CHAPTER THREE

COAL ENERGY AND ELECTRIC GENERATION

DECISION-MAKERS
FIELD CONFERENCE 2002
San Juan Basin

NEW MEXICO'S ENERGY, PRESENT AND FUTURE

Policy, Production, Economics, and the Environment

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New Mexico's Coal Industry: Resources, Production, and Economics

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Coal-bearing rocks underlie one-fifth of the state of New Mexico, but most citizens are unaware of the important role coal plays in the economy of the state. Coal mining has been a significant part of our economic development since the 1850s. Today, New Mexico ranks 12th in U.S. coal production (27.34 million short tons), with 1.39 billion short tons of recoverable coal reserves at producing mines.[1] Forty-six percent of the state's total energy needs are met through power generated from coal. The coal industry's contribution to New Mexico's state budget is the third largest source of revenue from mineral and energy production. State tax revenues from the coal industry in New Mexico totaled $31.8 million in calendar year 2000. In addition, the state receives 50% of all royalties from coal leases on federal lands, and all rents and royalties from state lands. The coal industry in 2000 employed over 1,700 people with a payroll of nearly $100 million. While the present-day market for coal is dominated by electrical generation, this is just one of the factors that ultimately determine the economic feasibility of mining coal in New Mexico.

NEW MEXICO'S COAL INDUSTRY TODAY

Six coal mines currently operate in New Mexico; five of them are in the San Juan Basin (Fig. 1). All of these operations mine coal at or near the surface, although the San Juan mine is in the process of converting to an underground operation. Three of those five mines are captive, which means that all the coal produced at those mines is destined for a specific electric power plant. The San Juan and La Plata mines supply coal to the San Juan generating station (operated by Public Service of New Mexico); the Navajo mine supplies coal to the Four Corners generating station (operated by Arizona Public Service). The McKinley mine near Gallup and the Lee Ranch mine northwest of Grants have access to rail transportation and ship their coal to Arizona power plants. Lee Ranch supplies coal to the Escalante generating station (operated by Tri-State Generation & Transmission Association) near Prewitt, New Mexico. The Ancho mine in the Raton Basin delivers high-rank coal by rail to a power plant in Wisconsin; the quality of the coal from the Ancho mine and the proximity of the mine to rail make it economically feasible to transport the coal out of state.

ECONOMICS OF COAL

The regional geology of an area determines whether coal is present or absent, and, if present, if the coal beds are thick enough to be considered minable with the available mining techniques. The structure of the coal-bearing deposits—whether the rock units are flat lying, have significant dips, or are faulted—also determines whether a coal bed can be mined with the techniques available.

Coal quality is important as well. There are two important considerations in this regard: sulfur content, which significantly affects the quality of the emissions produced when the coal is burned (how "clean" or "dirty" the coal is), and the heating value, expressed in Btu/lb, which is a measure of how much heat (or energy) can be produced per pound of coal. The relationship between these two factors is the ultimate measure of coal quality.

To meet current standards of the Clean Air Act (as amended in 1990), electric generating stations may not discharge gaseous effluent containing more than 1.2 lb of sulfur dioxide (SO_2) per million Btu, which translates to about 0.6% sulfur per million Btu. Installing combustion gas scrubbers helps remove sulfur from power plant emissions if a coal has higher sulfur content than the standards allow, but this increases the cost of operations.

Another important quality to consider is the ash content of the coal: the greater the ash content, the greater the amount of combustion byproduct that must be disposed of (see article by Hoffman on fly ash in this volume). Ash is also corrosive to materials used in the combustion chamber, so the greater the ash content of the coal, the higher the cost of maintaining the boiler. Finally, combustion byproducts associated with high ash content must be periodically removed to maintain an efficient and safe operation.

Other factors that affect the economics of coal mining are 1) proximity to available transportation networks, 2) distance to a market and competition within that market, and 3) the technology available for

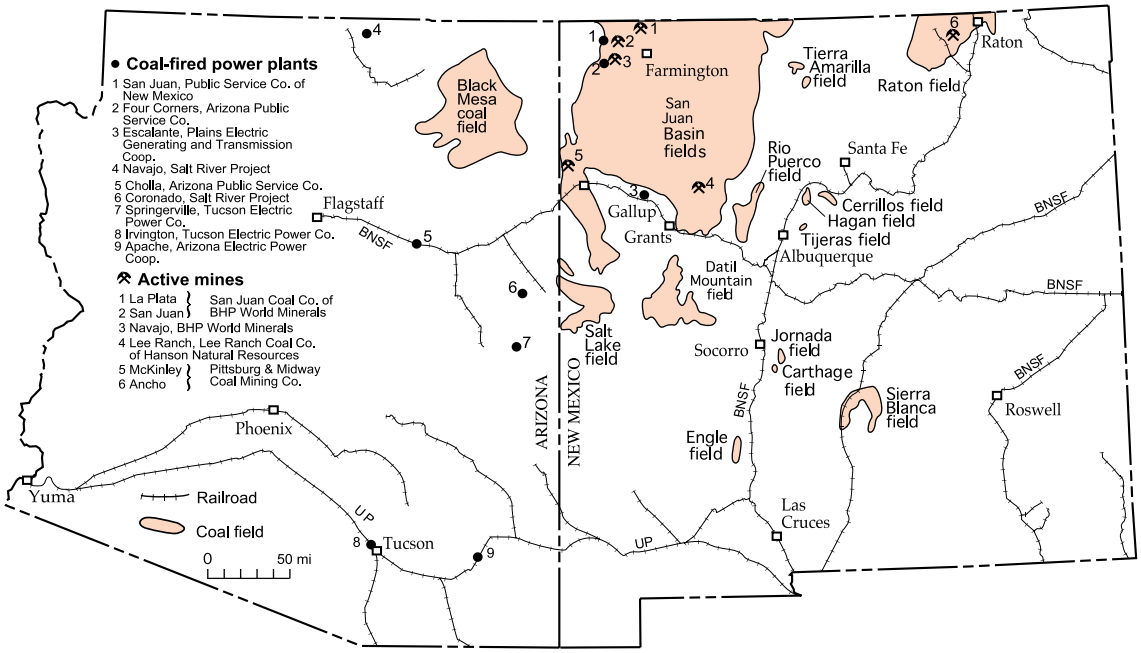

FIGURE 1 Coal fields of New Mexico with active mines, coal-fired power plants, and transportation network.

extraction. Throughout the history of coal mining in New Mexico (and elsewhere), the relative importance of each of these factors has changed in response to changes in the end users of the coal produced.

GEOLOGY

Several areas in New Mexico are defined as coal fields (Fig. 1), but most of the economic coal lies within the San Juan and Raton Basins. Coal-bearing rocks in the San Juan Basin are of Late Cretaceous age (95–60 million years ago) and were deposited in peat swamps in coastal environments. Most San Juan Basin coals thick enough to have economic potential developed from sediments that accumulated as the seas slowly retreated to the northeast, in response to increased sediment supply from the continental highlands to the southwest. This slow and uneven retreat allows for greater buildup of organic material (peat) and for preservation of coal in the rock record. Pressure from the weight of overlying sediments, deposited by rivers, wind, lakes, and seas, compresses the peat. Compaction of the plant material forces out oxygen, hydrogen, and other volatiles, leaving a greater percentage of carbon. This compaction decreases the thickness of the material, as well: an accumulation of 15–20 feet of peat produces a 1-foot thick coal bed.

Heat and time are the most effective elements that increase the heating value of the coal. Coals in the San Juan Basin do not have great lateral extent. They tend to exist in multiple thin seams within the coal-bearing rock formation, in varying thickness, and typically pinch out laterally. The thickness and extent of coal-bearing strata are important factors in their ultimate economic value.

There are three major coal-bearing rock sequences in the San Juan Basin: the Crevasse Canyon, Menefee, and Fruitland Formations (Fig. 2). The Crevasse Canyon Formation is the oldest unit; coals in this formation are not being mined at this time. The Menefee Formation has two coal-bearing sequences (the Cleary Coal Member at the base and the upper coal member at the top) and is the oldest coal-bearing formation actively mined in the San Juan Basin. Coals in both the Cleary and the upper coal members are thin, averaging 3–5 feet, with some seams as much as 25-feet thick. These coals have limited lateral extent, and there are multiple seams within the coal-bearing sequence at any one location. Surface-minable coal in the Cleary Coal Member is present along the southern edge of the basin and is near the surface on the western and eastern flanks of the basin where the rock units dip steeply. The Menefee Formation coals are low in ash content (inorganic noncombustible material, 7–15%) and are subbituminous in rank

(9,500–11,500 Btu/lb). The sulfur content of the Menefee coals can be over 1% in some areas (which is considered high for New Mexico; New Mexico coals average 0.8% sulfur content). These values limit the economic potential of these reserves. Of the 1.1 billion short tons (st) of surface-minable coal within the Menefee, only 106 million meet Clean Air Act standards of 0.6 lbs sulfur/million Btu. The McKinley and Lee Ranch mines extract coal from the Cleary Coal Member in the southern part of the San Juan Basin (Fig. 1, 2).

The Fruitland Formation is the youngest coal-bearing unit in the San Juan Basin and crops out along the basin's western, southern, and part of its eastern edges (Fig. 2). Some of the thickest coals in the basin are near the base of the Fruitland. Coal seams in the Fruitland Formation can reach 30 feet in thickness, but 5–10-foot seams are more common. The lateral extent of these coals is limited, but they tend to have greater continuity than coals in the Menefee Formation. Fruitland coals are very high in ash (18–22% by weight), and the sulfur content is variable, depending on the geographic and stratigraphic location, but averages 0.8%. Most of the coals in the Fruitland Formation are of subbituminous rank, but coals near the Colorado border, thermally altered by the San Juan volcanic complex, are of a higher rank (high-volatile bituminous) and therefore have higher heating values (11,500–13,000 Btu/lb). Fruitland coals are mined at the Navajo, San Juan, and La Plata mines west of Farmington (Fig. 1, 2). Demonstrated

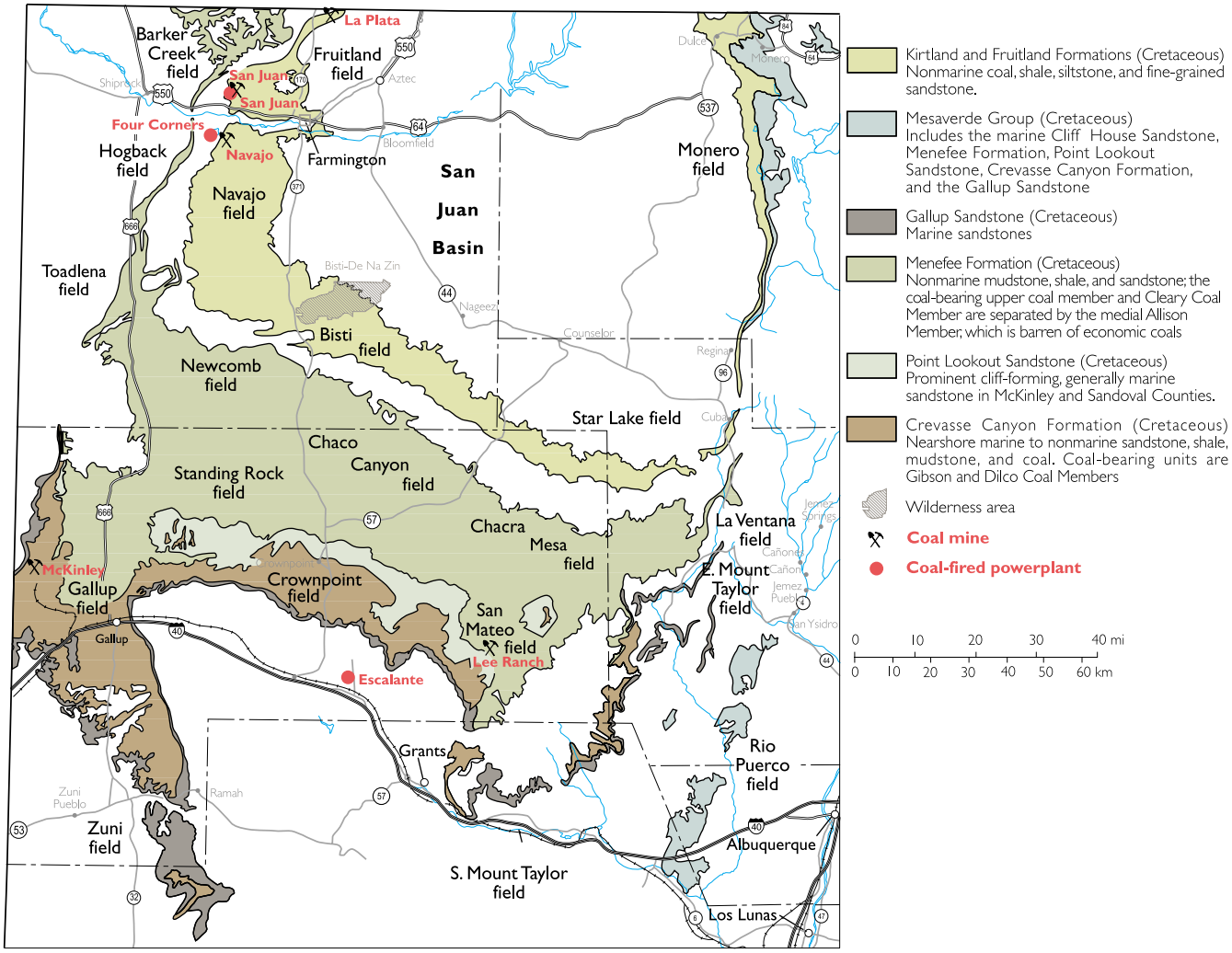

FIGURE 2 Coal fields and coal-bearing rock units within the San Juan Basin.

reserves of compliance coal (coal meeting Clean Air Act standards) within the Fruitland Formation are 883 million short tons (Hoffman, 1996).

TECHNOLOGY

Throughout the history of coal mining, methods of extraction have changed, becoming more efficient, safer, and less labor intensive. Coal mining in New Mexico began in the 1850s with crude methods (pick and shovel) to mine coal from surface outcrops. Advances were made in underground mining: using explosives to break the coal for easier removal, and employing mules and then battery or electric cars to bring the coal to the surface. With these improvements, along with better ventilation systems, mines increased in size and efficiency. The introduction of large earth-moving machinery, such as large bucket shovels and draglines, made surface mining feasible. Although surface mining began in the 1920s, underground methods prevailed until the 1960s in New Mexico and across most of the nation. The increased mechanization of both surface and underground mining and the use of computers and global positioning systems have increased productivity significantly in the past few years. Although fewer mines are operating in New Mexico now than in the 1980s, production has continued to rise, partly because of technological improvements.

MARKETS AND TRANSPORTATION

New Mexico coal was first used locally as a home heating fuel. The introduction of railroads to New Mexico Territory spurred the development of many small mines to supply coal to power steam locomotives. Ore smelters in the Southwest provided an additional market for New Mexico coal, particularly coal from the Raton Basin because of its high quality and metallurgical properties. The railroad industry's switch to diesel engines in the 1950s led to the loss of markets for many of the small coal mines and a significant drop in coal production statewide.

Our modern coal industry in New Mexico began in the 1960s, with the increase in population in the Southwest coupled with the demand for cheap electricity. The San Juan Basin was a major area of development because the geology and structure of the area were ideal for surface mining. The Navajo and San Juan mines opened in 1963 and 1973, respectively, to supply coal to adjacent electrical generating stations, built to be near both coal and water. Instead of transporting coal to distant power plants, electricity is generated on site and shipped via transmission lines.

A major restriction for marketing coal from most of the San Juan Basin is the lack of transportation infrastructure (Fig. 1). The lack of railroads is most significant because the only cost-effective way to transport coal is by rail. The only rail line in the northwest part of the state is along the southern edge of the basin, and this line allows the McKinley and Lee Ranch mines to ship coal to power plants in Arizona. Other areas within the San Juan Basin lack coal development in part because of this lack of rail transportation.

In the past, several rail lines have been proposed to provide access to markets, but a major stumbling block has been land access. Although the federal government owns large portions of land in the basin, federal lands are broadly dispersed among tribal, state, and private lands, in checkerboard fashion (see article by Hiles in this guidebook).

The market for New Mexico coal is limited to New Mexico and the greater Southwest, but most of the surrounding states also produce coal. Although New Mexico coal is of a desirable quality that surpasses other coal in the market area—moderate to low sulfur content, high Btu values—transportation and the high cost of mining multiple thin seams has limited the market.

MINING COSTS

The Clean Air Act of 1970 (as amended in 1990) made the sulfur content of coal relative to its Btu value a major criterion in meeting emission standards. The lower sulfur standard led to a nation-wide shift to low-sulfur coal at generating stations and contributed to the growth of Wyoming's Powder River Basin coal industry, with its vast reserves of low-sulfur coal. The Powder River Basin has 14.7 billion tons of surface-minable, low-sulfur coal compared to the 1.6 billion tons of low-sulfur coal in the San Juan Basin. Development of the Powder River Basin has influenced the entire U.S. coal market. The thick, low-sulfur coal beds in this region allow for very low coal prices, and the extensive rail network in Wyoming allows Powder River Basin coal to be shipped anywhere in the country.

Wyoming coal currently dominates the industry throughout the U.S. The Power River Basin produces about 30% of the nation's coal. The cost of Wyoming coal in 2000 was $5.45/short ton at the mine; the average cost of New Mexico coal in 2000 was $20.29/short ton. The net result is that Wyoming coal

can be shipped far greater distances before approaching the cost of New Mexico coal at the mine.

In addition to extraction costs, reclamation and safety regulations are part of the coal mining economics. The Coal Mine Health and Safety Act (1969) and the Surface Mine Control and Reclamation Act (1977) added many safety and reclamation regulations. Compliance with these regulations increased mining costs and made it difficult for small operators to stay in business. The average price of New Mexico coal in 1974 was under $5/short ton. Between 1974 and 1981 the price jumped to over $17/short ton. Smaller companies have gotten out of the coal-mining business, and large corporations now own most of today's operating mines.

The Clean Air Act directly affected the electric generation industry, a major consumer of coal and has had a significant influence on the coal industry. Pollution controls at the San Juan generating station, for instance, account for 35% of the operating costs. Electric utilities consume 87% of the nation's coal production. Approximately 56% of all electricity generated in the U.S. comes from coal-fired generating plants. The dependence on coal to produce electricity varies depending on the region. In New Mexico 46% of the state's total energy needs including electricity, gasoline for cars, and propane for heating is produced from burning coal. The cost of electricity in New Mexico is directly tied to the cost of New Mexico's coal because almost all coal burned at power plants within the state is locally mined. The real price of coal has declined in part because of the greater competition, greater productivity, and the replacement of long-term contracts with reliance on short-term or spot market pricing by utilities. With the pending deregulation of utilities, the coal industry may have to find other ways to cut costs to stay competitive.

TAXES

The last part of the coal economics equation is taxes levied on coal production. Taxes on coal production are complex and vary from state to state. Most states have four types of tax: sales, corporate income, property, and severance. Royalties are also paid to the owner of the property from which coal is mined, be it state, federal, tribal governments, or private entities. Sales, corporate income, and property taxes are common for an individual or company to pay, but severance taxes are unique to the mining industry. Severance taxes are levied on the value or volume of material extracted from the ground. These taxes may be levied by percent of value (ad valorem) or per unit, or as a combination of the two.

The average effective tax rate (the actual collections divided by output or by gross revenue) in New Mexico is high compared with other western states' tax rates (Fig. 3). Only Montana has a higher tax rate than New Mexico. When calculated by cost per ton, New Mexico is actually the highest in the western states (Fig. 4). Figure 3 shows the breakdown of the different taxes and illustrates where New Mexico has higher tax rates. Neither Utah nor Montana charges sales tax on coal, and Colorado charges a small fraction of a percent. In fact, all states except Arizona and New Mexico provide an exemption on sales tax for coal sold to utilities. These two states levy a sales tax on both electricity and coal, resulting in a double taxation on coal: once as a product from the mine and then again as a component of the price of electricity.

Utah and Arizona do not charge severance tax. The severance tax in New Mexico consists of a severance tax (2.67%) and severance surtax (2.03%). Beginning in 1990, any coal sold under new contract is exempt from the surtax, effectively lowering the total severance tax by 43%. This legislation was renewed in the 1999 legislature until June 30, 2009. The exemption

State	Volume (1,000 tons)	Average Price ($/ton)	Average Effective Coal Tax Rate ($/ton)
Arizona	11,787	NA	NA
Colorado	29,989	17.23	0.55
Montana	41,102	8.82	1.34
New Mexico	29,156	20.97	2.54
Utah	26,373	17.33	0.10
Wyoming	337,119	5.38	0.51

FIGURE 3 Western states coal production and average price for 1999 (EIA, 2001).

	UT	AZ	CO	WY	NM	MT
Sales	0	1.8%	.03%	0.1%	5.3%	0
Severance	0	0	2.6%	4.8%	4.7%	10.5%
Property	0.6%	0.8%	0.5%	4.4%	1.3%	1.0%
Other	0	0%	0%	0%	0.8%	3.7%
Total	0.6%	2.6%	3.2%	9.4%	12.1%	15.2%

FIGURE 4 Average effective coal tax rates by state—percent of gross receipts. From O'Donnell and Clifford, 1999.

also applies to pre-existing contracts but only to amounts sold in excess of average sales from 1987 to 1989. This legislation has resulted in great savings to the New Mexico coal industry. The prospective elimination of the severance surtax is on the horizon. The surtax will likely be eliminated as present contracts expire. This will remove a $0.60 charge on each ton of coal produced and reduce the effective severance tax rate in New Mexico to 2.67%.

For many years coal mines operating on the Navajo Nation paid taxes to both the State of New Mexico and the Navajo Nation, but legislation passed in 2001 permits mines operating on Navajo Nation lands and paying taxes to the Navajo Nation to qualify for a credit against gross receipts tax due the state. This new credit means substantial savings for the McKinley and Navajo mines and any new mines to operate on Navajo Nation land. With this legislation and the elimination of the severance surtax, New Mexico's coal taxes will be more in line with those of other western states.

The remaining taxes, property and other (e.g., resource excise, conservation) shown in Figure 3 are low for New Mexico. Property tax constitutes a large percentage of the tax burden in Wyoming, and Montana levies a "coal gross proceeds tax" amounting to 3.7% of the effective tax rate.

CONCLUSION

If we examine all the factors (geology, transportation, market, and taxes), we can better understand why New Mexico coal is relatively expensive compared to coal from other western states (Fig. 4). Most of New Mexico's coal mines are 20 years old or older, which means the reserves in the mines are deeper and more expensive to mine now than at the beginning of each mine's operation. The San Juan mine switch from surface to underground operations is in response to the increased cost of surface mining. By going underground, San Juan hopes to maintain a competitive product. No new mines have been developed in the San Juan Basin for many years, in part because of the lack of transportation and the inability to reach new markets, as well as the high cost of mining the multiple thin seams characteristic of San Juan Basin coal. Some areas that have potentially economic coal reserves have not been developed because of land access issues. Land access issues are a major stumbling block for new mines trying to acquire land and right-of-ways for transportation. In the 1990s there was no real demand for new coal resources in the New Mexico market area, but with the recent energy crisis in California there has been renewed interest in coal. The most viable option for new coal mines in New Mexico is captive mines, where coal is shipped directly to a nearby generating station and electricity, not coal, is transported to its destination.

Before electric utility deregulation, the cost of New Mexico coal was not as much of an issue as it is in today's market. Deregulation of the electric utilities would likely bring greater pressure on the coal industry to lower the cost of coal. Recently, several contracts between local coal companies and the utilities have been renegotiated, but more cost-cutting measures may be necessary to maintain a competitive coal industry in New Mexico. Some of these cost-cutting measures may have to come in the form of tax relief. Major reductions in coal production would adversely affect the state's economy, not only in decreased revenues for the state but also in jobs lost within the state.

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ENDNOTE

[1]Coal in New Mexico can be divided into resources—the coal that is in the ground—and reserves: coal that is economically produceable at this time, given our current technology, the cost of energy, competition from other markets, etc.

Regulation of the Coal Industry in New Mexico

James O'Hara, *New Mexico Energy, Minerals and Natural Resources Department*

I've heard it said that the coal industry is the most regulated business in America. Having regulated surface coal operations for almost eight years, I think I'd have to agree. But if it's one of the most regulated industries, it is also one of the most environmentally responsible. The dynamic between these two can serve as a model for striking a balance between development and environmental protection.

I'd like to introduce you to coal regulation in New Mexico by briefly summarizing:

- the laws affecting surface coal mining in New Mexico;
- what goes into a surface coal mining permit;
- the role the state of New Mexico plays in the operation of a mine;
- how the coal operators and the state work together, to protect the environment and achieve quality reclamation that will be productive long after the mine is gone.

The regulation of surface coal mining is governed by the federal Surface Mining Control and Reclamation Act (SMCRA), enacted by Congress and signed into law in 1977. The act created a national regulatory authority, the Office of Surface Mining (OSM) that is responsible for permitting, inspection, and enforcement of surface coal mines through regulation (30 CFR 700-7900). Title V of the act allows OSM to transfer regulatory responsibilities for surface coal mining to the states, provided that a state program that is no less effective than SMCRA can be created through statute and regulation.

New Mexico was granted primacy in 1980 with the passage of the Surface Mining Act (NMSA 1979 69-25A-1 et seq.) and its implementing regulations, developed through the Coal Surface Mining Commission, 19.8 NMAC. New Mexico's coal program, which is part of the EMNRD's Mining and Minerals Division, regulates federal, state, and private lands, excluding only lands falling within the bounds of Indian reservations, which are regulated by OSM under the federal program.

New Mexico's three hundred pages of coal regulations cover every aspect of mining and the effects it may have on the environment or the public. These include air quality, protection of surface and ground water, protection of topsoil, and disposal of trash on a permitted mine. More importantly, the regulations set a standard for reclamation of lands affected by mining.

WHAT'S IN A COAL MINING PERMIT?

There are three main parts of a surface coal mining permit application:

1 *Legal, Financial, Compliance, and Related Information* An applicant must provide information on who owns the mining company and will conduct mining. Included is a detailed description of the corporation, affiliated corporations, and the parent corporation. The federal Office of Surface Mining established the Applicator Violation System, which uses this information to identify "bad actors" and prohibit them from operating a coal mine anywhere in the U.S. This part of the permit also identifies all landowners of surface or mineral estates, any other permits and licenses that may be needed (NPDES, MSHA, etc.), and documentation that the applicant has a right-of-entry or leases to conduct mining.

2 *Background on Existing Environmental Conditions* A permit must contain detailed information about the nature of the site before mining. This includes sections on surface and ground water hydrology, geology, topography, climate, vegetation, soils, fish and wildlife (including threatened and endangered species), and current, pre-mining land use. There are specific requirements for the various types of information listed in each section. For example under vegetation, an applicant must collect:

- A comprehensive listing of species by plant community;
- Information on ground cover, and frequency and constancy values for each species (herbaceous, tree, and shrub);
- Acreages for each community correlated to soils, slope, and aspect;
- Information on the above that is collected over two growing seasons.

3 *A Reclamation and Operations Plan* The purpose for collecting the environmental information is to develop a reclamation plan that will reconstruct as many of the

Mine	Mine location (County)	Permit area (acres)	Acres disturbed	Current bond	Phase released	Amount released	Acres released
Ancho[2]	Colfax	15,909	2,080	$10,000,000			
Black Diamond[1]	San Juan	249	23	$89,732	I	$134,597	23
Carbon No. 2[1]	McKinley	361	308	$308,000	I II	$2,976,687 $1,676,458	468.4 308
Cimarron[1]	Colfax	5114	54	$1,102,694			
De-Na-Zin[1]	San Juan	820	172	$251,402	I II	$2,815,176 $1,373,980	170 149.3
Fence Lake[3]	Catron & Cibola	17,702	0	$7,739,773			
Fence Lake No. 1[1]	Catron	500	116	$998,743	I	$665,829	92.6
Gateway[1]	San Juan	600	144	$468,742	I II	$703,113 $260,811	144.1 144.1
La Plata[2]	San Juan	3,300	1,902	$56,000,000			
Lee Ranch[2]	McKinley	15,522	4,835	$75,500,000			
McKinley[2]	McKinley	10,727	4,262	$44,489,000	Liability Release	$0	1,745.6
Mentmore Section 33 Industrial Park[1]	McKinley	1,813	1,746	$1,587,000	I Final	$0 $0	618.9 455.7
San Juan[2] NW Pinion	San Juan	18,050	5,127	$67,000,000	I Final	$0 $0	1,832 236.74
York Canyon Surface[1]	Colfax	2,733	1,174	$2,258,000	I & II	$5,525,319	1,053
York Canyon Underground[1]	Colfax	4,792	650	$14,598,577	I & II	$2,210,019	190

[1]No production, all areas are under reclamation in the 10-year liability period; [2]Currently producing coal, with areas of reclamation in the 10-year liability period; [3]Permitted, but has not begun mining operations.

FIGURE 1 A summary of New Mexico's surface coal mine operations in 2001.

pre-mining conditions as possible. The reclamation plan includes an approved post-mining land-use and topography, replacement of topsoil, the type of vegetation (seed mix) needed to meet post-mining land uses, and any special mitigation required to prevent toxic or acid-forming materials from affecting the long-term viability of the final reclamation.

The operation plan sets forth a process by which coal will be mined and all the requirements of the reclamation plan will be implemented. Unlike other types of mining reclamation, coal mine reclamation is contemporaneous with the removal of coal. There are strict provisions that limit the amount of disturbance that may take place without corresponding reclamation.

HOW ARE PERMITS APPROVED?

When an application is received by the Mining and Minerals Division (MMD) it undergoes an in-depth review to ensure that all of the elements are present, correct, and in the prescribed detail. The Mining and Minerals Division works with the applicant until the application is administratively complete. At that time the public is notified and given the opportunity to review and comment on the application. Public hearings may be held, and additional technical issues are typically addressed.

Upon completion of the public comment period, the director will make a decision on the disposition of a permit. If it is judged to be approvable, the operator must submit a bond that is based on a calculation of what it would cost MMD to complete reclamation should the operator go out of business or not meet the permit requirements. The regulations specify that a bond adequate to carry out reclamation must be held for no less than ten years after the last seeding is completed and specific performance standards have been met, based on a post-mining land use. For example,

criteria for the amount of ground cover, production, diversity, and shrub reestablishment are specified in the permit. Once the bond instrument is in place, the permit can be approved. It can take up to a year or more to process a new application, depending on the quality of the submittal.

One last comment on the permitting process: The regulations include provisions for appealing a permitting decision. This ensures that the public interest is protected.

WHAT GOES ON DURING THE LIFE OF A COAL-MINING OPERATION?

Most of the permitted coal mines have a minimum life of about twenty years for the smaller mines and thirty to fifty years for the larger ones. During this time MMD relies on a series of performance standards and the stipulations of the permit to inspect and enforce all operations; violations can be written on infractions of the rules or the permit. Inspections to review how well the mine is following its operation and reclamation plans are conducted on a monthly basis.

Permits are generally renewed every five years. A renewal is similar to a new application, except that a mine has a right of successive renewal unless an opponent can show the director that the original permit was improvidently issued. The purpose of renewals is to update permits and fine-tune issues associated with operation or reclamation planning. Permits will often undergo minor changes that do not go through a public notice process. MMD completes 50–75 modifications for its mines every year.

BOND RELEASE - GETTING CLOSURE

Since reclamation is contemporaneous with mining, bonds are recalculated every couple of years and adjusted as necessary. As reclamation is completed, permittees can also apply for phased bond releases. Phase I credits completion of backfilling and grading by establishment of an approved post-mining topography. Phase II recognizes revegetation success and evaluates the performance standards for successful revegetation included in the permit. A bond can be reduced upon the director's approval of a bond release application. Final bond release, Phase III, documents that the permittee has waited ten years and demonstrated to the director that the reclaimed lands can support the post-mining land use, which in most cases is grazing. Once the bond is released, the permit is terminated.

A SUMMARY OF COAL PERMITS IN NEW MEXICO

New Mexico has 16 surface coal mines currently permitted (Fig. 1). Ten of these are under the ten-year reclamation liability period and are not in production. Five are under production, producing about 20 million short tons of coal a year. The remaining mine, Fence Lake, is permitted but has not begun operation.

Coal mining continues to be an important element of New Mexico's economy. The regulatory process seeks to strike a balance between the economic and energy needs of the nation and protection of the environment.

Coal Mine Reclamation in New Mexico

Douglas Bland, *Mining and Minerals Division, New Mexico Energy, Minerals and Natural Resources Department*

The primary goal of coal mine reclamation is the establishment of an appropriate post-mining land use. Regulations require that disturbed areas be returned to the approximate original contour of the land. In this paper I will discuss standard reclamation practices that have been used at most mines in New Mexico. I will also discuss how we address areas that have steep slopes or that require drainages be reconstructed, and special habitat areas where unique reclamation techniques are used to create diversity in landforms and wildlife habitat.

There are differences of opinion regarding the most appropriate post-mining land use for mine sites. In addition, there can be disagreements as to whether the mine should be constructed at all. One reason for opposition to energy development is use of the land for religious purposes. In New Mexico, Native Americans claim that development on certain lands may impede their historic use of the land for religious practice. Such claims can be made even if title to the land is not currently held by the claimant. In 2000 the New Mexico Legislature passed the Religious Freedom Restoration Act to address this issue. At the end of the paper I've included a discussion of the Religious Freedom Restoration Act and its implications for coal mining.

STANDARD RECLAMATION: PRODUCTIVE SHRUB/GRASSLANDS

Grazing land and wildlife habitat are the most common post-mine land uses for New Mexico reclamation. Creating a diverse, effective, and permanent vegetative cover on all affected lands is the best way to achieve these land uses (Fig. 1).

Standard reclamation practices on coal mines are geared toward maximizing the potential for post-mine plant productivity. All surface or strip coal mines create open pits when the coal is removed. The backfilling and grading operations following coal removal typically result in a gentle, rolling reclamation topography (Fig. 1). Any rock or other material that is toxic or detrimental to plant growth is buried below the rooting zone. Soils are generally more evenly distributed, in terms of both location and depth, than they were before mining. Native grasses, shrubs, and forbs are seeded; each species is selected for its ease of establishment, adaptation to site conditions, and seasonal forage value. Management of surface water and precipitation runoff is usually better than the pre-mine condition. Finally, careful management is applied to all reclaimed lands during the minimum 10-year bond liability period.

FIGURE 1 Reclaimed land including a small area depression and productive grasslands at Ancho mine, Colfax County, New Mexico.

The reclamation bond liability period can be thought of as a proving-up time. Livestock grazing is conducted, revegetation is monitored, and wildlife usage is recorded. The quantity and quality of surface and ground water are also monitored. The mine operator is required to demonstrate that reclaimed lands can and do support the post-mine land use, while meeting all approved revegetation and hydrology success criteria, and the bond is not released unless the post-mine land use has been successfully implemented.

The results of these reclamation practices are impressive. Post-mine production of palatable forage is typically double the pre-mine productivity. If the site

was in poor range condition before mining, the post-mine vegetation productivity gains can be much higher. Without question, the essential reclamation mandates are being achieved in New Mexico.

Although reclamation of coal mines has been ongoing since the federal Surface Mining Control and Reclamation Act was passed in 1977, it is an evolving science. The following topics discuss refinements and enhancements to basic reclamation that are being incorporated into reclamation practices in New Mexico.

FIGURE 2 Complex slopes and drainage construction at San Juan mine, San Juan County, New Mexico.

STEEP SLOPE AND DRAINAGE CONSTRUCTION

Revegetation can take several seasons to become fully established in New Mexico because of our generally dry climate and the use of perennial species that take more than one year to mature. Erosion can be a problem during the first few years following seeding when surface roughness, mulch, and sparse annual weed cover are the only protection against the forces of nature. Cut-and-fill terraces and rock-lined drains are sometimes used to limit erosion on steeper slopes, but the long-term stability of terraces and drains is a concern. Complex slopes, talus slopes, and substrates with high coarse rock fragment concentrations can be effective alternatives to terraces for steep-slope reclamation. Erosion control is achieved on complex slopes by creating branched drainage patterns. The length of steep slopes is thereby effectively shortened, reducing runoff velocity. Slopes are built with an overall concave longitudinal profile, steeper at the top and flatter at the bottom, so that gradients are reduced as surface runoff accumulates (Fig. 2).

Adjacent undisturbed areas can provide models for drainage construction. Sinuosity within low-flow channels is used to reduce drainage gradients and erosion potential. Rock fragments that do not easily wash away may be used at critical spots in the drainage bottom. Wider flood-stage channels are added in the larger drainages to spread and slow the runoff from major precipitation events.

SPECIAL HABITAT FEATURES

Special habitat features include badlands and cliffs, small area depressions, and wetlands. The creation of special habitat features is an important component of modern reclamation. Animal and plant species diversity on the reclaimed landscape is dependent on the creation of a variety of appropriate habitats.

The reclamation of badland sites, such as the Gateway mine in the San Juan Basin, present some unique challenges. The Gateway mine is on state trust lands that were used for grazing before mining; grazing is also the post-mining land use. The coal that was mined there provided much more revenue to public schools than badland grazing ever could. The absence of fertile, or even neutral, soil material made it very difficult to establish an effective vegetative cover. Several experimental soil amendments were tried at Gateway to improve reclamation success, including various combinations of wood chips, fertilizer, calcium chloride, gypsum, and phosphorus. However, red scoria gravel, which was salvaged before mining and applied as surface mulch during reclamation, resulted in the best vegetative cover. Forage production on Gateway reclamation, although still sparse, is seven times greater than was measured before mining.

Sandstone-capped plateaus, mesas, and cuestas are common and dramatic pre-mine features that are important both to plant and animal diversity as well as to the aesthetic value of the landscape. Several competent sandstone highwall segments at New Mexico coal mines have been retained as cliff habitat. Recently a raven established a nest on one reclamation cliff while grading operations were still being completed. Rock surfaces concentrate precipitation and enhance soil moisture at the bases of cliffs. The increased moisture encourages the establishment of trees and shrubs, and the depressions created at the bases of cliffs provide seasonal water sources (Fig. 3).

Small area depressions are commonly built on reclamation to furnish temporary drinking water for livestock and wildlife, to control erosion, and to create vegetation diversity. They also provide breeding habi-

tat for insects and amphibians, and foraging sites for predators. Depressions are completely incised and have gentle slopes, and they are re-soiled in a manner consistent with adjoining areas. Depending on the climate of the site and the size of the contributing watershed, small area depressions may vary from western wheatgrass-dominated communities to seasonal wetlands.

Rare plant species are commonly associated with shale and sandstone rock outcrops or springs and seeps. Mitigation is required when mining impacts springs or other wetland habitat, or if the plants are listed as threatened or endangered. Sediment and flood control ponds may be retained as wetlands or developed water resources, with landowner concurrence. Ponds fed by artesian wells have also been used to replace spring-fed wetlands. Outcrop-type rare plant habitat can be provided by simply not re-soiling small areas of reclamation, where the rocky material provides suitable physical and chemical characteristics for the species of concern, and then transplanting the plants and a bucketful of their original soil to the replacement site.

FIGURE 3 Reclamation cliff at Mentmore mine, McKinley County, New Mexico.

The science of reclamation is evolving. Natural ecosystems are extremely complicated, and as understanding of them expands, so do efforts to address the critical elements of re-creating ecosystems that are both useful and long-lasting.

ACKNOWLEDGMENTS

Many thanks to Dave Clark, Senior Reclamation Specialist with the Mining and Minerals Division, for his assistance with this paper.

The Religious Freedom Restoration Act

Proper reclamation becomes a major issue at a mine site only after mining begins. The decision to begin mining involves successfully addressing any challenges as to whether mining is appropriate for the site. One mechanism that may be used to prevent mining from starting is the Religious Freedom Restoration Act (RFRA), signed into law by Governor Gary Johnson in 2000.

In the 1990s Congress passed the federal RFRA in response to certain court decisions that were perceived by some to unduly restrict certain religious practices. RFRA was intended to change the law in order to provide more religious protection. Subsequently, the federal RFRA was found unconstitutional on the grounds that it was beyond the power of the U.S. Congress, and the court ruled that the states alone could pass such legislation. Many states including New Mexico have since passed their own RFRA. There is currently very little case law on RFRA, because states have just begun to pass RFRAs. General First Amendment law will likely be used in RFRA analysis, because RFRA also addresses the protections contained in First Amendment law. To better understand the position courts have taken on such issues in specific circumstances, case law related to the First Amendment should be consulted.

In part, the New Mexico RFRA provides that a government agency shall not restrict a person's free exercise of religion unless:

A the restriction is in the form of a rule of general applicability and does not directly discriminate against religion or among religions; and

B the application of the restriction is essential to further a compelling governmental interest and is the least restrictive means of furthering that compelling governmental interest.

RFRA goes on to provide for injunctive and declaratory relief and damages pursuant to the Tort Claims Act.

RFRA analysis requires consideration of several key phrases in order to better understand the statute.

"Substantially motivated" Any analysis of a RFRA issue must begin with the question whether the "free exercise of religion" is involved. Under RFRA, the religious conduct sought to be protected must be "substantially motivated by religious belief." ("Free exercise of religion" means an act or refusal to act that is substantially motivated by religious belief.")

"General applicability" This simply means that a restriction must apply equally across the board to everyone. Any restriction that targets a specific group will be invalid.

"Compelling governmental interest" RFRA does not prohibit every governmental restriction that impacts religious practice. It essentially contains a balancing test, under which the governmental justification for the restriction is weighed against the practice. Because religious practice is highly protected under our laws, the government bears a heavy burden to justify its restriction with a "compelling governmental interest."

"Least restrictive means" In addition to requiring the government to justify its regulation by compelling interest, the government must show that its regulation is narrowly tailored to achieve its purpose.

The proper forum for a RFRA challenge appears to be the District Court. The legislature provided that RFRA violations may be asserted "as a claim or defense in a judicial proceeding and obtain appropriate relief including injunctive or declaratory relief and damages pursuant to the Tort Claims Act." "Judicial proceeding" refers to District Court. This may result in a second, separate process being used by challengers to government permits or actions as a sort of citizens suit, in that a challenged decision proceeds through normal administrative appeal channels, while at the same time someone can bring a RFRA challenge in District Court, without going through administrative channels.

Exactly how and under what circumstances New Mexico's newly enacted RFRA will be used is not yet known. However, the clear message is that religious freedom is an important issue to the state legislature and the governor, and it must be properly considered when energy and mineral development is contemplated in areas where this is an issue.

Coal-Fired Electric Power Generation in New Mexico

Pat Goodman, *Public Service Company of New Mexico*

Most New Mexicans understand that New Mexico is an "oil and gas state." We are among the nation's top producers of those energy forms. But many don't know that New Mexico is blessed with huge coal reserves, as well. In fact, our coal reserve—the amount of coal in the ground—are the fourth largest in the United States. Yet New Mexico takes little advantage of these rich reserves. As a coal producer—actually pulling coal out of the ground—we only rank 13th nationwide.

Why? Rail service from the Four Corners area, site of the state's largest coal reserves, is virtually nonexistent. Coal in New Mexico is used primarily at power stations built at the mouth of a mine. As a result, coal mined in New Mexico is used primarily for electricity production at two major generating stations: the San Juan Generating Station, operated by Public Service Company of New Mexico (PNM), and the Four Corners Power Station, operated by Arizona Public Service Company.

San Juan Generating Station is the seventh largest coal-fired generator in the western United States. The plant burns between 6.5 and 7 million short tons of coal a year. The nearly 1,800 megawatts of energy produced at the station, located in the northwestern corner of New Mexico, serves PNM's approximately 369,000 electric customers in Albuquerque, Santa Fe, Las Vegas, Clayton, and Deming. Power produced here but not needed for PNM customers or the plant's other owners reaches across the West through a transmission network that stretches across 11 western states, two Canadian provinces, and into Baja, Mexico. With eight different owners from as far away as southern California to nearby Farmington, New Mexico, the plant's product is a vital part of the regional economy.

The nearby Four Corners Power Plant, operated by Arizona Public Service, provides even more energy, at 2,040 megawatts. Together, the two plants produce enough energy for more than 3.6 million homes. Their location on the western grid, with major switching facilities, makes the two power plants key facilities in the Southwest. Despite this, when a unit goes down, power flows across the transmission system from other generators, and PNM customers don't even notice.

RELIANCE ON COAL

PNM customers rely on coal for the majority of their electricity. But other resources make up the fuel mix. Nuclear power from Palo Verde Nuclear Generating Station west of Phoenix provides about 24% of the energy PNM customers might use on any given day. Eighteen percent of the energy PNM produces comes from natural gas and oil. Still, coal remains the workhorse fuel, providing 58% of the energy for our New Mexico customers. Nationally, the United States burns coal for about 51% of its electricity generation.

The average PNM customer uses 526 kilowatt-hours of electricity a month. If all this energy came from coal, it would take about 660 pounds of coal each month to generate that amount of electricity. At this writing (January 2002), PNM is exploring renewable resources like wind for investment in our energy future. But today, and into the foreseeable future, PNM and other utilities will continue to rely heavily on coal for meeting our energy needs.

In order for coal to be used far into the future, it must be burned as cleanly as possible. More than 25 years old, the San Juan Generating Station meets all regulations for air emissions. It has also been a zero-discharge plant since 1983, keeping all water discharged on the plant site rather than returning it to the area's rivers and streams. But strict compliance with environmental law is only part of the station's focus. The plant has substantially "raised the bar" on emissions and other environmental practices. We've made a serious commitment to getting the most out of every ton of coal burned while reducing emissions at the same time.

For example, between 1997 and 2001, we were able to dramatically reduce sulfur dioxide emissions by 50%, even while we burned more coal (Fig. 1). And, the plant has teamed up with BHP Minerals, supplier of the coal the plant burns, to provide cleaner-burning coal at a reduced cost. This kind of innovative thinking will lead to the development of the largest longwall mining operation in North America. And it's located right in San Juan County.

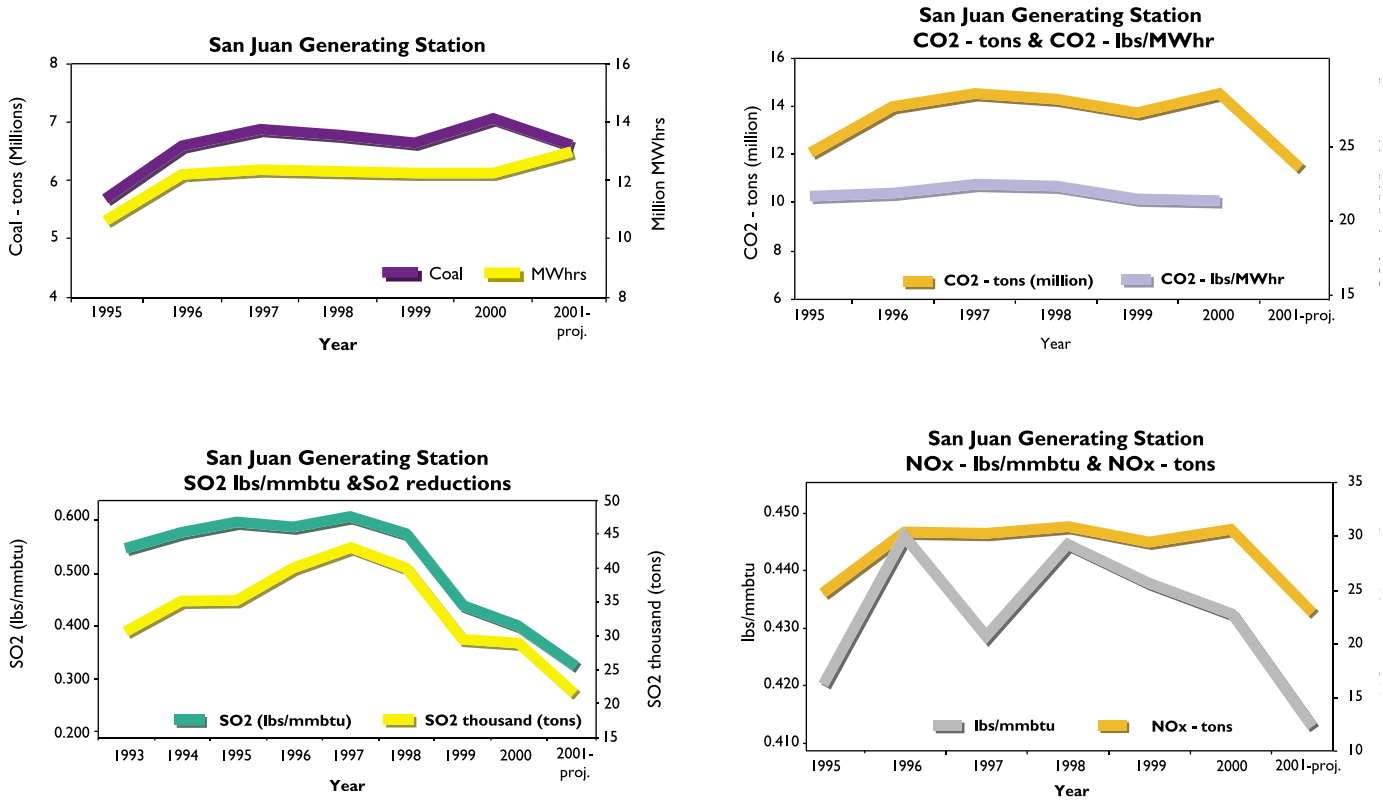


FIGURE 1

REDUCING AIR EMISSIONS

Burning coal with less and less emissions is at the heart of PNM's goals for its coal-fired generation. New Mexico had some of the most stringent state laws for air quality in the nation when the majority of San Juan Generating Station was under construction in the 1970s. To meet those standards, PNM installed a state-of-the-art and very expensive air emissions control system. The system allowed the plant to meet the new air quality laws of the time.

That original Wellman-Lord regenerative sulfur dioxide-removal system was replaced with a new limestone-forced oxidization system in mid-1998. The new system takes gases from the flue, once combustion is complete, and forces them through a spray of limestone slurry in huge absorber cells. The slurry containing the gases becomes calcium sulfate, or gypsum. Once the moisture is removed, the gypsum can be safely returned to the mine to be buried as part of the mine reclamation process.

The new limestone system not only performs better, reducing emissions such as sulfur dioxide by about 50% over the old system, but it also costs much less to run. Operating and capital costs related to the new system also dropped a significant $20 million a year for the plant's owners, helping to keep San Juan power prices competitive in the marketplace and rates low for PNM customers. And the numbers continue to improve with our expanding operating knowledge and experience.

Nitrogen oxide (NOx) is another significant emission associated with coal burning. The plant has installed low-NOx burners and burns coal at slightly lower temperatures to further reduce NOx emissions. The electrostatic precipitators at the plant remove 99.7% of the particulates from the flue gas to ensure cleaner emissions.

SAN JUAN GENERATING STATION'S ENVIRONMENTAL MANAGEMENT SYSTEM

Emissions control systems are only part of the solution to burning coal cleaner. In 1999 the San Juan Generating Station took an ambitious step by implementing an Environmental Management System (EMS). And we took it one step farther with our commitment to obtain ISO 14001 certification.

ISO 14001 standards are international standards for environmental management systems that are set by the

International Organization for Standardization in Switzerland. The standards are based on the concept of continuous improvement of environmental performance. In March 2000 an independent auditor certified San Juan Generating Station's Environmental Management System to the ISO 14001 standards.

In December 2000 the San Juan Generating Station was recognized by the Environmental Protection Agency (EPA) as a charter member in its Performance Track Program. The Performance Track Program was developed by the EPA to recognize companies that achieve superior environmental performance and to develop partnerships with these companies. San Juan was one of only two coal-fired generating stations in the United States to be recognized as a charter member in the Performance Track Program.

San Juan's membership in the Performance Track Program includes a commitment to additional reductions in emissions and support of the recovery of endangered species. As part of the Performance Track Program, San Juan Generating Station recently signed a contract with Phoenix Cement to provide fly ash for use in cement products and road building. This represents a significant reduction in solid waste to be buried as part of the mine reclamation process—a reduction of about 300,000 short tons a year.

The plant has served as a model for other power plants PNM operates. The company is committed to implementing an Environmental Management System at all its power plant facilities, from the oldest members of the generating station "fleet," to the newest plants under construction today.

A NEW COAL SUPPLY

Later this year, the coal supply for San Juan Generating Station will come from a new source. BHP Minerals, owner and operator of the mine located next to the plant, is currently making the transition from its surface mining operation to an underground mine.

To mine the coal, BHP Minerals has invested in new "longwall mining" equipment. The technology employs massive hydraulic roof supports and speedy conveyer belts to mine and move large amounts of coal. The underground facility will take advantage of large underground coal seams that could not be reached by surface mining equipment. The coal that is removed will not contain the dirt or other materials often found in the surface-mined coal. As a result, the plant will receive higher grade coal. Switching to an underground mine will allow the mining company to offer a lower-priced and cleaner-burning coal supply, keeping San Juan Generating Station's future power supply economic and competitive long into the future.

FUEL DIVERSITY

Investing in power plants is capital intensive. San Juan Generating Station represents a total investment of over $1 billion today. Those costs have been borne not only by utility customers but also by shareholders and other owners in the plant. Selling the plant's excess power when available also helps keep costs down. The end result is competitively priced electricity.

Part of what helps keep prices competitive is the concept known as "fuel diversity." PNM's generation resources represent a mixture of fuels, from coal to nuclear to natural gas and oil. Each source is traded in a larger market for energy. Most consumers are familiar with the volatility of the market when it comes to natural gas for heating their homes. Power plants running on natural gas see the same ups and downs, too.

Newer plants under construction today use clean-burning natural gas as a fuel but the cost to produce that electricity can suffer great price swings. To counter this effect, coal-fired plants offer stable fuel costs over many decades. When managed as a portfolio of resources, power produced by diverse fuel sources offers better protection against price swings over the many decades of service that each plant provides. Each fuel has its strengths and weaknesses. With power plants serving 40 years or more, such decisions have long-lasting effects.

PNM believes that there will still be a place for new coal production in the next generation of power plants. But these new plants will have the advantage of well-developed "clean coal technologies." This new generation of coal-fired plants must address concerns about carbon dioxide and global warming. An integrated gasification combined-cycle approach may prove to offer the benefits of coal while significantly reducing the impacts on the environment.

Utilities like PNM must consider these long-range impacts and develop a clear understanding of how to manage them. At San Juan Generating Station, we have struck a good balance, reducing the effect of burning coal while producing reliable, affordable energy.

ADDITIONAL RESOURCES

For more information on PNM's power plant operations or environmental focus, visit the PNM website: www.pnm.com

For information on the electric industry in the United States, visit the Edison Electric Institute's website: www.eei.org

Air Quality and the Clean Air Act Amendments

Sandra Ely and Mary Uhl, *New Mexico Environment Department*

Haze is caused when light is absorbed or scattered by air pollution. Haze makes the view less clear and diminishes the range of visibility. Air pollutants that are responsible for haze include sulfates, nitrates, organic carbons, soot, soil dust, and nitrogen dioxide. The greater the quantity of these pollutants that are in the atmosphere, the more regional haze will obscure the view. Generally, haze is worse in the summer when there is more humidity; some of the pollutants that cause haze, such as sulfates, grow in size when exposed to water particles. Larger particles are more effective at scattering and absorbing light, so haze becomes worse. There are many sources of the air pollutants that cause haze to form. Electric power generating facilities are large contributors of haze-forming air pollutants. These facilities emit particulates, nitrogen dioxide, and sulfur dioxide. Sulfates and nitrates are formed when sulfur dioxide and nitrogen dioxide are transported long distances. Other sources of air pollution that contribute to haze formation include automobiles, forest fires, windblown dust, and other industrial facilities.

The pollutants that cause haze have major impacts to our health and environment. Small particles of air pollution can be inhaled and reside in the lungs, increasing the risk of respiratory illness, damage to

FIGURE 1 Map of 156 national park and Wilderness areas protected by EPA's regional haze rule

lung tissue, and even premature death. Sulfates and nitrates are formed from sulfur dioxide and nitrogen dioxide emitted from facilities such as power plants, refineries, and copper smelters. These pollutants cause acid rain. Acid rain damages plants, buildings, and bodies of water. Acid rain may cause lakes, rivers, and streams to become so acidic that there is harm to aquatic plants and fish. Many of the pollutants that cause haze also contribute to the formation of ozone at ground level. Ozone causes respiratory problems and damages plants and ecosystems. Nitrogen dioxide emitted from electric power generating stations and oil and gas facilities can increase the nitrogen loading in lakes, streams, and rivers, upsetting the balance of nutrients in the water and harming plants and fish.

In the western United States, visual range in national parks and Wilderness areas has decreased from an average of 140 miles in the late 1800s to anywhere from 35 to 90 miles today. In the eastern United States, visual range has also decreased. In national parks and monuments, including Grand Canyon, Bandelier, and Yosemite, this decrease in visibility also decreases the quality of the visit for tourists, while increasing the health and environmental problems caused by the haze-forming pollutants.

Congress mandated that the Environmental Protection Agency (EPA) address the problem of haze in our nation's parks and Wilderness areas in the Clean Air Act Amendments of 1990. In 1997 EPA proposed a regulation to reduce emissions that cause haze to form. The rule was issued in April 1999. It requires states to establish quantifiable goals for improving visibility and returning visibility to "natural conditions" in 156 national parks and Wilderness areas (Fig. 1) by the year 2065. The rule requires a coordinated effort between states because tiny particles of air pollution can be transported hundreds of miles by the wind. Each state must develop a plan that addresses the contribution of sources of air pollution to national parks and Wilderness areas within the state and in neighboring states.

New Mexico has nine national parks and Wilderness areas where visibility must be improved under the EPA's new regional haze rule (Fig. 2). These areas are designated as Class I areas, meriting special protection by Congress because of their scenic vistas, wild areas, and historic landmarks. In New Mexico the Class I areas are:

- Wheeler Peak Wilderness
- San Pedro Parks Wilderness
- Pecos Wilderness
- Bandelier National Monument
- Bosque del Apache National Wildlife Refuge
- White Mountain Wilderness
- Carlsbad Caverns National Park
- Salt Creek Wilderness
- Gila Wilderness

These areas attract thousands of tourists to New Mexico each year. Class I areas in neighboring states that may be affected by air pollution from New Mexico include Mesa Verde National Park, Guadalupe Mountains National Park, Weminuche Wilderness, and Chiricahua National Park. In most of these Class I areas, visibility has been improving on the "cleanest" days over the past ten years, but degrading on the "dirtiest" days. Clean days are days when visibility range is greatest; dirty days are days when visibility range is reduced by the greatest amount. EPA's 1997 regional haze rule requires improvement in visibility on the cleanest and the dirtiest days. At most of these Class I areas, acid rain has also increased over the past ten years.

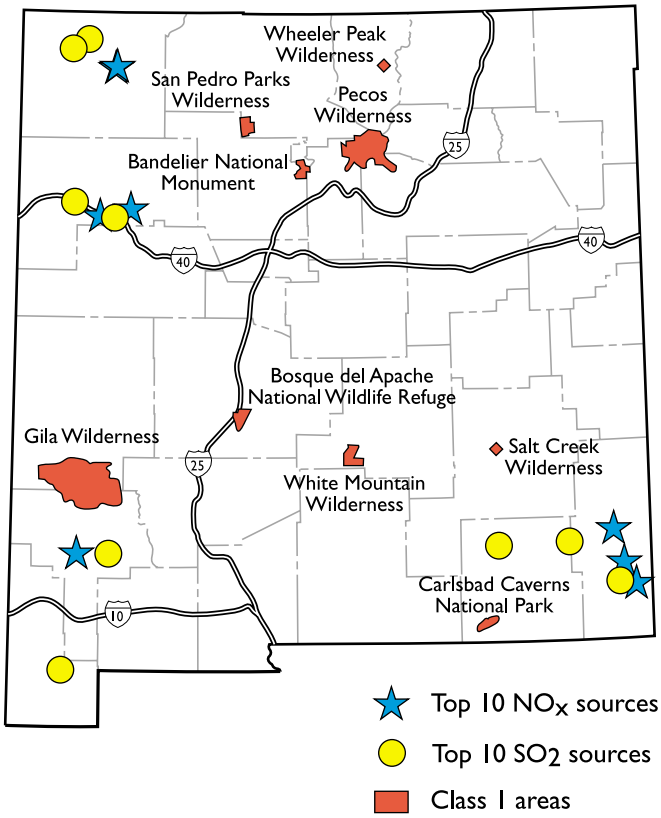
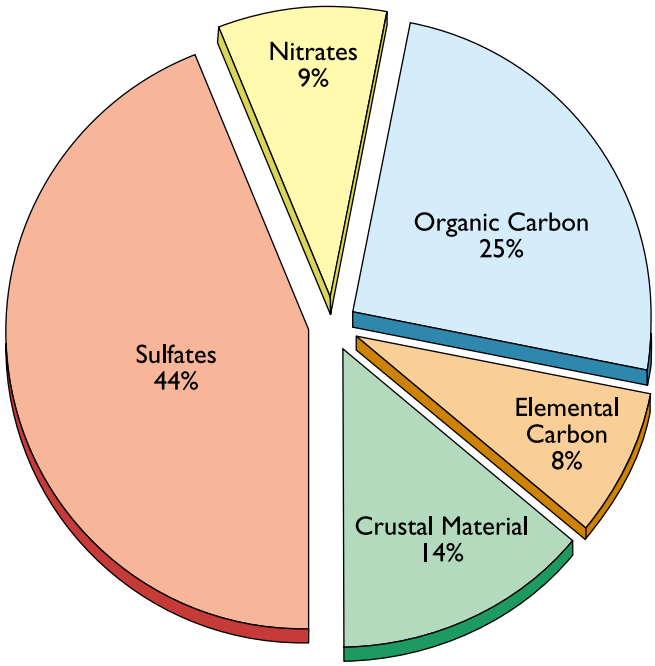


FIGURE 2 Class 1 areas in New Mexico.

In the San Juan Basin (San Juan, McKinley, and Rio Arriba Counties), there are many sources of nitrogen dioxide and sulfur dioxide pollution. There are electric power generation facilities, oil and gas production and transmission facilities, refineries, other small industrial facilities, automobiles, wind-generated dust emissions, and occasional forest fires. There are currently three large electric power generation facilities in the San Juan Basin: Public Service Company of New Mexico's San Juan plant, Arizona Public Service Company's Four Corners plant, and Tri-State's Escalante plant. These three electric power generating facilities account for a large percentage of the emissions of haze-forming pollutants in the San Juan Basin; they contribute approximately 66% of the nitrogen dioxide emissions and 92% of the sulfur dioxide emissions from industrial facilities in the region.

Transport of air pollution from the San Juan Basin and other areas of New Mexico contributes to the formation of regional haze in Class I areas in New Mexico and in neighboring states. For example, in Bandelier National Monument 44% of the reduction in visibility on the dirtiest days in 1997 was due to sulfates, 9% to nitrates, 25% to organic carbon, 8% to soot, and 14% to soil dust (Fig. 3). In other Class I areas, the reduction in visibility may be due to differing proportions of pollutants, depending on nearby sources and the predominant wind direction for transport of pollutants. Emissions from San Juan Basin facilities do appear to be increasing, however, as monitored ozone concentrations have recently been elevated and are close to the National Ambient Air Quality Standard for ozone.

New Mexico is currently participating in the Western Regional Air Partnership to develop goals and a plan for reducing the emissions that form haze in the West. The Western Regional Air Partnership membership includes other states in the West, such as Utah, Arizona, and Wyoming. This organization is determining which sources contribute most to pollutants that cause haze to form, which pollutants need to be reduced, and how those reductions can be made to achieve the visibility goals established for Class I areas in the western U.S. Because the ultimate goal is to achieve natural visibility conditions by 2065, the states will establish milestones every ten years to ensure that the visibility improves enough incrementally to achieve the ultimate goal. For most of the states in the U.S., visibility goals will be achieved through traditional "command and control" methods. For example, EPA has designated several categories of air pollution facilities built between 1962 and 1977 that will be required to install new air pollution control technology in order to reduce pollutants that contribute to the formation of haze. However, several western states with Class I areas on the Colorado Plateau have the option of meeting visibility goals through a combination of voluntary actions and a "cap and trade" program.



Sulfates- predominantly from utility and industrial boilers

Nitrates- predominantly from automobiles and utility and industrial boilers

Organic carbon particles- from sources such as automobiles, trucks, and other industrial processes

Elemental carbon (soot)**-** from diesel, wood, and other combustion

Crustal material (soil dust)**-** from roads, construction, and agricultural activities

FIGURE 3 Pollutants that contributed to reduced visibility on the worst days in 1997, Bandelier National Monument, New Mexico.

The cap and trade program offers flexibility to industry by setting caps on annual emissions. Emissions are tracked annually to determine if voluntary reductions are keeping emissions below the caps. If the caps are exceeded, a regional trading program is initiated, whereby industrial sources trade air pollu-

tion emissions credits to ensure that regional emissions of haze-forming pollutants do not increase further. New Mexico must submit a plan to EPA for improving visibility between 2003 and 2008, depending on whether the state intends to follow the traditional command and control method or the more flexible cap and trade method. Careful analysis of the advantages and disadvantages of both methods is currently underway. The Air Quality Bureau is in the midst of planning several public meetings to ensure comprehensive stakeholder involvement in the decision.

Regional haze goals for Class I areas in the West will require significant reductions in air pollution in New Mexico. Recent degradation in visibility in Class I areas in and near New Mexico will have to be reversed in order to meet the requirements of this federal mandate. Power generating facility emissions contribute a large proportion of industry-generated pollutants that form haze, but the complete picture must be analyzed to determine which emission-reduction and air pollution-control technologies will result in the greatest steps toward visibility goals and the improvement of the health and environment of New Mexico. The EPA's regional haze rule offers an opportunity for the state of New Mexico to examine not only the impacts of air pollution from New Mexico sources, but also the impacts of sources outside of New Mexico. This cooperative program should help to clarify the causes and contributors to haze in New Mexico, with a long-term goal of increasing air quality statewide.

The Uses of Fly Ash in New Mexico

Gretchen K. Hoffman, *New Mexico Bureau of Geology and Mineral Resources*

One of the natural byproducts of coal combustion is *fly ash*, the noncombustible particulate matter that remains behind once the organic component of coal is consumed and the volatiles are expelled. Fly ash is composed mainly of minerals and rock fragments that exist naturally in the coal. For many years this byproduct was considered waste and required disposal (the fly-ash industry in the U.S. dates only to the 1960s). But in recent years, fly ash has been determined to have commercial uses and economic value, providing an important resource for other industries and an economic gain to coal-fired power plants. Commercial uses of fly ash include as an admixture to concrete (to improve its strength and durability), in railway construction, as structural fill, and in waste stabilization.

New Mexico coals, high in ash content (from 13% to 27%), create a significant amount of coal combustion byproducts, most of which is fly ash. Of the 28.8 million short tons (st) of coal produced in New Mexico in 1999, over half was delivered to three electrical generating stations in New Mexico. Furthermore, New Mexico coals produce fly ash with high silica and low calcium content, characteristics that make New Mexico fly ash a beneficial admixture for portland cement concrete. The quality of New Mexico fly ash makes it marketable not only in New Mexico but throughout the Southwest.

ORIGIN OF THE ASH IN COAL

The inorganic, noncombustible portion of coal—minerals and rock particles—are introduced either during or after deposition of peat, or during the coalification process. Minerals are transported into the swamp by water or air. Bottom-dwelling organisms in the coal swamp may mix minerals into the peat at the time of deposition. Windblown dust and volcanic ash can both make significant contributions because of the slow accumulation rates of peat in the swamp environment. Swamps downwind of volcanic activity may periodically receive large amounts of volcanic ash. Most (95%) of the mineral matter present in coal is clay, pyrite, and calcite. Clay minerals make up 60–80% of the total mineral content of coal. Clay minerals can be finely dispersed throughout the coal or form layers. During the transformation of peat to coal, other minerals also precipitate along joints and in voids and may occur as finely disseminated particles or mineral aggregates. Other noncombustibles can be introduced during mining. Small partings are often mined with the coal, and some of the roof and floor, above and below the coal seam, may also be mixed with the coal. This will add to the total content of noncombustible material in the coal, and ultimately to the quantity of ash byproduct.

A BYPRODUCT OF THE COMBUSTION PROCESS

Coal used for electric power generation is finely crushed, pulverized, and air-fed into a 1900°–2700°-F combustion chamber where carbon immediately ignites. During coal combustion, the volatile matter vaporizes to gas, and carbon burns to heat the boiler tubes. The molten minerals, including clay, quartz, and feldspar, solidify in the moving flue gas stream leaving the combustion chamber. The rapid cooling of the moving particles tends to create spheres, and as much as 60% of fly-ash particles display a spherical shape (Fig. 1). Coarse particles settle to the bottom of the ash hopper, forming bottom ash, and some clings to the sides of the boiler tubes, forming boiler slag. Boiler slag is a problem, because it lowers the efficiency of the boiler tubes and has to be removed periodi-

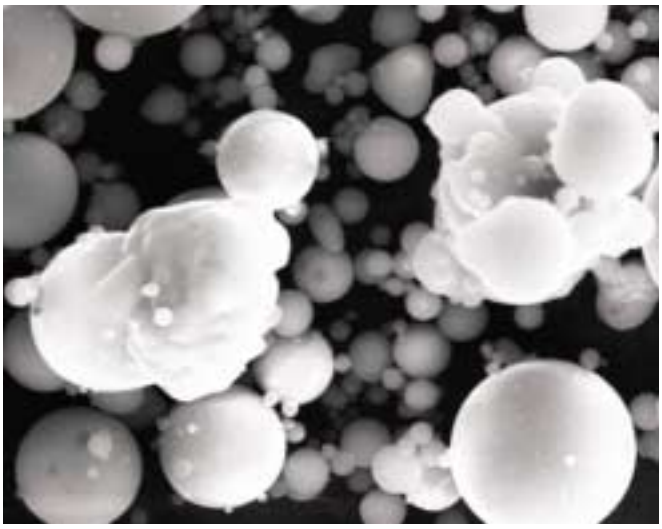


FIGURE 1 Secondary electron image of fly ash with glass spheres and masses. End product from Phoenix Cement, Cholla Generating Station. Field of view is 42 microns.

cally. The ratio of fly ash to bottom ash produced by coal combustion is dependent on the type of burner and the type of boiler. Pulverized coal (PC) burners are the most common type used for coal-fired electrical generation, and the fly-ash percentage for these varies from 65% to 85%.

Fly-ash particles consist primarily of glass spheres (often hollow) and spongy masses. Physical characteristics of fly ash include size, morphology, fineness, and specific gravity. Fineness is usually determined by the percentage of the ash retained on a 45-µm (325-mesh) sieve; standards requires that no more than 34% of fly ash be retained. Size distribution can be quite variable, depending on the type of precipitator, and size can vary with coal even when it is from the same source. Fly ash is removed from the flue gas stream by either electrostatic or mechanical precipitators.

OTHER COAL COMBUSTION BYPRODUCTS

All byproducts of coal-fired electrical generation must be disposed of or used in some application. Coal combustion products (CCPs) include fly ash, bottom ash, boiler slag, and flue gas desulfurization material (FGD). Several factors determine whether these byproducts are marketable: (1) quality of the product—a result of the chemical and physical composition, (2) consistency of product, (3) distance to and economics of the market for these products, (4) transportation network and facilities, and (5) availability and cost of competing materials.

The American Coal Ash Association compiles statistics on the use of coal combustion products in the United States. Of the CCPs, fly ash has the largest production, greatest usage, and widest applications. In 1999, 62.67 million short tons (st) of fly ash were produced in the U.S., and 33% of this was put to use. Cement, concrete, and grout capture over half of the market for fly ash (11.35 million st). Thirty-two percent of bottom ash is used, most of it in structural fill (1.38 million st) and road base/subbase (1.29 million st). Almost all boiler slag (82%) is used in the manufacture of blasting grit, because of its considerable abrasive properties. Only 18% of FGD is used, primarily in the manufacture of wallboard (1.60 million st). Significant amounts of FGD do not meet the purity specifications for wallboard without further processing. The majority of CCPs are disposed of in ponds or landfills. Some generating stations that are adjacent to the coal mine supplying the coal will return the fly ash to the mine for disposal in the pits or for use in reclamation. All disposal methods are regulated, and all cost money.

USE OF FLY ASH IN CEMENT AND CONCRETE PRODUCTS

Fly ash is used in cement for its pozzolanic nature. A pozzolan is a siliceous or siliceous and aluminous material that in itself is not cementitious—that is to say: it does not in itself act as a cement, but reacts chemically with calcium hydroxide in cement at ordinary temperatures to form compounds possessing cementitious properties. Natural pozzolans have been used for centuries; both the Greeks and Romans were aware that certain volcanic rocks, when finely ground and mixed with lime, yielded a mortar that was superior in strength and resistant to fresh or salt water.

As an admixture, fly ash provides many attractive characteristics to concrete, including strength, durability, and increased workability. The fine grain size enables fly ash to fill void space within the concrete, reducing the need for fine-grained aggregate. The size of the fly-ash particles (0–45 µm) also improves the packing of cementitious materials and reduces the permeability of the concrete through pozzolanic action. Reduced permeability means the concrete is more resistant to chemical attacks by seawater or sulfate-bearing ground water. The spherical shape of the fly ash increases the workability of the concrete. Use of fly ash lowers the cost of the concrete and saves energy. Cement manufacturing is an energy intensive process, so the savings can be significant. The average cost of cement in the U.S. is $83/short ton. The average cost of fly ash is approximately $22/ short ton. The use of fly ash also reduces the mining of other materials for cement. Because fly ash is a byproduct, it has some advantages over other artificial and natural pozzolans. There are environmental considerations, as well; carbon dioxide generated in the manufacture of cement is lowered as much as 50% with the use of fly ash. The primary benefit of fly ash is to the generating station, reducing fly-ash disposal costs and providing additional income through its sale.

OTHER USES

The most significant use of fly ash is in cement and concrete products, including concrete for large construction projects such as dams. But there are other uses, as well. Fly ash has been used as structural fill, in embankments, highway shoulders, and as load-bearing structural fill. It can be compacted with normal construction equipment and shows little settling compared with conventional fill materials. Fly ash can be used to stabilize hazardous materials by solidifying them into an inert mass.

A minor amount of the total fly ash produced consists of hollow spheres called cenospheres, which have specific high-value applications. Cenospheres float; consequently, they can be collected from the surface of fly-ash disposal ponds. The spherical shape, small size, low density, relatively high-strength in uniform compression, good thermal and acoustical insulating, and dielectric properties allow for a multitude of uses. These applications include fillers for paint, varnishes, and ceramics as well as applications in electronics.

FLY-ASH PRODUCTION IN NEW MEXICO

Most of New Mexico's coal is used to produce electricity, both here in New Mexico and in Arizona. New Mexico produced 27.3 million short tons (st) of coal in 2000 from six surface operations (New Mexico Energy, Minerals, and Natural Resources Dept., 2001), five of them in the San Juan Basin. New Mexico coal was burned primarily at seven coal-fired electrical generating plants (four in New Mexico and three in Arizona; see Fig. 2). The total estimated fly ash produced in 1999 from these seven generating stations is 4.34 million st, or about 15% of the coal consumed. In that same year, 32% of fly ash produced was landfilled or disposed on site at those plants. (Some of the fly ash from the Springerville and Cholla plants is contaminated by the scrubbers and cannot be used in other products.) The total useable fly ash from New Mexico coals in 1999 was estimated at about 2.4 million st. Approximately 29% of that was sold for use; the remaining 61% was used in mine reclamation or as fill in mine pits. This is a significant amount, bearing in mind that only 33% of the fly ash produced nationwide is used, and the average usage of all coal combustion products from the western U.S. is 20%.

MARKETING OF NEW MEXICO FLY ASH

Generating stations burning New Mexico coal sell their fly ash to marketers for resale or admixing (Fig. 2). Marketers, knowledgeable about the fly-ash market, handle the quality control, load-out facilities for transport, technical support, sales, and promotion of the product for all New Mexico fly ash that is being sold. Fig. 2 summarizes the source and ultimate destination of this material.

Several factors make New Mexico fly ash a marketable product. The high percentage (over 60%) of silica in New Mexico fly ash is particularly important, because the alkaline rocks available in the region as aggregate require the use of high-silica ash. As with most industrial minerals, transportation and proximity to markets is crucial. Some plants have rail transportation on site or nearby. Because many of the generating stations in New Mexico and Arizona are not close to large markets, this access to railroad transportation is important. However, because fly ash is a low-cost product

Company	Plant name /State	Coal source	Ash marketer	Transportation	Market area	Major use
Arizona Electric Power	Apache/AZ	McKinley	Boral Material Technologies	Rail and truck	AZ, CA, Mexico	Concrete products
Arizona Public Service	Cholla/AZ	McKinley, Lee Ranch	Phoenix Cement	40% rail, 60% truck	AZ, CA, NM	Concrete products
Arizona Public Service	Four Corners/ NM	Navajo	Phoenix Cement	60% by truck to rail head	NM, CO, CA, AZ	Concrete products, backfill
Salt River Project	Coronado	McKinley	Mineral Resources Technology	Rail and truck TX, NM, CA	AZ, CO,	N/A
Tri-State Generation	Escalante/NM	Lee Ranch	Minerals Solutions	Rail and truck	AZ, NV, West TX, NM	N/A
Tucson Electric Power	Springerville/AZ	Lee Ranch	None—fly ash is contaminated by dry scrubbers			
Public Service Company of New Mexico	San Juan/NM	San Juan, La Plata	Phoenix Cement	100% truck	NM, AZ, UT	Backfill

FIGURE 2 Coal-fired power plants and fly-ash marketers (see Fig. 1 on page 66 for location of mines and plants).

and specialized rail cars are needed, very few marketers send all their fly ash by rail. A unique situation exists at the Four Corners plant (New Mexico) where 60% of their marketed fly ash is shipped by truck to a railhead near Gallup, then shipped to California and Arizona markets. The Arizona Cholla plant ships 40% of its marketed fly ash by rail to California. Having storage facilities at different locations in the market area is also important, particularly with the seasonal fluctuation in the production of fly ash. Most of the marketers of New Mexico fly ash have this capability, which allows them to have product available year round.

ENVIRONMENTAL CONCERNS

The Environmental Protection Agency (EPA) did an in depth study in 1980 of the use and disposal of fly ash on human health and environment under the Resource Conservation and Recovery Act. Their report to the United States Congress recommended classification of pure stream fly ash, bottom ash, boiler slag and FGD material as nonhazardous. Individual states were left with the responsibility to develop solid-waste programs to deal with coal byproducts (EPA 1988). Early in 2000, the EPA reconsidered this decision. On April 25, 2000, the EPA decided to not reclassify coal combustion wastes as hazardous substances. EPA does plan to develop national standards to address wastes from coal burning plants that are presently either land disposed or used as fill in mining. Had fly ash been regulated as a hazardous material, the economic impact on coal-fired power plants and ash marketers would have been significant. The cost would have included (a) the loss of revenue from sale of a product, (b) the cost of disposal for this combustion byproduct, and, perhaps most important, (c) the cost of handling what might then have been classified as a hazardous material.

CONCLUSIONS

The use of fly ash as a commercial product has significantly reduced costs associated with what has otherwise traditionally been a combustion byproduct requiring disposal. The birth of the fly-ash industry in the U.S. in the 1960s not only solved this problem, but provided an additional source of income to producers of fly ash. The importance of fly ash as a commercial product, with its many beneficial applications, has allowed the development of a viable industry. The future of that industry will depend upon whether the Environmental Protection Agency continues to view fly ash as a nonhazardous byproduct. Whatever the future of the fly-ash industry, it will continue to be closely tied to the coal-generated power industry in New Mexico and adjacent states.

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Can We Achieve Zero Emission Coal Power?

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Fossil-energy resources currently provide 85% of all energy consumed worldwide and are readily available. Resource exhaustion could lead to a decline in the use of oil and gas within the next few decades. On the other hand, coal resources in the U.S. and elsewhere could satisfy world energy demand for several centuries. Based on studies by the U.S. Geological Survey, coal resources in the U.S. exceed 10,000 Gigatons (Gt). This number should be compared to an annual carbon consumption of about 6.5 Gt of carbon in all fossil fuels combined. As technologies improve, interchangeability between the various fuels becomes easier. In short, we are not likely to run out of fossil-fuel resources in the foreseeable future. As we discuss below, it is the environmental concerns associated with their use, particularly concerns about air quality, that need to be resolved.

In the 1970s environmental concerns focused on certain air pollutants, particularly heavy metals like lead and mercury, and compounds of sulfur and nitrogen. Regulations were adopted to reduce those emissions. Over the last decade, however, carbon dioxide (CO_2)—the primary end product of fossil-fuel combustion—has itself become a concern, mainly because of its probable role in human-induced climate change. Unlike other pollutants, CO_2 is harmful not as a single emission, but through its long-term accumulation in the atmosphere. Coal is the most carbon-intensive fossil fuel, producing large amounts of CO_2 as a byproduct of combustion. As governments impose carbon production constraints, both energy producers and consumers will be affected. To be most effective, carbon constraints should aim for zero emissions. A power plant that converts its waste byproducts to reusable or disposable solids and eliminates airborne emissions altogether would be ideal.

Current annual atmospheric CO_2 emissions are increasing at a rate of 1.7 ppm/year (ppm = parts per million), which exceeds 1% of the total pre-industrial carbon content of the atmosphere (280–370 ppm). Given a minimum worldwide population growth of 2% per annum, CO_2 levels in the atmosphere will exceed 500 ppm before 2050, or within the expected lifetime of a coal-fired power plant built today.

Halting the increase of atmospheric CO_2 accumulation requires drastic reductions of emissions. Model calculations suggest that in order to fix the total carbon dioxide level in the atmosphere, yearly emissions will have to fall by a factor of about 3 below those of 1990 in a matter of a decade or two. If, in the coming century, we lower worldwide CO_2 emissions to 30% of what they are today, and given a world population of ten billion sharing equally, the allowable *per capita* emissions would only be 3% of today's *per capita* emission in the United States.

Energy demand will rise rapidly over the course of the next century. In the twentieth century, energy consumption grew by a factor of twelve. In the coming century the remainder of the world may repeat what Europe, Japan, and North America accomplished in the last century in terms of industrialization and energy consumption, but with a population that is billions larger. The importance of energy to the world's economic development should not be underestimated. Figure 1 shows the primary energy consumption per dollar of gross domestic product (GDP) in various countries. In spite of energy efficiency improvements, which already have been dramatic, the amount of energy required for a dollar of GDP is remarkably large. Without access to cheap and abundant energy, further industrial development of the world is limited.

FIGURE 1 Relationship between energy and GDP

Thus, fossil energy must be a major contributor to satisfy the ever-growing energy demand. However, for fossil energy to play such a role in the next century, carbon dioxide emissions, together with all other airborne emissions, will have to be drastically reduced or eliminated. This affects not only coal-based power plants, but also any use of fossil energy. But because power plants are such large and concentrated sources of carbon dioxide, they are also likely initial targets for mandated reductions. In the long run, mandated emissions reductions must apply to natural-gas-based power as well as coal-based power.

Los Alamos National Laboratory (LANL), in collaboration with university, government, and industrial partners, is developing an integrated zero emission process for power plants that is based on a combination of improvements in the power generation process and a method of sequestering CO_2. Sequestration refers to methods used to temporarily or permanently isolate the CO_2 that is a natural byproduct of combustion from the atmosphere.

THE POWER GENERATION PROCESS

The goal of current research is to develop a process that will produce hydrogen from coal, hydrogen that will then be used in fuel cells to generate electricity. The multi-stage process gasifies coal, using hydrogen to produce a methane-rich intermediate state (methane is the most common component of natural gas). The methane is subsequently reformed using water and a calcium oxide (CaO)-based sorbent. A sorbent is a compound that removes, in this case, CO_2 from the process. The sorbent supplies the energy needed to drive the reforming reaction and simultaneously removes the generated CO_2 by producing calcium carbonate ($CaCO_3$). The resulting hydrogen product stream is split, approximately half going to gasify the next unit of coal, and the other half being used to generate electricity from solid oxide fuel cells (SOFC). The inevitable high-temperature waste heat produced by the SOFC would in turn be used to convert the $CaCO_3$ into CaO (which can be reused in the process) and pure CO_2 (which must be sequestered). The SOFC yields an exhaust stream that is largely recycled back to the reforming stage to generate more hydrogen with a slipstream (a small fraction of exhaust flow from the fuel cell) being extracted and condensed. The slipstream carries with it the other initial contaminants present in the starting coal. Overall the process is effectively a closed loop, with zero gaseous emissions to the atmosphere. The process also achieves very high conversion efficiency (about 70%) from coal energy to electrical energy. In addition to our work, several other groups are also employing variants of this process to produce hydrogen from a number of carbon-based fuels.

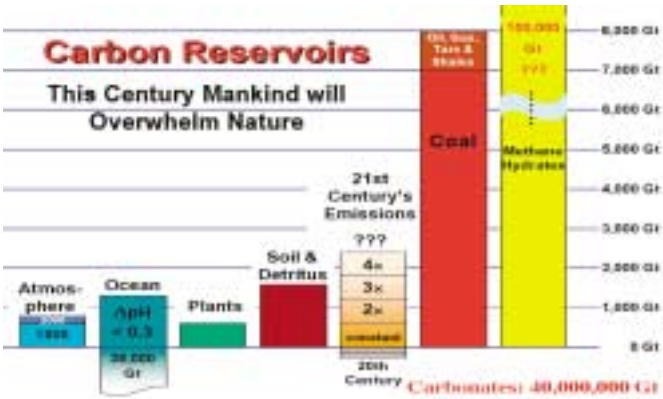

FIGURE 2 Carbon reservoirs.

THE SEQUESTRATION PROCESS

Sequestration methods that have been proposed and are being studied (Fig. 2) are both temporary and permanent storage in underground reservoirs (such as old oil fields), deep ocean disposal where CO_2 forms a solid hydrate in reaction with cold water, or mineral sequestration where the CO_2 is "locked away" into a new mineral by chemical reaction. We favor the latter, through formation of mineral carbonates from readily available magnesium or calcium silicate minerals. This natural process, which happens spontaneously on geological time scales, is virtually unlimited in its uptake capacity. The difficulty lies in the design of an efficient industrial-scale chemical process. An accelerated mineral carbonation process is now being developed by a collaboration that includes Los Alamos National Laboratory, the Albany Research Center, Arizona State University, and the National Energy Technology Laboratory. Carbon dioxide reacts with magnesium-rich silicate minerals, serpentine or olivine, forming magnesium carbonate, silica, and possibly water. The process would permanently sequester CO_2, the end products are all naturally occurring, and they can be safely disposed of in landfills.

Available mineral deposits required for this process far exceed humankind's capacity for generating carbon dioxide. The necessary magnesium silicates exist in vast, rich deposits worldwide. A single deposit in Oman contains over 30,000 cubic kilometers of magnesium silicates, which alone could handle all of the world's coal. The mining operations to obtain magnesium silicates would be large, but in terms of volumes mined and areas disturbed they are substantially smaller than the associated above-ground coal mines. The mining

The Energy–Water Connection

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Energy production requires a reliable, abundant, and predictable source of water, a resource that is already in short supply throughout much of the U.S. and the world. The energy industry is the second largest user of water in the United States. According to the U.S. Geological Survey, electricity production from fossil fuels and nuclear energy requires 190,000 million gallons of water per day, accounting for 39% of all freshwater withdrawals in the nation, with 71% of that going to fossil-fuel electricity generation alone. Coal, the most abundant fossil fuel, currently accounts for 52% of U.S. electricity generation; each kilowatt hour generated from coal requires 3.3 gallons of water. Coal and nuclear energy account for 72% of U.S. electricity generation and together account for more than a third of all freshwater withdrawals. That means U.S. citizens may indirectly use nearly as much water turning on the lights and running appliances as they directly use taking showers and watering lawns. According to the Bush administration's 2001 *National Energy Policy*, our growing population and economy will require 393,000 megawatts of new generating capacity (1,300 to 1,900 new power plants—more than one built each week) by the year 2020, putting further strain on the nation's water resources. In summary, the intimate link between clean, affordable energy and clean, affordable water is crystal clear. There cannot be one without the other.

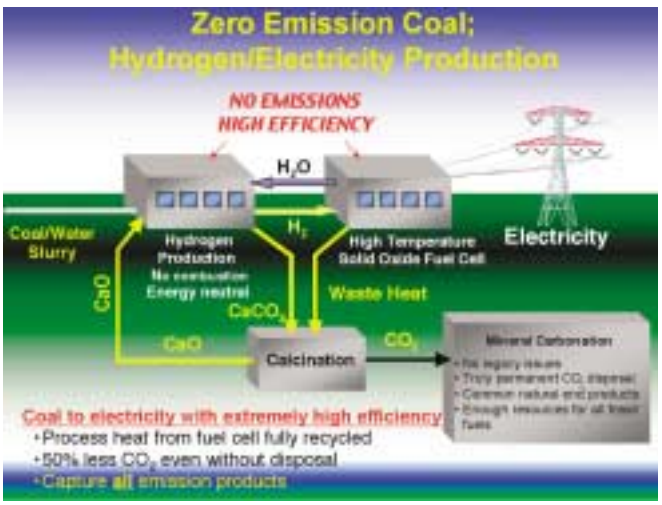

FIGURE 3 Outline of the zero emission coal process.

operation suitable for a large electric power plant is smaller than that for a large open-pit copper mine. The end products from the carbonation process would be used to refill the mine. It is estimated that the mining, crushing, milling, and reclamation costs for this sequestration process are low: around $7 to $20 per ton of CO_2. With a power plant operating at 70% efficiency, this would be about 1¢ US/kWh of electricity.

COMBINED PROCESSES ELIMINATE ATMOSPHERIC EMISSIONS

The zero emission coal process is illustrated in Figure 3. It combines a high-efficiency, coal-based electric power plant with a process for safely and permanently disposing of the carbon dioxide generated. What makes the process attractive is the elimination of all harmful airborne emissions. The process has no smokestack, because there is no combustion of coal. The ash from the coal is fully contained, making compliance with ever-tighter restrictions on particle emissions straightforward. A small amount of calcium oxide or calcium carbonate is used to capture the sulfur in the coal. The sulfur is pulled out of the reaction vessels in a solid form, also eliminating hydrogen sulfide or SO_X emissions. Additionally, the reducing conditions inside the hydrogen production vessel do not lead to the formation of NO_X, and because there is no combustion involved, NO_X emissions are eliminated. Finally the CO_2 generated in the hydrogen production is initially extracted as a solid before being converted to a concentrated gas stream. As this is an integral part of the hydrogen production process, no additional expenses are incurred in producing a concentrated stream of CO_2 exhaust. The exhaust will be permanently disposed of by reacting it with abundant, naturally occurring minerals to form harmless, stable mineral solids that will not leave a greenhouse gas legacy for future generations.

In conclusion, coal has an important and even dominant position in the energy future for the world. It is important that the value of this resource be recognized, and that the resource be utilized. We are confident that technological solutions exist that will allow the realization of "green" coal, which can be used to ensure a clean world and a long term, prosperous, healthy, and secure global economy.

Current Status of Electric Retail Competition

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The process of deregulating industries has been with us for decades. Deregulation of the airline, railroad, trucking, telecommunication, and even the natural gas industries, all preceded the move to make electric utilities competitive. To a large degree, at least in the electric power business, the impetus came from the large industrial customers who were being forced by market competition to reduce their costs, and who reasoned that there would be significant savings in the bulk quantities of energy they consumed if only they could choose their energy providers. The energy crises of the 1970s resulted in government-encouraged development of independent generators, and of co-generators that produced electric power as a byproduct of some other industrial process. This energy frequently was priced low enough to be attractive to the industrial customer, if only there had been a way for that customer to get around (by deregulation) the locally regulated utility with its franchise protection and higher-cost electricity.

A significant move in this direction was the national Energy Policy Act of 1992. This law permitted federal energy regulators to require utilities, under certain conditions, to open their transmission lines to others who wished to ship (or "wheel" in industry terms) the power across the utility's lines to get it to the customer. This law was very specific, however. It limited such transactions to wholesale power sales only. This was essentially a market in which utilities sold power to each other. The decision to implement retail competition that would allow the end-user or retail customer to choose their power supplier was left to the states.

NATIONAL TREND

Many states took up that cause, and by the year 2000 roughly half of the states had either begun some form of retail electric competition or had set target dates to begin doing so. Congress, too, has debated this issue for years because of the interstate nature inherent in modern electric generation and transmission technology. Many proposals have been put forth in Congress, both as comprehensive industry restructuring legislation, and as proposals to deal with individual aspects of the deregulation process. None had gained wide enough support by late 2001 to become law. Energy policy legislation has now become a high priority, however, as there is growing recognition of the urgency to act, especially following the September 11 terrorist attack. There is increased awareness of the role that a strong power industry plays in our economy and of its importance to national security.

Among the various federal issues are questions concerning transmission planning, coordination, limits on the market power of utilities that own both generation and transmission infrastructure, defining the boundary between state and federal jurisdictions, and the modification or repeal of federal laws that currently discourage competition in the electric power business.

DEREGULATION VERSUS RESTRUCTURING

So what exactly do we mean by deregulation? Perhaps deregulation is the wrong word. Most people who have studied the matter agree that it is more accurate to speak of "restructuring" the electric industry. In any event, we are not likely to see less regulation, only changes in how the industry is regulated.

To better understand the typical restructure proposal, let's look at how the traditionally regulated electric utility functions. Since the early twentieth century, utilities have been vertically integrated: a single company owns its own generators to produce the power (or purchases the power on the wholesale market to resell), and it owns the transmission lines to move the electricity over long distances. That same company owns the distribution systems that convert the high-voltage electricity coming over the transmission lines to lower voltages and distributes it to businesses and homes.

Because of the enormous expense of building and operating this system, it has been economically more efficient to build only one such system for a single service territory. For this reason, electric utilities historically have been considered natural monopolies and given franchised service territories. In exchange for this exclusive right (and obligation) to serve, utilities accepted government regulation of their rates and terms of service.

Most restructuring proposals would separate the generation component from the other two services provided by the utility. Utility customers would be allowed to choose the company from which they purchase the electricity. This company might be the local utility, it might be a different utility, or it might be a power generator or marketer from in or out of state. The price of the power would be unregulated, set by supply and demand in the market.

The local utility would continue to own the transmission and distribution systems, but other power companies would be able to send their power across these lines. The transmission and distribution systems would remain regulated by the government, which would set rates for their use. Regulators also would have the responsibility to set rules to encourage competition and ensure fairness for all participants. Consolidating transmission systems into regional transmission organizations that plan, build, and operate transmission systems exclusively, independent from power suppliers, is a concept being pushed at the federal level.

Restructuring proponents argue that retail competition will bring customers lower costs and more diverse services. It remains an open question whether retail competition will lower costs. There has been limited success, at least initially, in some of the first states to deregulate their electric utilities, but one such state – California – has experienced disastrously huge rate increases following its bungled restructuring efforts.

Restructuring the electric utility industry in New Mexico began in earnest with the introduction of several proposals in the 1993 New Mexico Legislature and in following years. Those proposals never got beyond committee debate, but lawmakers did establish a bipartisan study committee every year from 1993 through 1998, which, under the chairmanship of Senator Michael Sanchez (D-Belen) devoted six years to a careful examination of restructuring approaches taken in other states. That effort culminated in New Mexico's Electric Utility Industry Restructuring Act, which became law in 1999.

NEW MEXICO'S ELECTRIC UTILITY RESTRUCTURING LAW

The law, which moved through the legislature as Senate Bill 428, permitted retail electric customers to choose their power supplier, beginning with residential customers, schools, and small businesses, as of January 1, 2001. It permitted choice for all other customers as of January 1, 2002. The New Mexico Public Regulation Commission (PRC) was given the authority (which it subsequently exercised) to delay those dates so that choice would become an option for the first group on January 1, 2002, and for all others on July 1, 2002. The law required all investor-owned electric utilities to participate and to file plans for the transition to open access for the PRC's approval. The state's 16 distribution cooperatives are required either to serve as an aggregator for their members, or to choose from three other business models for providing retail service, including open access. Municipal electric utilities may choose to provide open access, but they are not required to do so.

The law eliminates regulation of the price of electricity as a commodity, but state regulation is retained over transmission and distribution. Utilities may (but are not required to) sell off their generation assets. Utilities may keep these unregulated assets, however, only if they are separated from their regulated distribution utility, to prevent cross subsidies and to discourage favoring their own generation over competing power suppliers. Utilities may recover, through rates, at least half of their "stranded" investment in generation before deregulation, and they may recover some or all of the remaining stranded costs, as well as transition costs, with PRC approval.

Other provisions of the law include a "standard offer" service from the native utility for customers who do not choose their power provider, or who wish to return to service from their home utility. The law also funds renewable energy projects, protects customers against "slamming" and other market abuses, and directs the PRC, among other things, to educate consumers about customer choice. All billing and local service issues will continue to be handled through the local utility, although service issues surrounding the energy commodity itself will be the responsibility of the company providing the energy.

CALIFORNIA'S EXPERIENCE

By early 2001 California's dismal experience with electric deregulation forced New Mexico and many other states to reconsider their own plans. At least one state partially repealed its deregulation law. Some states that had authorized competitive retail electric sales, including New Mexico, opted for delay. Three states continue on course with their deregulation plans.

Many in New Mexico, including some of the customers who had advocated most strongly for competition only a year or two before, were fearful that we

would experience California's fate, and they now wanted more time to get ready. Others argued that provisions in New Mexico's law would prevent the lack of generation, which was California's basic problem and which caused dramatic spikes in that state's wholesale energy costs.

Senator Sanchez, sponsor of New Mexico's 1999 law, held public meetings. He concluded that there was strong support for the proposition that, although deregulation might be a good idea and New Mexico's law avoided some of California's problems, the market had changed or not responded as expected; that the market was too unpredictable; and that electric supply in the West was too limited. Therefore, New Mexico should delay its deregulation plans until the market was more favorable.

Sanchez sponsored Senate Bill 266, which passed in the 2001 New Mexico legislative session and was signed by Governor Gary Johnson. It delays the start of electric retail competition in this state for five years, or until January 2007. However, legislators were worried that New Mexico, although it has adequate generation for the near-term, might end up like California if there isn't enough generation for a competitive market in New Mexico by 2007. So the law also permits electric utilities to proceed with developing their holding company structures, and to invest in unregulated generation plants. The PRC is currently considering how to administer this law.

UNCERTAIN FUTURE

However uncertain the future of electric deregulation may be, it is highly likely that we will see some change in the way the electric industry serves customers and how it is regulated. Regulated or unregulated, the power industry, especially generation, is largely dependent on private investors for the enormous capital needed to build infrastructure. There must be certainty in the rules to attract that investment, and there will be no investment if we pursue the notion that we can go to markets when market prices are less than cost, and that we can go to cost – meaning regulation – when cost is less than market.

For the customer, the promise of restructuring this business is not, and never has been, the certainty of lower electric bills, however politically appealing that may be in selling this proposition to the public. Rather, the goal is to establish competitive markets that use resources more efficiently and send proper price signals to customers regarding their usage. This in turn provides incentives to the marketplace to innovate and provide more options from which customers can choose.