed Sithe Global Desert Rock Power Plant

The proposed 1,500-MW (gross) coal-fired Sithe Global Desert Rock Power Plant would consist of two 750-MW electric generating units. The facility would be located about 30 miles southwest of Farmington, New Mexico, on Navajo lands. Like the other large coal plants already clustered in the Four Corners region, the facility will very likely target the California market. The Sithe Global Power Company, formed from the German firm Steag Power and owned by a private equity fund, would be the principal owner of the proposed facility.[119]

Although the plant owners have committed to use a more efficient, supercritical boiler in place of a conventional subcritical boiler, they have declined to use advanced technology to reduce global-warming pollution. Therefore, the plant will discharge about 12 million tons of heat-trapping carbon dioxide each year, adding to the already staggering amounts of global-warming pollution originating from coal plants in the Four Corners region. By itself, this source would erode one-third of the global-warming reductions forecast from the full implementation of California's landmark restrictions on its millions of motor vehicles.

Although some pollutants will be relatively well controlled, the sheer size and proximity of this plant will exacerbate the problems in a region hard hit by air pollution from large coal plants. The thousands of tons of haze-forming pollution from the proposed facility will adversely affect Grand Canyon National Park. The facility will also add mercury and other hazardous air pollutants to a region with mercury fish consumption advisories in lakes and reservoirs as well as some of the United States' highest levels of mercury pollution.

The coal for Desert Rock will come from the Navajo mine, located on the Navajo reservation. This is the same mine that supplies the Four Corners Power Plant, and it currently produces about 8 million tons of coal each year.[120] In 2004, BHP Billiton, the owner of the Navajo mine, applied for a permit for the 550-MW Chaco Valley Energy Facility, a conventional pulverized coal plant to be located on the Desert Rock site as an alternative to Sithe Global's proposal.[121]

CHAPTER 6
The West's coal challenge

The power plants constructed now are likely to still be operating in 2050, when our children's children are reaching adulthood. Is it possible to satisfy the West's growing power demands without leaving them a devastating environmental legacy? Doing so will require a mix of policy, business, and consumer choices that include greater energy efficiency, a dramatically expanded use of renewable energy, the use of low-carbon fuels like natural gas, and the construction of genuinely emissions-minimizing coal-fired power plants that meet progressive clean air and global-warming standards. Although some of these options will cost more in the short run than simply building another conventional coal plant, in the long run they will deliver tremendous human health and environmental benefits.

Are there cleaner ways to burn fossil fuels? Table 6.1 presents estimates of the direct cost of energy and the air pollution emission rates associated with alternative fossil fuel-fired technologies for producing electricity. The emission rates and efficiency estimates reflect typical values from new power plant proposals or the literature and are not intended to indicate the best performance that is achievable. Furthermore, the cost estimates in Table 6.1 reflect conservative long-term estimates of coal and natural gas prices. If the recent sharp escalation in fossil fuel prices persists, the cost of energy from coal and gas plants could be significantly higher than shown here. Additional information about the assumptions used to produce these estimates is provided in Appendix C.

Nearly all the power plants built in the United States in the 1990s were natural gas combined-cycle (NGCC) plants. Behind coal and hydropower, natural gas plants are the third most common source of electricity in the western United States. Natural gas plants accounted for nearly one-half of California's in-state electricity generation in 2002.[122] Electricity generated from NGCC plants produces negligible sulfur dioxide, mercury, and particulate pollution, an order of magnitude lower nitrogen oxides emissions, and nearly 60% lower heat-trapping carbon dioxide emissions per megawatt-hour (MWh) of power generation than conventional pulverized coal combustion. But temporary excess capacity and the increases in natural gas prices over the past five years have slowed the development of new natural gas combined-cycle plants.

Nearly all the existing and proposed coal plants in the West use conventional (subcritical) pulverized coal combustion technology. The emission rates from these facilities are determined partly by regulatory requirements and partly by technical feasibility and economics. Newer, supercritical coal combustion technology has a modest advantage in increased thermal efficiency and slightly lower CO_2 emissions compared with conventional pulverized coal, at essentially no added cost. Ultra-supercritical combustion is projected to improve thermal efficiency still more, at a slightly lower cost.[123]

Integrated gasification combined-cycle (IGCC or coal gasification) technology is viewed by many industry analysts as the path forward for advanced coal combustion power systems. IGCC comprises two distinct processes: a gasification plant that converts coal into a synthetic gas while removing sulfur dioxide, nitrogen oxides, and mercury; and an energy-efficient power plant utilizing combined-cycle gas turbines.

TABLE 6.1

Emission rates and costs of energy for competing fossil-fueled electricity-generating technologies

Technology	Size (MW)	Primary pollution controls	Fuel	Plant efficiency (%)	Cost of energy (¢/kWh)	CO_2 rate (lb/MWh)	Hg rate (lb/MWh)	NO_x rate (lb/MWh)	PM rate (lb/MWh)	SO_2 rate (lb/MWh)
Natural gas combined cycle	500	SCR	Natural gas	47.4%	5.0[a]	840		0.07		
Conventional sub-critical pulverized coal	600	FGD, SCR, Baghouse or ESP	Bituminous	36.6%	4.5	1900	1.8E-05	0.74	0.28	1.86
			Subbituminous	34.6%	4.2	2100	3.9E-05	0.68	0.30	0.99
Super-critical pulverized coal	600	FGD, SCR, Baghouse or ESP	Bituminous	39.3%	4.5	1800	1.7E-05	0.72	0.16	1.19
			Subbituminous	37.1%	4.2	2000	3.7E-05	0.64	0.28	0.92
Ultra super-critical pulverized coal	600	FGD, SCR, Baghouse or ESP	Bituminous	42.7%	4.4	1600	1.6E-05	0.72	0.16	1.19
			Subbituminous	40.3%	4.1	1800	3.4E-05	0.59	0.25	0.85
Circulating fluidized bed coal	250	Limestone injection, SNCR	Bituminous	34.1%	4.6	2100	5.8E-06	0.90	0.11	1.50
			Subbituminous	34.1%	4.1	2100	4.5E-05	0.90	0.11	0.75
IGCC current (spare gasifier)	550	Amine scrubber, activated carbon bed, particulate filter	Bituminous	39.5%	4.8	1800	5.6E-06	0.50	0.06	0.47
			Subbituminous	38.8%	5.1	1900	3.7E-06	0.50	0.06	0.47
IGCC advanced	550	Rectisol or Selexol, particulate filter, SCR, activated carbon bed	Bituminous	44.9%	4.2	1600	4.9E-06	0.05	0.03	0.05
			Subbituminous	40.8%	4.0	1800	3.6E-06	0.05	0.03	0.05
IGCC with carbon capture	450	Water-gas shift, Rectisol or Selexol, particulate filter, SCR, activated carbon bed	Bituminous	37.0%	5.9	190	6.0E-06	0.06	0.04	0.06
			Subbituminous	33.0%	6.0	220	4.4E-06	0.06	0.04	0.06

[a] Recent escalation in the cost of natural gas would increase the cost of energy for NGCC significantly compared to the estimates shown here, which were based on long-term forecasts for natural gas prices from the Energy Information Administration, Annual Energy Outlook, 2005.

The United States has two IGCC facilities in operation, with more proposed; IGCC facilities also are operating in Europe and Japan. Coal gasification may have potential for repowering aging pulverized coal units, in addition to fueling new capacity expansions.

Current IGCC technology matches supercritical pulverized coal technology in efficiency and carbon dioxide emission rates. Coal gasification technology offers some reduction in sulfur dioxide, particulate, and mercury pollution. As Table 6.1 shows, most estimates suggest that the current IGCC technology imposes a cost premium of 10% to 20% compared with the cost of energy from supercritical pulverized coal. However, the costs of the two technologies are close enough that the differential may disappear or favor coal gasification in some cases, depending on the plant's design and location, the cost of the coal, and the emissions reduction or offset requirements associated with a particular proposal.[124]

The "advanced" coal gasification plant data shown in Table 6.1 represent what IGCC technology is expected to achieve as cost and performance are improved based on the commercial experience gained from building and operating several plants. In short order, IGCC could deliver more impressive improvements in SO_2, particulate pollution, mercury, and NO_x reductions at a cost that is competitive with or slightly lower than current pulverized coal technology, along with a relatively modest further improvement in efficiency and lower CO_2 emissions. Nevertheless, even advanced coal gasification technology cannot compete with the CO_2 emission standards achieved by natural gas combined-cycle plants. For coal, earning that label will require taking the next step: requiring CO_2 capture and sequestration.

With CO_2 capture and sequestration, IGCC units are expected to be able to cut CO_2 emissions to one-tenth those of conventional pulverized coal plants and one-quarter the emissions of natural gas combined-cycle power systems. Based on current estimates, the added cost of carbon capture would increase the cost of energy by 30% to 40% if coal gasification technology is used. Technologies for separating and capturing CO_2 from coal gas have been used commercially in the industrial sector, but not on full-scale IGCC power plants. Research is under way to find the best systems for carbon capture; improvements in capture technologies could significantly reduce the cost of using them in the future.

To protect against enormous amounts of global-warming pollution and the human health burden from the suite of contaminants discharged from traditional coal power systems, policymakers in California and across the interior West must look first and foremost to clean energy alternatives such as energy efficiency and renewables. These alternatives also offer major advantages in minimizing water consumption and eliminating the environmental impacts of coal mining. If new coal is part of the mix, coal-fired power plants built from today onward must have maximum thermal efficiencies, must use state-of-the art pollution controls, and must find safe, reliable ways to capture and sequester carbon dioxide. Carbon sequestration projects should be undertaken immediately to gain experience with the safety and reliability of these technologies. Policymakers must also set binding targets and timetables for capping and then dramatically reducing global-warming pollution, so that utilities can plan appropriately for the investment decisions they are making today.

CHAPTER 7

Harnessing abundant renewable energy and energy efficiency resources in the West

If policymakers accept the challenge to ensure that coal technologies will be deployed only if they use maximum thermal efficiencies and state-of-the-art pollution controls and capture and sequester heat-trapping carbon dioxide, western coal can help satisfy the region's energy demands in an environmentally responsible way. Nonetheless, even the cleanest coal technology will cause much more environmental damage from global warming gases, air pollution, mining impacts, and the consumption of scarce water resources than will energy efficiency and renewable energy resources. Therefore, to reduce the health and environmental impacts of electricity production and help move the West toward a clean energy future, the region must fully tap the cost-effective energy efficiency and renewable resources that are available.

California leadership in energy efficiency

Energy efficiency is the least cost resource available to California. It is a sustainable resource with minimal environmental impacts. The most important step that California and other western states can take to reduce their environmental footprint is to make use of all the cost-effective energy efficiency resources available within the region.

Since the 1970s, California has been a national leader in energy efficiency and already has done much to increase the efficiency of its electricity use. Nonetheless, while California's efficiency gains are an impressive model for the rest of the region, even more could be done to tap the state's full energy efficiency potential. Recent studies estimate that if all the achievable, cost-effective energy efficiency resources in California were acquired, by 2011 the state's annual electricity consumption would be reduced by more than 30,000 GWh each year.[125] Achieving these energy savings would avoid the need to construct approximately eight new 500-MW coal plants.

Encouragingly, over the past several years, California has begun to take important new steps toward realizing this full potential. California's loading order policy, adopted jointly by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC), makes energy efficiency the state's highest priority resource. In 2004, the CPUC adopted the nation's most aggressive goals for electricity and natural gas efficiency program savings for the state's three major investor-owned utilities. If the utilities achieve these goals, the energy efficiency programs would yield an annual savings of 23,000 gigawatt-hours (GWh) of electricity and 450 million therms of natural gas by 2013.[126] Similarly, the appliance standards that California adopted in 2001 and 2004 are expected to save 740 GWh each year they are in effect.[127] Most recently, state regulators approved a $2 billion increase in energy efficiency incentives through 2008 to curb the growing demand for energy, to lower energy prices, and to save consumers money. Indeed, the state estimates that these investments will save consumers some $5.4 billion over the program's three-year duration.

The potential for increased energy efficiency in the interior West

In contrast to California's leadership, the other states in the interior West have generally trailed other areas in the country in investing in energy efficiency resources—even though the region has enormous energy efficiency potential. A study published in 2002 by the Southwest Energy Efficiency Project for the six-state region of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming estimated that aggressively pursuing commercially available, cost-effective energy efficiency measures across the region would result in annual energy efficiency savings of 99,000 GWh by 2020.[128] Achieving these energy savings would avoid the need to construct 26 new 500-MW coal plants.[129]

ABUNDANT RENEWABLE ENERGY RESOURCES IN CALIFORNIA AND THE INTERIOR WEST

Like energy efficiency, renewable energy offers a much more sustainable way to supply the West's energy appetite than does the continued development of fossil fuels. Beyond its environmental advantages, renewable energy provides fuel diversity that reduces the consequences of volatile fossil fuel prices. As an indigenous resource, renewable energy also enhances the nation's energy security.

As it has in energy efficiency, California has been a leader in recognizing the benefits of renewable energy and promoting its use. In 2002, the California legislature established the California Renewable Energy standard, which requires that 20% of the state's retail electricity supply come from renewable energy by 2017. In 2004, the state's Integrated Energy Policy Report Update recommended accelerating the 20% RPS goal from 2017 to 2010 and establishing a longer-term goal of 33% by 2020. These accelerated goals are supported by Governor Schwarzenegger and have been embraced by the California Public Utilities Commission and the California Energy Commission.

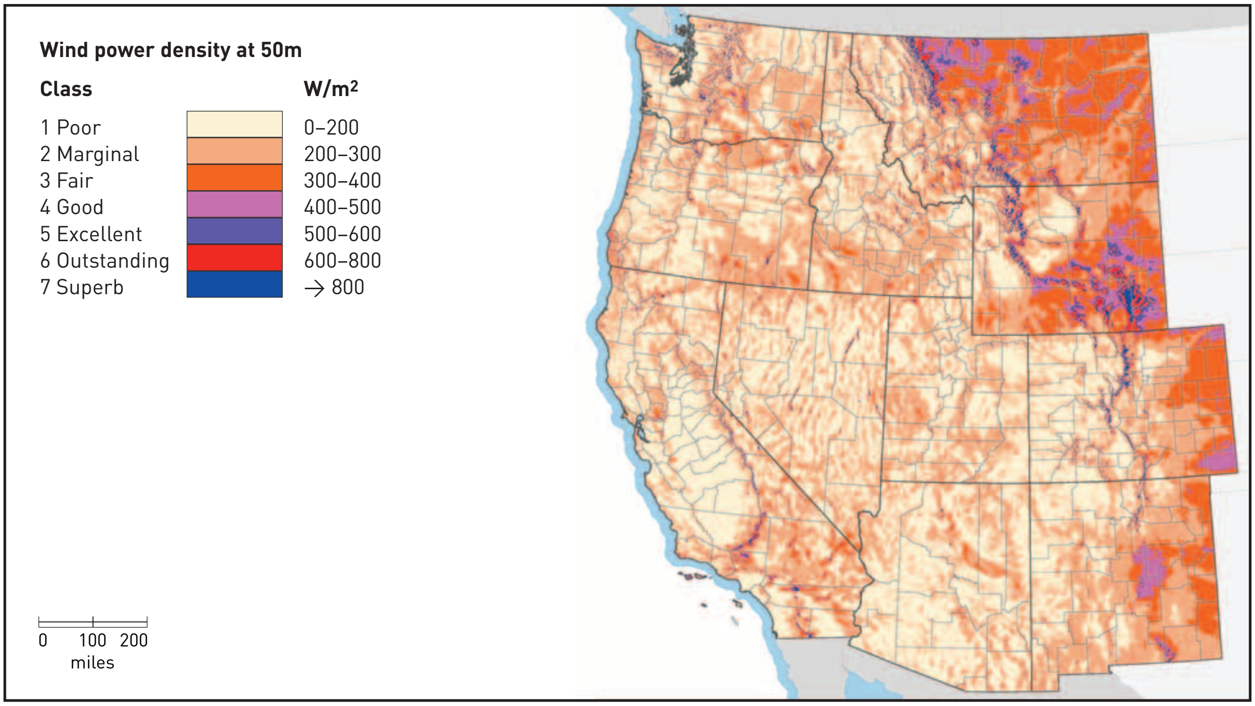
California itself has abundant renewable resources. The California Energy Commission estimates that the technical potential for wind, geothermal, solar, and biomass resources is roughly 256,000 GWh per year.[130] If small-scale hydro power is included, the potential climbs to over 262,000 GWh/year.[131] For comparison, the total amount of electricity generated in California in 2002 was 273,000 GWh.

In addition, outside California, vast amounts of renewable energy across the western United States could also be used to meet California's and the region's electricity needs. Figures 7.1 through 7.4 show the location and quality of the West's wind, solar, and biomass resources, and Table 7.1 gives the total potential of renewable resources in each western state. The total potential in the region is nearly 4 million GWh per year. Tapping just 3% of this potential would equal the output of over 30 500-MW coal plants.[132]

Several important factors will limit the amount of renewable resources that can be economically and reliably integrated into the western electric grid below the potential levels shown in Table 7.1, at least within the next 20 years. These factors include the challenge of integrating large amounts of intermittent renewable resources, such as wind, into the electric grid; the need for new transmission lines to move remote renewable resources to population centers where power is needed; and the comparatively high cost of power from some renewable resources, such as solar.

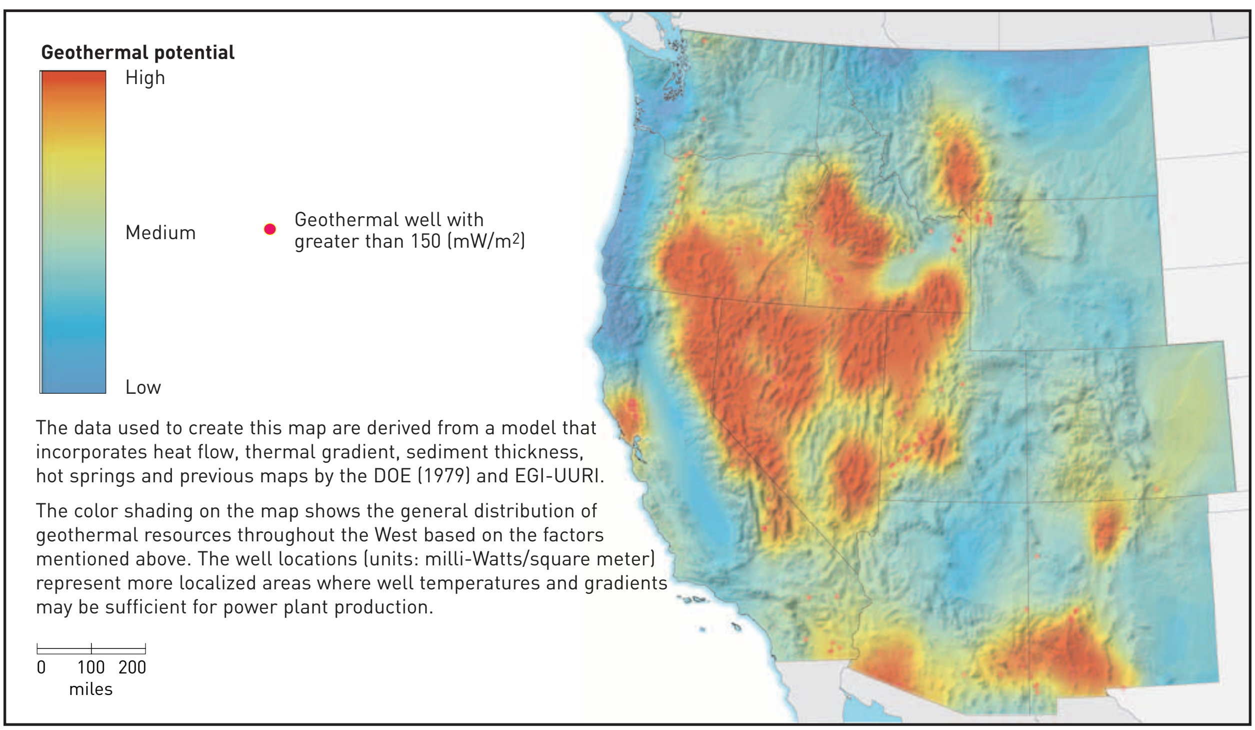
Despite these obstacles, renewable resources can be reliably and economically deployed across the West on a much larger scale than is currently being used. A 2004 study by Western Resource Advocates developed and analyzed a diversified energy portfolio for the seven-state interior West region of

FIGURE 7.1
Wind resources in the western United States



Source: National Renewable Energy Laboratory, 2004.

FIGURE 7.2
Geothermal potential in the western United States



Source: Western United States Geothermal Database, Southern Methodist University Geothermal Lab 2001

FIGURE 7.3

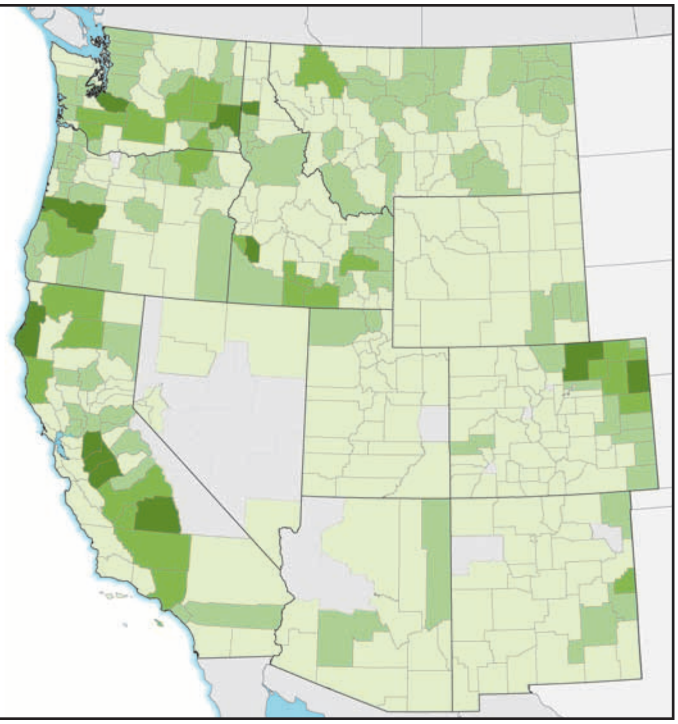
Total energy potential from biomass residue by county

Total potential (mmbtu)

- 50–775,000
- 775,001–2,500,000
- 2,500,001–5,500,000
- 5,500,001–11,200,000
- No Data

Biomass resources were calculated by combining county totals of corn, barley and wheat residues from USDA agricultural crop estimates (2001–2002), animal waste from USDA county estimates (1996), forest and mill wood wastes from USDA Forest Service (1996), and potential and existing landfill gas recovery systems from the EPA landfill database (2001).

0 100 200
miles



Source: U.S. Department of Agriculture 1996, 2002; Environmental Protection Agency 2001

FIGURE 7.4

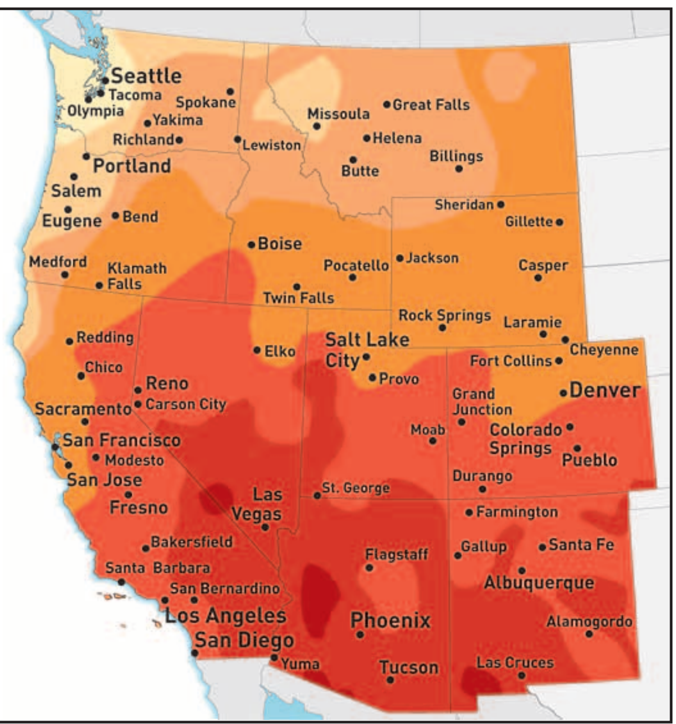
Annual solar potential for flat plate collection (PV)

Solar insolation annual average
kWh/m²/day

kWh/m²/day	
3.5–4.0	Moderate
4.1–4.5	Good
4.6–5.0	Good
5.1–5.5	Very Good
5.6–6.0	Very Good
6.1–6.5	Excellent
6.6–7.0	Excellent

This map provides monthly average daily total solar resource information based on grid cells of approximately 40 km by 40 km in size. The original gridded data were smoothed and contoured for easier interpretation. The insolation values represent the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal equal to the latitude of the collector location.

0 100 200
miles



Source: National Renewable Energy Lab 2002

TABLE 7.1
Renewable resource potential in the western United States (GWh/year)

State	Wind	Geothermal	Biomass	Solar	Total
AZ	5,000	5,000	1,000	101,000	112,000
CA	44,000	37,000	18,000	157,000	256,000
CO	601,000	-	4,000	83,000	688,000
ID	49,000	5,000	9,000	60,000	123,000
MT	1,020,000	-	6,000	101,000	1,127,000
NM	56,000	3,000	500	104,000	163,500
NV	55,000	20,000	1,000	93,000	169,000
OR	70,000	17,000	10,000	68,000	165,000
UT	23,000	9,000	1,000	69,000	102,000
WA	62,000	-	11,000	42,000	115,000
WY	883,000	-	-	72,000	955,000
Total	**2,868,000**	**96,000**	**61,500**	**950,000**	**3,975,500**

Source: Estimates for California are from *California Energy Commission, Renewable Resources Development Report, 500-03-080F, November 2003, C-14* (note that in Table 7.1, figures have been rounded to the nearest 1000 GWh). Estimates for other states are from Western Resource Advocates, *Renewable Energy Atlas of the West, Boulder, CO, 2001, 13.*

Arizona, Colorado, Montana, Nevada, New Mexico, Utah, and Wyoming.[133] The diversified portfolio included large new investments in energy efficiency, combined heat and power, and renewable energy resources. The diversified portfolio assumes that by 2020, 20% of the electricity generated in the region will come from renewable energy technologies, compared with less than 2% today. This portfolio was then compared to a business-as-usual portfolio that assumes the region will continue to rely almost exclusively on coal and natural gas to meet growing electricity demands. By 2020, the more diversified portfolio with 20% renewable energy penetration and large investments in energy efficiency was shown to lower regional electricity production costs by 2.5 billion dollars per year, with no adverse impact on the electric system's reliability.

Transmission planning in the West: renewable energy versus coal

Moving renewable energy to California from other western states will require new interstate transmission lines. A number of transmission projects that could deliver power to California and other urban centers across the region are currently being considered. Unfortunately, the same transmission lines that can facilitate the development of clean renewable energy sources can also be used to move power from conventional coal plants. Although some of the regional transmission projects under way would also support renewable energy resources—principally wind power—current planning efforts are still primarily focused on building transmission to support new conventional coal plants.

The proposed Frontier Line is an example of the tension between renewable energy and coal. The Frontier Line is a multibillion-dollar proposal to build a large new transmission line from Wyoming across Utah and Nevada into California and is supported by the governors of those four states. The proposal envisions sending up to 12,000 MW of power to California along this line. It is unclear, however, exactly what kind of power this would be. Promoters of the line claim that it would lead to the development of up to 6,000 MW of wind power and 6,000 MW of clean coal. But supporters of the Frontier Line have not clearly defined what they mean by "clean coal." Statements from the governor of Wyoming and the Wyoming Infrastructure Authority indicate that the Frontier Line is being proposed to facilitate construction of conventional coal plants and that the term "clean coal" is not intended to mean maximizing thermal efficiencies, using the full suite of state-of-the-art pollution controls, and capturing and sequestering global-warming pollution.[134] Moreover, while the California Energy Commission and the California Public Utilities Commission have issued proposals that would require strict greenhouse gas performance standards for new coal power imported into California, it is disconcerting that there has been no clear statement from Governor Schwarzenegger's office that the state will not import conventional coal power as part of the Frontier Line project.

If California is going to reduce its environmental footprint in the interior West while continuing to import power from the region, it cannot participate in new transmission projects that promote the development of new conventional coal plants that would not meet California's own clean air and global-warming standards. If the state does participate in new regional transmission lines, those lines should be built, first and foremost, to move clean renewable energy to the state. If any new coal power moves over those lines, it must use the full suite of state-of-the-art pollution controls, and capture and sequester global-warming pollution.

CHAPTER 8

A fresh vision of clean air and clean energy in the West

California and the states of the interior West are at a critical juncture that will determine how the environmental impacts of energy production in the region affect our children and grandchildren. Forecasts of dramatically increasing electricity demand in California have stimulated proposals for transmission lines and coal-fired power plants across the region. Constructing these facilities as proposed would represent a misguided expansion of California's long reliance on high-polluting coal plants in distant western states. At the same time, the population in the interior West is briskly growing along with its own demand for electricity.

There could not be a more critical time for bold ideas and visionary leadership. The decisions made today about how to address expanding energy demands will shape the West's energy and environmental future over the course of the 21st Century. Protection of peoples' health and many of the country's most prized landscapes and ecosystems are at issue as policymakers decide how best to meet the energy demands of their communities and how to regulate power projects that are built with exports in mind. Today's policies will also be decisive in the urgent fight against global warming, either complementing or undermining California's historic initiatives to curb global-warming pollution. With genuine leadership in California and the interior western states, the region can realize a fresh vision of clean air, clean energy and a more stable climate for the 21st Century.

We recommend the states in the interior West adopt the following policies:

1. Stabilize and reduce emissions of global-warming pollution through binding caps and require all new power generation proposals to incorporate provisions to meet their obligations under these limits. The foundation for protective action is being laid by new global warming policies under development in Arizona, California, New Mexico, Oregon, and Washington.

2. Tap into energy efficiency resources as the foremost priority in addressing growing electricity demand. Important steps that states in the interior West can take to increase energy efficiency include well-designed regulatory incentives for public utilities to curb growing consumption, adoption of advanced building codes, comprehensive efficiency standards for electrical appliances, innovative pricing and metering policies to spur efficiency, and incorporation of energy efficiency as an essential alternative in electricity procurement and transmission project proceedings.

3. Adopt or strengthen renewable portfolio standards to harness the West's vast renewable energy potential. In the interior West, Arizona, Colorado, Nevada, and New Mexico have established renewable energy standards requiring greater reliance on renewable energy. The region's other states should adopt this powerful policy tool as well. By 2020, at least 20% of the region's electricity generation should come from renewable wind, solar, biomass, and geothermal resources.

4. Work with California and the Western Governors' Association to complete the development of the Western Renewable Energy Generation Information System (WREGIS). WREGIS is a renewable energy generation-tracking system designed to provide the data necessary to substantiate and support the verification and tracking of renewable energy credits across the West. States should join WREGIS and implement policies to allow regional trading of renewable energy credits.

5. Require all new coal plants to maximize thermal efficiencies, use state-of-the-art pollution controls for all airborne contaminants including toxic pollution, and seriously curtail the heavy burden of global-warming pollution. As a starting point, all new fossil generation should be required to meet global-warming performance standards equivalent to the emissions from natural gas combined-cycle plants.

6. Support transmission pricing, access, and operating policies that maximize the efficient use of the existing transmission system. Where new transmission lines are needed, regional transmission planning that identifies areas rich in renewable resources and develops plans to tap those resources should be supported.

7. Clean up the existing coal plants that contribute to ground-level ozone in our communities both near and remote, to haze in our national parks, to mercury fish consumption advisories in precious western water bodies, to pollution that threatens the viability of high-elevation ecosystems, and to the burden of greenhouse gases on the global atmosphere. This would have immediate benefits in reducing the impact of existing coal plants on human health, the planet's stressed climate, and vital natural systems.

California has led the region and the country in developing new ways to control air pollution from cars, trucks, oil refineries, and many other significant sources. The state has also led the country in clean power developments, from energy efficiency improvements to breakthrough technology for wind power and fuel cells. Now the Golden State has an opportunity to build on these landmark policies by remedying the legacy of pollution from its distant coal plants and requiring new coal-fired facilities that would supply the California market to meet the state's own protective clean air and global warming standards.

We recommend California put in place the following policies:

1. Adopt a comprehensive, binding greenhouse gas cap-and-trade program to implement the targets established in Governor Schwarzenegger's June 2005 executive order, ensuring that the program thoroughly encompasses imported electric generating resources, and harmonizes standards for in-state and out-of-state sources of California's electricity.

2. Lead from the front, as it so often has, by adopting progressive standards for global-warming pollution from electricity generators. California has recently taken significant strides in this direction as the California Public Utilities Commission and the California Energy Commission have both proposed energy procurement standards that would require all sources of the state's electricity to achieve the emissions levels of a state-of-the-art, combined-cycle natural gas plant. These proposals should be adopted by both bodies. The California Public Utilities Commission should ensure that the standards are met in procurements by investor-owned utilities, and the legislature should require the same standards for publicly or municipally owned utilities. Governor Schwarzenegger should encourage the region-wide adoption of these standards through his leadership role in the Western Governors' Association.

3. Tap all cost-effective in-state energy efficiency investments, consistent with the state's loading order policy. The California Public Utilities Commission's recent authorization of $2 billion for energy efficiency investments by the state's investor-owned utilities demonstrates its ongoing commitment to this course of action. The state must follow up to ensure that the utilities' customer-funded programs translate into real energy savings.

4. Accelerate and expand the state's renewable portfolio standard to achieve a 20% renewables share by 2010 and commit firmly to the goal of a 33% share by 2020, as Governor Schwarzenegger has proposed. Our analysis shows that only this expanded level of commitment will put a significant dent in new coal-fired energy imports into California. In addition, the state must back up the existing renewable portfolio standard with accountability, including real, after-the-fact accounting to ensure that actual energy purchases meet the renewable targets, as well as stiff penalties for noncompliance that make it worthwhile for utilities to comply.

5. Complete the development of WREGIS to establish a rigorous tracking system for renewable energy credits. With WREGIS in place, California should adopt and implement policies to allow the trading of renewable energy credits across the West and the use of renewable energy credits to comply with California's renewable portfolio standard requirements.

6. Extend incentives to promote decentralized self-generation through renewables and other forms of ultraclean distributed generation.

7. Limit the state's participation in transmission projects to those that bring renewable energy to market. The state should begin by pursuing environmentally responsible transmission line development to harvest in-state renewable resources.

California coal demand forecasts

Modifying the U.S. DOE National Energy Modeling System output: imports and exports

To make use of the National Energy Modeling System (NEMS) output, we had to make some assumptions regarding imports and exports. Within each region (including California, the Northwest, and the Rocky Mountain/Southwest), the NEMS output indicates how much electricity is generated using coal and other technologies. NEMS also quotes total TWh of imports and exports for each region, but does not specify the generation technology used to produce imported or exported electricity, or where the imports and exports come from or go to. While the western region is generally thought of as an interconnected closed grid, imports and exports do not balance perfectly for the region taken as a whole (the union of California, the Northwest, and the Rocky Mountain/Southwest regions).

Since our region of concern is California, we are not concerned with the destination of California's exports. As for the technology used to generate them, we assume that an equal fraction of all "in-state" generation in NEMS, including dedicated out-of-state generation, is exported. We assume that exports are not subsequently imported back into California.

The amount of coal-generated electricity imported into California is estimated by calculating the fraction of generation by coal in the Northwest and Rocky Mountain/Southwest NEMS regions, then normalizing the amount of electricity each exports by the amount California imports to ensure that the electricity flows balance each other. We assume that imports are not subsequently exported.

The dedicated coal value appears directly in NEMS as 33.71 TWh of "in-state" coal. For import/export purposes, this dedicated coal is treated as California electricity, meaning that a small fraction of it is exported.

One caveat is that the NEMS region designated "California" is not in fact coterminous with the actual state boundaries; it excludes the extreme northern portion of the state (which belongs to the Northwest region). There is very little capacity and no major population centers in the excluded area, so the impact of this exclusion is likely small.

Modifying the NEMS output: incorporating RPS scenarios

Our model "forces" generation to meet the renewable portfolio standard (RPS), essentially adding as much renewable generation to DOE's output as necessary to meet the RPS requirements each year. We model the increase in renewable generation as a linear increase from the present renewable generation to the amount of generation that will be required to meet the target RPS in the target year. Unfortunately, the NEMS model does not have a dedicated category for RPS-qualifying generation; instead, such generation is lumped with non-qualifying hydropower into the "renewables" category. Therefore, NEMS does not tell us what the current level of qualifying renewable generation is. We used California Energy Commission data for the current renewable generation value, which was 24.4 TWh for 2003.

This additional generation has to displace some other type of generation predicted by the NEMS model, or else supply and demand would not balance. We make the additional renewable energy production displace projected energy production from whatever new capacity the NEMS model adds that year (or proportions of two different types of capacities if more than one type is added), to reflect the fact that increasing renewable capacity would make it unnecessary to build some of this new capacity.

APPENDIX B

Ozone concentrations in excess of California's health standard in the interior West

Western areas outside California that would not meet California's 8-hour ozone standard (0.070 ppm)

Based on 2002–2004 data (does not include existing 8-hour ozone nonattainment areas—Las Vegas, urbanized Denver, Phoenix)

State	Area	Number of violations of 0.070 ppm	Number of exceedances of federal standard (0.08 ppm)
Arizona	Chiricahua National Monument	14	0
Arizona	Grand Canyon National Park	40	0
Arizona	Tonto National Monument	85	8
Arizona	Petrified Forest National Park	12	0
Arizona	Saguaro National Monument	37	1
Arizona	Tucson Area	76	3
Arizona	Yuma	21	1
Arizona	Hillside	42	4
Colorado	Rocky Mountain National Park	79	13
Colorado	Mesa Verde National Park	4	0
Colorado	Air Force Academy	23	0
Idaho	Craters of the Moon National Monument	4	0
Idaho	Boise Area	33	1
Idaho	Elmore County	4	0
Nevada	Great Basin National Park	18	0
Nevada	Reno Area	72	1
Nevada	Carson City	5	0
Nevada	Cave Rock	9	0
New Mexico	Albuquerque Area	280	3
New Mexico	Dona Ana County	153	4
New Mexico	Carlsbad	12	0
New Mexico	San Juan County	51	0
Utah	Canyonlands National Park	21	0
Utah	Zion National Park	12	0
Utah	Salt Lake Area	329	25*
Utah	Provo-Orem Area	103	4
Utah	Logan	11	0
Utah	Brigham City	44	5
Utah	Tribal monitor	1	0
Wyoming	Thunder Basin Grassland	11	2
Wyoming	Campbell County	9	0
Wyoming	Yellowstone National Park	1	0
Total		**1616**	**75**

*Although this number appears to put the Salt Lake area above the 8-hour ozone NAAQS, the number reflects a combined total for several different monitoring sites, while violations are based on separate calculations for each monitor. The Salt Lake area is currently designated as attaining the 8-hour ozone standard.

APPENDIX C

Costs and performance of advanced fossil generating technologies—data sources and methods

This study relies on published data from the Electric Power Research Institute (EPRI), Department of Energy (DOE), company reports, and academic studies to develop typical cost and performance estimates for different fossil fuel power plant technologies. While much of the published information is generally consistent, there remain significant differences in the precise cost and performance estimates provided by different groups at different times. Our objective was to draw on the most current estimates in the existing literature to develop a set of representative data that are internally consistent for each technology (e.g., cost estimates are aligned with the emissions and operating performance estimates) and are as consistent as possible across technologies to facilitate comparison. The data are meant to be representative and should be viewed with the understanding that actual costs and performance may differ when commercial facilities are built.

The discussion below describes the data sources and methodologies used in the analysis, beginning with the assumptions applied across all technologies and then providing technology-specific data references.

Data sources and methods applied to all technologies

Plant size Representative plant sizes are listed. While sizes can vary significantly depending on a number of factors, the sizes listed are consistent with those identified in the data sources used for cost and emissions information.

Capacity factor All plants are assumed to operate at an 85 percent capacity factor. This level of operation is representative of a base load coal facility and is consistent with the capacity factor assumption in other coal technology studies. At current natural gas prices ($6-7.50/mmBtu or higher), NGCC plants are unlikely to operate at 85 percent capacity factors. Nonetheless, the analysis assumes 85 percent for NGCC for consistency. Decreasing the capacity factor assumption for NGCC would significantly increase the cost of energy for this technology. At a 40% capacity factor, for example, the NGCC plant shown would produce energy at over $6.00/MWh.

Coal cost Scenarios are shown for each coal plant assuming both use of bituminous (based generally on Pittsburgh #8) and subbituminous (based generally on Powder River Basin (PRB)) coals. Coal quality (ash content, moisture, sulfur, etc.) and transportation costs can significantly affect the cost of coal delivered to a power plant. The coal costs used here are meant to represent what might be expected at a power plant located in the western U.S. Actual fuel costs depend to a great degree on the precise location and fuel specifications of a power plant and therefore may differ from these generalized estimates.

For the purposes of this analysis, a cost of $1.50/mmBtu for bituminous coal is used to represent a typical long-term price contract and is consistent with assumptions used recently by EPRI (Booras and Holt, 2004) and others in evaluating coal technologies. The analysis assumes a $1.00/mmBtu cost for subbituminous coal, which equates to about $17/ton, and is consistent with PRB coal costs assumed by EPRI in evaluating coal technologies (Holt, 2004). All fuel costs in $/MWh are calculated based on the heat rates identified for each technology.

Financing Financing assumptions for all cases are based on EPRI assumptions described by Booras and Holt (2004). A 20-year constant dollar levelization factor (carrying charge) is applied to the Total Plant Cost to give the capital charge in $/MWh. The carrying charges applied are 14.2% for all PC cases, 13.5% for NGCC, and 14.6% for current IGCC. 14.2% is used for the Next Generation IGCC case under the assumption that the additional startup costs identified for IGCC that account for its higher carrying charge are eliminated as experience is gained with IGCC.

CO_2 emissions rates CO_2 emissions rates are calculated for all plants based on fuel input emissions factors: 117 lb/mmBtu for natural gas, 205.3 lb/mmBtu for bituminous coal, and 212.7 lb/mmBtu for subbituminous coal. These emissions factors are taken from the Energy Information Agency (EIA) 1605B reporting program (www.eia.doe.gov/oiaf/1605/factors.html). Emissions factors are converted to lb/MWh rates for all plants based on plant heat rates. For the carbon capture IGCC case, calculated emissions rates are reduced by 90%.

Technology-specific data sources and methods

NATURAL GAS COMBINED CYCLE (NGCC)

- **Natural Gas Price** is assumed to be $5.50/mmBtu. The Henry Hub price as of July 20, 2005 was $7.75/mmBtu. EIA's long-term forecast (Annual Energy Outlook, 2005) projects electric generator prices between $4.27–$5.44 through 2025.
- **Total Plant Cost, Heat Rate, Variable O&M** and **Fixed O&M** are from EPRI (Dalton, 2004).
- **NO_x Emissions Rate** based on a 0.01 lb/mmBtu emissions rate (consistent with a facility operating at 2–3 ppm) converted to lb/MWh (NETL, Dec. 2002; GE Energy, 2004).
- **SO_2, PM and Hg Emissions Rates** are assumed to be negligible (NETL, Dec. 2002).

CONVENTIONAL SUB-CRITICAL PC

Bituminous Coal

- **Total Plant Cost, Heat Rate, Variable O&M, and Fixed O&M** are from EPRI (Booras and Holt, 2004).
- **Hg Emissions Rate** based on the 1.96 lb/TBtu rate that EPA reports for bituminous coal and FGD (Eddinger, 2005).
- **NO_x and SO_2 Emissions Rates** based on projected performance of Peabody Energy's Thoroughbred Plant, which Peabody reports will achieve 0.08 lb NO_x/mmBtu and 0.167 lb SO_2/mmBtu. (Available at: www.peabodyenergy.com/Operationsproducts/thoroughbred.html) Rates converted to lb/MWh based on EPRI's heat rate of 9,310 Btu/kWh.
- **PM Emissions Rate** based on a 0.03 lb/mmBtu input emissions rate from NETL (Dec. 2002).

Subbituminous Coal

- **Total Plant Cost** from EPRI (Holt, 2004).
- **Heat Rate** scaled up by a factor of 1.06 from bituminous heat rate, based on EPRI (Dalton, 2004) analysis for PC with PRB versus Pittsburgh #8 coal.

- **Variable O&M and Fixed O&M** assumed equal to those for bituminous coal and taken from EPRI (Booras and Holt, 2004)

- **Hg Emissions Rate** based on the 4.0 lb/TBtu rate that EPA reports for subbituminous coal and wet FGD (Eddinger, 2005).

- **NO_x and SO_2 Emissions Rates** based on permit data from the Spruce 2 PC plant near San Antonio, TX, with SCR and FGD and using subbituminous coal. Plant annual limits (based on a 30-day rolling average) are 0.069 lb NO_x/mmBtu and 0.10 lb SO_2/mmBtu (Preliminary Determination Summary, Permit Nos. 70492 and PSD-TX-1037; available at: http://www.seedcoalition.org/CPS_preliminary_permit.html).

- PM Emissions Rate based on a 0.03 lb/mmBtu input emissions rate from NETL (Dec. 2002).

SUPER-CRITICAL PC

Bituminous Coal

- **Total Plant Cost, Heat Rate, Variable O&M,** and Fixed O&M from EPRI (Booras and Holt, 2004).

- **Hg Emissions Rate** based on the 1.96 lb/TBtu rate that EPA reports for bituminous coal and FGD (Eddinger, 2005).

- **NO_x, SO_2 and PM Emissions Rates** taken from Eastman Gasification Services Company emissions comparison (Eastman, 2003).

Subbituminous Coal

- **Total Plant Cost and Heat Rate** from EPRI (Holt, 2003).

- **Variable O&M and Fixed O&M** assumed to be equal to those for bituminous coal and taken from EPRI (Booras and Holt, 2004).

- **Hg Emissions Rate** based on the 4 lb/TBtu rate that EPA reports for subbituminous coal and wet FGD (Eddinger, 2005). This rate is slightly lower than the Hg rate reported by PSCo for Comanche 3 (super-critical PC with FGD) of 5 lb/TBtu.

- **NO_x and SO_2 Emissions Rates** based on Comanche 3 (SCPC with FGD and SCR using PRB coal) modeled emissions rates (0.07 lb NO_x/mmBtu; 0.10 lb SO_2/mmBtu) reported in Public Service Company of Colorado, 2003 Least-Cost Resource Plan (April, 2004).

- **PM Emissions Rate** based on a 0.03 lb/mmBtu input emissions rate from NETL (Dec. 2002)

ULTRA SUPER-CRITICAL PC

Bituminous Coal

- **Total Plant Cost** from EPRI (Holt, 2004).

- **Heat Rate** from NETL/EPRI (2000).

- **Variable O&M and Fixed O&M** assumed equal to those for Super-Critical PC and taken from EPRI (Booras and Holt, 2004).

- **Hg Emissions Rate** based on the 1.96 lb/TBtu rate that EPA reports for bituminous coal and FGD (Eddinger, 2005).

- **NO_x, SO_2 and PM Emissions Rates** assumed to be equal to those for Super-Critical PC.

Subbituminous Coal

- **Total Plant Cost** scaled up 5% from the bituminous cost using the scaling factor for Super-Critical PC based on EPRI data (Dalton, 2004).

- **Heat Rate** scaled up from the bituminous heat rate using EPRI's PC scaling factor of 1.06 (Dalton, 2004).

- **Variable O&M and Fixed O&M** assumed to be equal to those for Super-Critical PC and taken from EPRI (Booras and Holt, 2004).

- **Hg Emissions Rate** based on the 4.0 lb/TBtu rate EPA reports for subbituminous coal and wet FGD (Eddinger, 2005).

- **NO_x, SO_2 and PM Rates** assumed to be equal to those for Super-Critical PC.

CIRCULATING FLUIDIZED BED

Bituminous Coal

- **Total Plant Cost, Heat Rate, Variable O&M, and Fixed O&M** from Babcock and Wilcox (Nickey, 2004).

- **Hg Emissions Rate** based on 0.58 lb/TBtu reported by NETL for AES Hawaii CFB using bituminous (Indonesian) coal (NETL, Dec. 2002).

- **NO_x, SO_2 and PM Emissions Rates** based on the JEA CFB demonstration project (Dyr et al., 2000).

Subbituminous Coal

- **Total Plant Cost, Heat Rate, Variable O&M, and Fixed O&M** assumed same as for bituminous and taken from Babcock and Wilcox (Nickey, 2004).

- **Hg Emissions Rate** based on the 4.48 lb/TBtu rate reported by NETL for R.M. Haskett CFB using subbituminous coal (NETL, Dec. 2002).

- **NO_x, SO_2 and PM Emissions Rates** based on JEA CFB demonstration project (Dyr et al., 2000).

IGCC CURRENT

Bituminous Coal

- **Total Plant Cost, Heat Rate, Variable O&M, and Fixed O&M** from EPRI (Dalton, 2004).

- **Hg Emissions Rate** based on a 13 lb/TBtu uncontrolled rate with bituminous coal (Eddinger, 2005) and assuming 95% control with carbon beds.

- **NO_x, SO_2 and PM Emissions Rates** taken from Eastman Gasification Services Company emissions comparison (Dec. 2003).

Subbituminous Coal

- **Total Plant Cost and Heat Rate** from EPRI assuming use of Shell dry-fed gasifier (Holt, 2003).

- **Variable O&M, and Fixed O&M** from Shell Gasification (Van der Ploeg et al., 2004).

- **Hg Emissions Rate** based on a 8.5 lb/TBtu uncontrolled rate with subbituminous coal (Eddinger, 2005) and assuming 95% control with carbon beds.

- **NO_x, SO_2 and PM Emissions Rates** taken from Eastman Gasification Services Company emissions comparison (Dec. 2003).

IGCC ADVANCED

The IGCC Advanced plant represents what IGCC technology is expected to achieve as improvements in cost and performance are realized from the commercial experience gained from building and operating several initial plants. As described below, the cost, efficiency, and emissions information are all based on published estimates. Naturally, as the technology is deployed and optimized over time, actual cost and performance characteristics may vary from those assumed here.

Bituminous Coal

- **Total Plant Cost** taken from EPRI estimates that assume no spare gasifier is required (Dalton, 2004). In contrast, the IGCC current case assumes use of a spare gasifier, which accounts for the higher Total Plant Cost.

- **Heat Rate** based on current efficiency estimates from Shell Gasification (Van der Ploeg et al., 2004), which tend to be at the high end of published efficiency estimates.

- **Variable O&M, and Fixed O&M** based on current IGCC data from EPRI (Dalton, 2004).

- Hg Emissions Rate based on a 13 lb/TBtu uncontrolled rate with bituminous coal (Eddinger, 2005) and assuming 95% control with carbon beds.

- **NO_x, SO_2 and PM Emissions Rates** based on performance estimates from EPRI assuming advanced SO_2 controls and SCR (Booras and Holt, 2004).

Subbituminous Coal

- **Total Plant Cost** based on the average of EPRI's estimate for a Shell Gasifier with no spare ($1,480/kW) and Shell's estimate for a Shell Gasifier with no spare ($1,144/kW) (Holt, 2004; Van der Ploeg et al., 2004).

- **Heat Rate** based on current efficiency estimates from Shell Gasification (Van der Ploeg et al., 2004) increased by 10% to account for coal drying.

- **Variable O&M and Fixed O&M** from Shell Gasification (Van der Ploeg et al., 2004).

- **Hg Emissions Rate** based on a 8.5 lb/TBtu uncontrolled rate with subbituminous coal (Eddinger, 2005) and assuming 95% control with carbon beds.

- **NO_x, SO_2 and PM Emissions Rates** based on performance estimates from EPRI assuming advanced SO_2 controls and SCR (Booras and Holt, 2004).

IGCC WITH CARBON CAPTURE

Technologies for separating and capturing carbon dioxide from synthesis gas have been used commercially in the industrial sector, but not on full-scale IGCC power plants. Considerable research is underway and planned to evaluate the best systems for carbon capture on these plants. The estimates provided are based on published information considering the current state of technology development. Future improvements in capture technologies could significantly change the actual costs when the technologies are deployed in the future.

Bituminous Coal

- **Total Plant Cost** based on the average of GE and E-gas capital cost estimates with capture, reported by EPRI (Holt, 2004).

- **Heat Rate** from NETL/EPRI (2000).

- **Total O&M** from NETL/Parsons (2002).

- **Hg Emissions Rate** based on a 13 lb/TBtu uncontrolled rate with bituminous coal (Eddinger, 2005) and assuming 95% control with carbon beds.

- **NO_x, SO_2 and PM Emissions Rates** based on IGCC Next Generation emissions rates, scaled to reflect the increased heat rate required for carbon capture.

Subbituminous Coal

- **Total Plant Cost and Heat Rate** from EPRI estimates for Shell gasifier with capture (Holt, 2003).

- **Total O&M** from NETL/EPRI (2000).

- **Hg Emissions Rate** based on a 8.5 lb/TBtu uncontrolled rate with subbituminous coal (Eddinger, 2005) and assuming 95% control with carbon beds.

- **NO_x, SO_2 and PM Emissions Rates** based on IGCC Next Generation emissions rates scaled to reflect the increased heat rate required for carbon capture.

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Notes

[1] Several coal-fired power plants or cogeneration facilities are located in California, but they are small facilities compared to coal plants located in other states. See the California Energy Commission's California Power Plants Database, available at http://www.energy.ca.gov/database/POWER_PLANTS.XLS.

[2] California Energy Commission database, 1983–2004 California Electricity Generation: Total Production by Resource Type, available at www.energy.ca.gov; California Energy Commission, 2004 Net System Power Calculation, April 2005. Renewables are defined as biomass, geothermal, small-scale hydro, solar, and wind.

[3] A watt is the basic unit of electric power, describing the rate at which energy is being produced or used. Powerplant capacities are normally measured in megawatts (MW) where 1 MW is equal to 1,000,000 watts. Related terms: kilowatt (1000 watts).

[4] A watt-hour is the basic unit of electric energy, describing the amount of energy running through an electrical circuit for one hour with 1 watt of power being supplied. Related terms: kilowatt-hour (1000 watt-hours), megawatt-hour (1,000,000 watt-hours), gigawatt-hour (1,000,000,000 watt-hours), and terawatt-hour (1,000,000,000,000 watt-hours or 1,000 gigawatt-hours). Residential electric bills are normally measured in kilowatt-hours. Powerplant generation is normally measured in gigawatt-hours.

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22 This analysis was based on a review of the available monitoring data at 144 state, federal, and tribal ozone monitors in ten western states (Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming). See appendix B for more detailed data. Elevated ozone concentrations may also be found in other areas that are not monitored or where data are not reported to the EPA.

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