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fte Closure of the Navajo Generating Station

Energy is a social issue with a technical component, rather than the other way around….One reason you can fail is you didn't pay enough attention to the societal aspects of the problem.
Martin Pasqualetti, Arizona State University

In November 2019, the last operating units of the Navajo Generating Station (NGS) in Page, Arizona, were shut down. As one of the single largest point-sources of carbon dioxide (CO_2) emissions in the continental United States, the closure was seen by many as a success for sustainability and climate change. For the communities that depended on the plant and associated coal mine for jobs and taxes, there were mixed views. Although the air would be cleaner and water resources better protected, the plant and mine closures meant that the Navajo Nation and Hopi Tribe faced large cutbacks in their budgets. fte plant and mine workers, almost all Native American, lost their jobs.

Exhibit 1. fte Navajo Generating Station

fte Navajo Generating Station

NGS, one of the largest coal-fired power plants in the United States and the largest west of the Mississippi, was owned by four utilities—Salt River Project, SRP (42.9%), Arizona Public Service (14%), Tucson Electric Power (11.3%), Nevada Power (7.5%)—and the U.S. Bureau of Reclamation (24.3%). SRP was the station manager, which meant it had operational responsibility for the plant. NGS consisted of three 750 megawatt generators. Construction on the facility began in 1974, the first unit powering up in 1976, the other two units going online in 1977 and 1978. The original power plant construction costs totaled $680 million, $200 million of which was for environmental controls alone.

Power plant site selection involves a mix of water, fuel, and transportation infrastructure factors. NGS had the added complexity of being hundreds of miles from any sizeable population centers. fte site chosen for the power plant was on land leased from the Navajo Nation just outside Page, Arizona. NGS was classified as a mine-mouth power plant, with coal sourced from Peabody Energy's Kayenta Mine, a surface mine 80 miles away on Navajo reservation lands in Northeast Arizona. fte mine produced six to seven million tons of thermal coal per year for the power plant's use and was the 25th largest operating coal mine in the United States. NGS was the mine's only customer. fte mine operated through lease agreements with the Navajo Nation and Hopi Tribe and paid a severance tax on a per ton basis to the tribes. fte mine also used 1,200 acre-feet of water per

year from the Navajo Aquifer. fte coal was transported 78 miles from the mine to the power plant by an electric railroad constructed solely for NGS.

NGS needed access to large quantities of water for cooling purposes. NGS pulled water from Lake Powell, the reservoir created by the Glen Canyon Dam, just above the Grand Canyon on the Colorado River. fte power plant was 15 miles from Grand Canyon National Park. NGS consumed 22,000 tons of coal per day while emitting 44,000 tons of CO_2 per day.

Ironically, NGS used massive quantities of water in order to move massive quantities of water. fte electricity produced was distributed in three different directions: (1) to Las Vegas and the customers of Nevada Power; (2) to Los Angeles and the customers of the Los Angeles Department of Water & Power; and (3) to the U.S. Bureau of Reclamation, which used it to pump Central Arizona Project (CAP) water from the Colorado River 300 miles south to Phoenix and Tucson. About 25% of NGS electricity was used for CAP. fte other two lines sent power to Phoenix and Tucson, for customers of SRP, Arizona Public Service, and Tucson Electric Power. Surplus power from the U.S. Bureau of Reclamation's 24.3% share not used for the CAP was sold and the revenue used to repay the $1.65 billion debt incurred to build the CAP. By 2018, surplus power sales had retired more than $600 million of CAP's debt. Exhibit 2 describes CAP.

Coal-Fired Power Generation

> *How long can men thrive between walls of brick, walking on asphalt pavements, breathing the fumes of coal and oil, growing, working, dying, with hardly a thought of wind, and sky, and fields of grain, seeing only machine-made beauty, the mineral-like quality of life?*
>
> Charles Lindbergh, Reader's Digest, November 1939

Coal-fired power plants and nuclear power plants composed the structural base for most of the electrical power systems in the United States. Coal and nuclear were *base-load* power sources (and in select regions hydroelectric power), meaning they generated 60% to 70% of the electricity regional power grids required 24 hours a day. (Most consumers of electricity are not conscious of the fact that the power lighting their lights and running their air conditioners was generated within a second or two of its use.) ftey therefore needed to be large, relatively low-cost in U.S. cents per kilowatt hour, and reliable. fte other power needed during peak periods in many regions of the U.S. was historically fueled by natural gas and liquid fuels like oil and diesel.

In the past 20 years, the world doubled its coal-fired electrical power generation capacity. New coal plants started up every year; the number of countries using coal rose from 66 in 2000 to 78 in 2019. Another 16 planned to use coal power, including Egypt and the United Arab Emirates.[1] fte two largest users of coal for electricity and industry were China and India. Seventy percent of electrical power in China came from coal, although this was expected to decrease to less than 50% by 2040.[2] In India, where per-capita electricity consumption was only one-third of the world average, coal plants generated 72% of power. Although coal use was expected to decline over the next few decades, it would remain the dominant fuel for power. Globally, the amount of electricity generated from coal plateaued in 2014. In select countries, including the U.S., this resulted in overcapacity.

As illustrated in Exhibit 3, U.S. electrical coal-fired power generation began to fall in 2009. In 2001, coal generated 54% of the electricity in the United States. By 2018, coal was down to 32%. fte primary replacement fuel was natural gas. fte gas share of national electrical power rose from 18% to 42%. Solar and wind were also growing. fte International Energy Agency predicted that the global investment wave in coal-fired power plants "*in our view, is coming to an end. At the very least, it is coming to a pause.*"[3]

fte growing competitiveness of natural gas arose from different technological innovations. fte first was the commercial development of the combined cycle gas turbine (CCGT). fte CCGT, developed commercially in the late 1990s, offered a power generation source which was relatively low in capital cost, demonstrated a high degree of energy efficiency in terms of fuel use and power output, and could ramp up and down in a short period of time. ftis allowed natural gas turbines to migrate in use from purely peak-load use to more intermediate-load use. fte second innovation was horizontal drilling and hydrofracking technologies used for the production of shale oil and natural gas. As these technologies were first deployed in scale in the 2007-2009 period, natural gas supplies in the U.S. increased rapidly, driving the price of natural gas down.

ExhiBit 2. fte Central Arizona Project (CAP)

fte passage of the Colorado River Basin Project Act of 1968 forever changed the west. fte Act authorized the U.S. Bureau of Reclamation to construct a system to move water from the Colorado River south to Central Arizona. fte state of Arizona was allocated 2.8 million acre-feet of Colorado River water per year under the Colorado River Compact, and the Central Arizona Project (CAP) would utilize a large portion of that allocation. CAP would eventually pump 1.5 million acre-feet of water up 3,000 feet from below Lake Havasu on the Colorado River through a system of 336 miles of pumping stations and canals south to central and southern Arizona. Although the water was originally intended primarily for agricultural use, its services over time would shift to more municipal and industrial uses in the state's two major metropolitan centers, Phoenix and Tucson, as their populations rapidly grew.

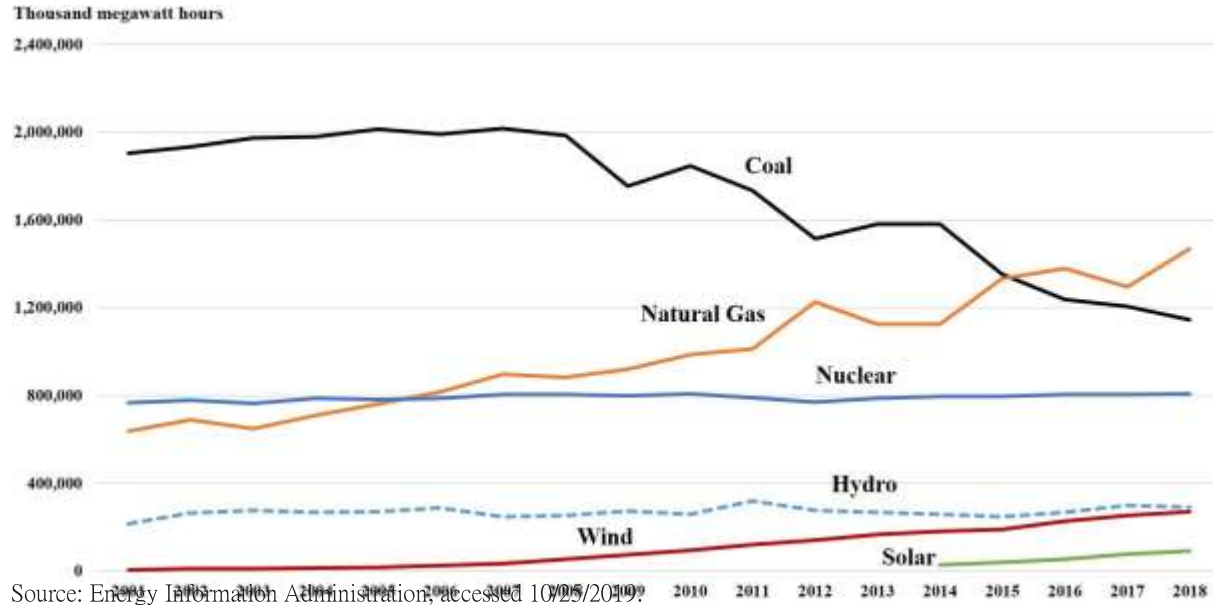
A critical additional authorization of the Act of 1968 was to authorize the Bureau of Reclamation to contract with non-federal parties for the construction of power plants to generate the power needed to operate CAP. fte Bureau then entered into an agreement to take a 24.3% interest in the Navajo Generating Station, a share entitling it to 4.3 terawatt hours (Twh) of power annually. CAP uses approximately 2.8 Twh of its NGS power allocation (65%) to drive all pumping operations; the balance of 1.5 Twh (35%) of the Bureau's NGS power allocation is available for sale. NGS provides more than 90% of the power needed for all CAP operations.

fte Central Arizona Water Conservation District (CAWCD) was created in 1971 as the organization responsible for management of CAP, including paying for CAP's power use and to manage the repayment of CAP construction costs to the federal government. fte U.S. federal government would not release any capital for construction until an organization accepting responsibility for raising revenues from CAP water use was in place to repay the construction costs. CAP's annual construction cost obligation to the federal government is $55 million, raised through a combination of user fees and property taxes.

As NGS's operator, Salt River Project (SRP) bills the various power plant owners for their respective shares of all operating, maintenance, and replacement costs (OM&R). SRP bills the Bureau of Reclamation for its 24.3% share of OM&R costs at NGS. fte Bureau in turn bills the CAWCD, manager of CAP, for its power use.

CAP construction did not begin until five years after its authorization. fte study and permitting process required was a much larger scale and scope than previously imagined, primarily as a result of the passage of the National Environmental Policy Act of 1969, immediately following the Basin Project Act. fte authorization process was additionally complicated in its need to address issues under the National Preservation Act of 1966, which required archaeological, social, and cultural analysis of the project. Construction started in 1973, with the completion of all pumping stations and aqueducts in 1985. First water was delivered in 1985. Over the following eight years, additional elements were completed, with the final stages of water delivery to Tucson in 1993. Over the 20-year construction period, the cost of CAP rose from an original estimate of $832,800,000 to a final completed cost of $4.4 billion.

Exhibit 3. U.S. Net Electrical Power Generation by Fuel, 2001-2018



Source: Energy Information Administration, accessed 10/25/2019.

Navajo Nation and Hopi Tribe

Coyote is always waiting. And Coyote is always hungry.
Navajo Folk Saying

fte majority of workers in the Kayenta mine and NGS were from the Navajo Nation and Hopi Tribe. fte Navajo, or Diné (meaning "fte People" in the Navajo language), migrated to the Southwest from Canada around the 15th century.[4] fte Navajo Nation is the largest reservation in the U.S., covering more than 27,000 square miles and extending from Arizona into Utah and New Mexico.

fte Navajo Nation has over 300,000 enrolled members, approximately 84% of whom are "full-blooded."[5] According to the 2010 U.S. census, 101,835 Navajo lived on tribal lands in Arizona, 65,764 lived on tribal lands in New Mexico, and 6,068 lived on tribal lands in Utah, for a total of 173,667 Navajo on tribal lands. fte Navajo are very spread out across the tribal lands. As shepherds and farmers, the arid land requires a large area to sustain sheep and crops.

fte current median household income for the Navajo Nation was $27,389. Median income for Arizona was $50,448. fte Navajo Nation had a poverty rate of 38%, more than twice the poverty rate for Arizona (15%). More than half of all workers were private wage and salary workers, while 43.7% worked for the government. About 7% of Navajo tribal members had college degrees.[6] About 15,000 homes on the reservation were without electricity, which was 75% of all unelectrified homes in the United States.[7] Health surveys showed that the Navajo County population was among the least healthy in Arizona. Key negative health indicators included high incident rates for obesity, smoking, alcohol use, diabetes, cancer, cardiovascular disease, respiratory disease, and accidents.[8]

fte Hopi Tribe reservation is located in northeastern Arizona in Coconino and Navajo counties and is completely surrounded by the Navajo Nation.[9] fte reservation is made up of 12 villages on three mesas (known as First, Second, and ftird Mesa) on more than 1.5 million acres. fte oldest continuously inhabited village in the United States is Old Oraibi, located atop ftird Mesa, said to have been in existence since 1150 A.D. when the Hopi came to the area. Access to Old Oraibi is limited to those who are members of the Hopi Tribe. ftere were about 20,000 Hopi Tribal members, with a median household income of $39,411, and a poverty rate of more than 30%.

fte Hopi and Navajo people have a long history of conflict over land. After years of escalating conflict, the Navajo-Hopi Settlement Act of 1974 split land across tribes and forced relocation for some tribal members. fte Kayenta Mine lease extended over both tribal land properties.

Mohave Power Station and the Black Mesa Mine

NGS was not the first experience with coal mines and power plants for the Navajo Nation and Hopi Tribe. In the 1960s, the tribes entered into lease agreements with Peabody Western Coal Company to mine coal on tribal lands. Coal from the Black Mesa Mine and water from the Navajo Aquifer were used to slurry the coal, a process of floating coal for transport, 275 miles to the Mohave Power Station (Mohave) in Laughlin, Nevada. fte power plant operated from 1971 through 2005.

Mohave was shut down when its majority owner, Southern California Edison, was confronted with a series of challenges. fte utility no longer needed the power, having new lower-cost alternatives. fte plant needed an investment of $1 billion in emission control equipment because of a series of environmental lawsuits. Finally, there was growing opposition by the tribal nations to the continued use of water from the Navajo Aquifer. Water was critical for both mine and power plant operations. fte mine closure was seen as a powerful exercise of indigenous water rights. fte mine closure also resulted in the loss of 165 jobs, largely held by Navajo and Hopi tribe members. ftese were some of the highest paying jobs on the reservations, and the Navajo Nation and Hopi Tribe had high unemployment rates. ftere was also a loss of coal severance royalties. fte Hopi Tribe lost $8 million, roughly 20% of its operating budget, as a result of the mine closure.

Economic and Social Impact from NGS and the Kayenta Mine

NGS and the mine had a number of major social and economic impacts on Coconino and Navajo counties and on the Navajo Nation and Hopi Tribe. Both developments were controversial in terms of their impacts on the environment and on their potentially disruptive impacts on culture and society. Both, however, had major economic benefits. Coconino County, the host county for NGS, received more than $250 million in taxes in 2011. In that same year, the Kayenta Mine paid taxes of $296 million, with the largest amount going to Navajo county. From 1987-2017, the Navajo Generating Station and the Kayenta Mine contributed nearly $1.3 billion to the Navajo and Hopi economies.[10]

fte jobs in the mine and the plant were among the highest paying jobs available to people living on the reservation. ftere were also substantial payments directly to the tribes. NGS payments to the tribes included property taxes; lease payments; payments to local school districts, state education equalization fund, Coconino County and local special purpose service districts; and performance payments. Payments from the mine to the tribes included annual coal royalties based on volume of production; coal bonuses; payments for water usage; and payments to the Navajo Tribal Utility Authority. fte total average mine payments were $37.2 million to the Navajo Nation and $14 million to the Hopi Tribe from 1987-2010.[11]

fte mine also provided other benefits:

- Resident land use payments
- Road maintenance and improvements
- Water supply assistance
- Free coal to area residents
- Annual health fairs
- 24-hour emergency health care facility and ambulance service
- Emergency assistance with roads, coal, and water

A 2013 study found that the NGS would contribute nearly $13 billion to the Navajo economy and help support thousands of jobs from 2020 through 2044, if the plant stayed open.[12]

Natural Resources and Navajo Land

Over the past century, the Navajo Nation's and Hopi Tribe's relationships with outsiders and resource development had mixed outcomes. In 1946, against the wishes of many Navajo, uranium mining started on tribal lands. Nearly 30 million tons of uranium ore were extracted from Navajo lands under leases with the Navajo Nation.[13] Mining continued until 1986, and thousands of Navajo worked in the mines. In the earlier years, workers were rarely informed of the radiation risks, and safety practices were poor.[14] fte Navajo people did not have a word for radioactivity when mining companies moved onto their land and they did not understand that radiation could be dangerous. ftey were not told that workers in the mines were breathing carcinogenic gas and showering in radioactive water, nor that the washing of work clothes could spread radionuclides to the rest of the family's laundry.[15] ftere were also accidental spills, putting more at risk.

Decades after their exposure ended, mortality ratios and risks for lung cancer and other respiratory problems were nearly four times higher in Navajo miners than in non-miners.[16] Estimated cancer rates for teenagers living near mine tailings were much higher than the national average. Some Navajo built their homes using contaminated rocks and tailings from the mines. ftere are now more than 500 abandoned uranium mines as well as homes and water sources with elevated levels of radiation. fte EPA was providing funding and technical assistance to clean up the abandoned mines. To deal with radiation exposure, there have been enforcement agreements and settlements of more than $1.7 billion from the uranium mining companies.

fte legacy of uranium and other developments was evident in the views of some tribal members. Despite jobs, taxes, and other benefits, not everyone saw the Kayenta Mine and NGS as good for the Native American communities. As one tribal member stated:

They're giving us pennies. I don't think even the Navajo Nation government really understands how we are subsidizing the lifestyle of all these people who benefit from our resources. I'm afraid this is a repeat of history. We've been robbed. We've been cheated. How do you turn the tables so we don't repeat that?[17]

NGS and Environmental Compliance

fte NGS environmental compliance story is similar to that of other U.S. coal-fired power plants. As scientific research on air pollutants progressed, EPA emission requirements became more stringent. Although NGS made various large investments in pollution control, the plant struggled to comply with increasingly stringent and complex standards that expanded from particulates to sulfur oxides to nitrogen oxides to trace elements including mercury.

Particulates – microscopic solids resulting from coal combustion—were a well-documented and regulated emission before NGS' s construction. A known human health hazard and a primary cause for orange sunsets, particulate emission controls in the form of electrostatic precipitators (ESPs) were part of the plant's original design. ESPs work by sending an electrical charge through the power plant emission stream. fte charge causes particulate matter to attach to metal plates inside the ESP. fte particulates are then periodically captured for removal and recycling. fte ESPs removed 99% of the fly ash created from coal combustion. (fte fly ash captured is then recycled for use in a variety of concrete, cement, and construction materials.)

At the time of NGS construction, sulfur emissions were the focus of most environmental rule-making regarding coal-fired power plants. Sulfur dioxide (SO_2) emitted during coal combustion combined with moisture in the atmosphere to create H_2SO_4, sulfuric acid or *acid rain*. *Acid rain* occurred in many regions around the world, such as the Ohio River valley in the United States, the coastal regions of southeastern China, and the Black Triangle area on the borders of the Czech Republic, the former German Democratic Republic, and Poland. *Acid rain* caused increased acidity of lakes and rivers, killing plant life, fish, and waterfowl.

fte EPA established New Source Performance Standards (NSPS) for coal-fired power plants in 1971 as part of the Clean Air Act. fte standards were based on an absolute limit on SO_2 emissions of 1.2 pounds per million Btu. All new power plants constructed after this date, like NGS, had to meet this requirement. Power plants in the western United States could meet the sulfur dioxide requirement by burning low-sulfur coal, which produced lower SO_2 emissions. Access to major deposits of low-sulfur bituminous coal on the Navajo and Hopi reservations was a key factor in the NGS site selection. Low-sulfur coal contains less than 1% sulfur by weight. Beginning in the 1970s, low-sulfur coal came into greater demand as environmental restrictions on sulfur emissions became more stringent. In general, the coal resources in the western U.S., like those deposits on the Navajo and Hopi reservations, were lower in sulfur content than those in the East and Midwest. Some power plants in the eastern United States found it easier to source low-sulfur coal from the West than to install sulfur reduction equipment.

fte 1971 NSPS standards set an absolute limit for sulfur emissions but did not require the use of best available technology. ftis led to a regulatory revision in 1979. All power plants, depending on the level of sulfur content of coal burned, would have to reduce SO_2 emissions by a sliding scale percentage (70% to 90%, from low-sulfur to high-sulfur coals). Meeting the new sulfur emission regulations required the installation of flue gas desulfurization (FGD) equipment, a costly and complex technology that added to operating cost and loss of reliability. Utilities, including NGS, fought the implementation of FGD technology. Finally, in 1991, after nearly a decade of litigation, EPA required NGS to install FGD devices. ftis cost NGS more than $420 million. In 1980, 65,000 tons of sulfur dioxide were emitted by NGS, while nitrogen dioxide and CO_2 were not recorded. SO_2 emissions dropped to just over 5,000 tons in 2017.[18]

With time, research, and public awareness, environmental concerns over coal-fired power plant emissions grew. Nitrogen oxide (NOx) emissions were the target of the next series of environmental regulatory revisions. In 2011, NGS completed the installation of low NOx burners to reduce NOx emissions. ftis required an investment of $45 million. New research resulted in new EPA concerns—fine particulates contributing to haze, mercury, and other trace metal emissions, and in 2014, clear identification of CO_2 emissions contributing to climate change. fte addition of scrubbers and other technology significantly reduced concentrations of SO_2 and NOx. An unintended side effect at NGS and other power plants was an increase in emissions of SO_3, known

as the *blue plume effect*. Exhibit 4 provides a brief overview of emissions, technologies used for their partial management, and their applicability to NGS.

Exhibit 4. Air Emittants and Navajo Generating Station

Emission	Emission Control Technologies	Navajo Generating Station
Particulates	(1) Electro-static precipitators (ESPs) (2) Fabric filtre baghouse and sorbent injection	Included in initial construction
Sulfur Oxides	(1) Burning low-sulfur coal (2) Flue gas desulfurization devices (FGDs)	Element of NGS' s site selection Added in the 1990s
Nitrogen Oxides	(1) Low-NOx SOFA burners (LNBs) (2) Selective Catalytic Reduction (SCR)	Installed in 2009-2011 80% reduction by 2030 + shutdown of 1 of 4 units by 2019
Haze (fine particulates)	----------	----------
Mercury and air toxics (MATS)	(1) Selective Catalytic Reduction (SCR) (2) Selective Non-Catalytic Reduction (SNCR)	Potentially avoiding BART with reduced power production
Carbon Dioxide	----------	None

Source: Constructed by authors.

Despite sizeable investments in new technology, NGS still produced significant air emissions - including CO_2. In 2014, the Obama administration proposed the Clean Power Plan to reduce point source CO_2 production. EPA published a finalized plan in 2015.

> *For now, it [NGS] has been granted a reprieve from complying with the Obama administration's new Clean Power initiative, which requires Arizona to reduce its carbon output by 52%. But the Environmental Protection Agency has said that it expects to work with the Navajo tribe to reduce emissions separately from Arizona's mandate, and will likely revisit that issue in the future. The plant will also soon be subject to a new federal environmental review process triggered by its renewed lease on Navajo lands. (June 2015).*

One of the challenges the EPA faced in getting compliance from NGS was that political leaders in Arizona rejected the view that CO_2 emissions contributed to global warming. John Kyl, one of Arizona's U.S. senators, said that *"the link between the plant's emissions and climate change is absolutely not proven, it is simply assumed."*[19]

Tribal Impact from NGS and the Kayenta Mine

> *In a dimly lit home off a tangle of dirt roads on the Navajo Nation, 80-year-old Simon Crank sits on his living room couch, recalling the days when executives from a coal company in St. Louis, MO, would visit, bringing sweets as gifts, promising jobs. Under a shady tree, they offered steady work at union wages in a place where most families could hope for nothing more lucrative than rug weaving.*
>
> *The room where Crank speaks 49 years later is heated with a pellet-burning fireplace because a doctor has forbidden the elderly man to burn wood. After a lifetime working in Peabody Energy's coal mines, his lungs can't tolerate the smoke. Crank now drives hundreds of miles a month, seeking medical care at hospitals in Flagstaff, AZ, and Colorado. "We were never told. We saw the income coming in, but the hazards—we never knew we were going to experience this," he said, laying his hand on the oxygen tank that connects to his nostrils via a narrow tube.*[20]

Despite the investments in emissions control, NGS remained a significant polluter. fte environmental organization Sierra Club called NGS Arizona's dirtiest coal plant. For many years, nearby residents blamed the power plant's particulates for high rates of asthma, pneumonia, and bronchitis. fte ready access to coal contributed to indoor health hazards on both reservations. Coal is frequently burned for home heating and cooking in stoves not designed for coal. In a survey of people living near the plant, 60% of respondents had at least one person in their family with breathing problems.[21] Smog from the plant could be seen at the Grand Canyon and national

parks in Utah. fte plant also emitted tens of thousands of tons of CO_2 per day. A study of U.S. coal-fired power plants found that NGS was the 8th largest emitter of CO_2 in the United States.[22]

fte mine's impact on water resources was another concern. fte mine, which opened in 1965, used groundwater from the Navajo Aquifer. fte aquifer was the sole source of drinking water for communities near the mine. According to a 2006 report by the National Resources Defense Council, the Navajo Aquifer was showing signs of material damage and continuing decline after several decades of pumping.[23]

Declining Competitive Economics

With new emphasis on air quality and visibility, particularly over the Grand Canyon, the EPA ordered the shutdown of one of the three power units at NGS in 2014. From this point forward, the owners of NGS began considering whether to renew their license, consider a permanent sale, or shut down NGS. A 2016 report produced under direction of the U.S. Bureau of Reclamation by the National Renewable Energy Laboratory (NREL) set an ominous tone for NGS' s future when it stated, *"Electricity produced at NGS is currently more expensive than electricity purchased on the wholesale spot market. Price trends examined in this analysis suggest a turnaround might be years away, especially if natural gas prices remain low."*[24]

In 2017, an Institute for Energy Economics and Financial Analysis report concluded:

> *The outlook for the Navajo Generating Station, a 2,250-megawatt coal-fired electricity generation plant in northern Arizona, is bleak. Declining energy market prices and rising production costs have made the power produced by the plant more expensive than power sold in the larger energy market. NGS, in a word, is no longer competitive.*
>
> *Three of those utilities—SRP, Arizona Public Service Company, and Tucson Electric—told the Arizona Corporation Commission in late April that they no longer require electricity from the generating station because they have access to cheaper gas-fired generation. The Central Arizona Project (CAP), the largest customer for NGS power, wants out as well; CAP managers say the agency could had acquired power in 2016 for $38.5 million less than it paid for power from the plant had it bought that power somewhere else. Both CAP and Salt River Project, which operates the plant, expect power from NGS will become even more expensive than market power in coming years.*
>
> *A wave of market and economic forces, including low natural gas, low-energy market prices (at both the Mead and the Palo Verde Hubs), higher NGS production costs, annual capex at the plant, and increasing competition from low-cost renewable resources, will prevent NGS from being a profitable and long-term viable investment—by any owner.*[25]

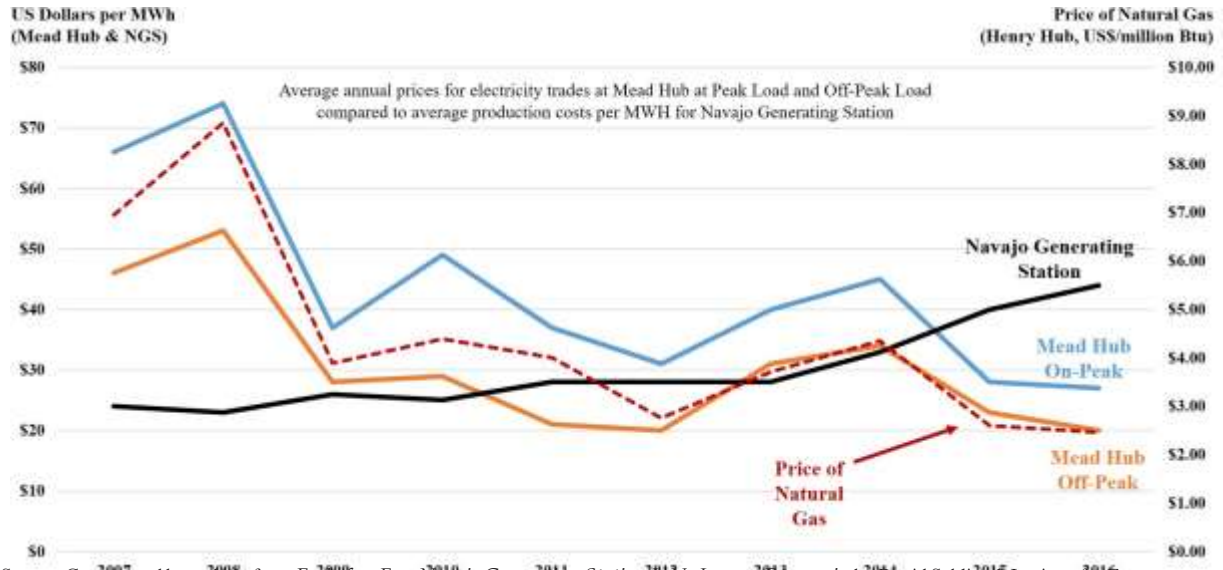
Power producers transmit their power to their customers over lines shared with other producers and consumers via an electrical grid. In the Southwestern United States, the major electrical interconnection points or hubs—trading points for electrical power—were the Palo Verde Hub, the Four Corners Hub, and the Mead Hub. Mead was NGS' primary connection. fte Mead Hub, located outside Boulder City, Nevada, generated market-clearing prices for power on a daily basis. ftis was the market in which NGS competed.

Exhibit 5 illustrates how NGS stacked up against competitors at the Mead Hub over a 10-year period. NGS' average cost of producing a megawatt hour of electricity (Mwh) was, as would be expected for a coal-fired base-load power plant, quite stable. fte cost began rising in 2014. At this time, prices from other producers trading at the Mead Hub declined. Both on-peak (that part of the 24-hour day in which power demand is highest, typically between 3:00 and 7:00 pm) and off-peak power prices were lower than the NGS cost in 2015 and 2016. ftis was the result of large volumes of natural gas-generated electrical power traded on the grid and the falling cost of natural gas. With continued growth in domestic oil and gas production, U.S. natural gas prices were expected to stay low, and possibly even fall, for the foreseeable future.

fte gap between NGS' production costs and the Mead Hub market prices in 2015 and 2016 had several results. First, in order to sell any power at the hub, NGS had to sell at rates below its cost of production. Second, with operating losses building, NGS produced less and less power over the period. In 2014, NGS produced 17 million Mwh of power. ftat dropped to 14 and 12 million in 2015 and 2016, respectively.[26] Much of the cost structure of a large-scale coal-fired power plant like NGS was fixed, which meant that regardless of capacity

utilization, the plant incurred the same labor, maintenance, and overhead costs. With costs fixed and revenue falling, NGS was losing money.

Exhibit 5. NGS Production Costs versus Power Prices at the Mead Hub



Source: Constructed by authors from *End of an Era: Navajo Generating Station Is No Longer Economic*, by David Schlissel, Institute for Energy Economics and Financial Analysis, May 2017, p. 6; *Navajo Generating Station and Federal Resource Planning*, National Renewable Energy Laboratory, November 2016; and *BP Statistical Review of World Energy, 2019*.

Plant Closure

In 2017, the four utilities with ownership stakes in NGS signed an agreement stating that they would not participate in operations at Navajo Generating Station after 2019.[27] By 2018, NGS was operating at a net loss for every megawatt of power sold. Initially, the Navajo Nation expressed an interest in keeping NGS operating, opening discussions on taking over the plant. In the following negotiations, NGS' s owners made it clear that any new owner would have to accept all known and unknown environmental liabilities. Unwilling to accept the liability risk, the Navajo Nation Council voted 11-9 in 2019 against the acquisition.

With the loss of coal revenue of $30-50 million, the Navaho Nation was forced to draw on its reserves for its 2020 budget. A 2018 economic study by the Hopi Tribe said it would face a collapse of its economy if the mine and power plant closed. Eighty-three percent of the tribe's total revenue came from the coal mine and NGS.[28] Many of the mine workers were from the Hopi Tribe because of its location near tribal lands.

Most of the 400-plus regular NGS employees were offered new positions within SRP, but nearly all were located at some distance from the reservations. SRP also provided moving assistance and opportunities for retraining. Two hundred ninety-one workers accepted transfers, 27 declined the offers, 80 retired, and 20 were terminated.[29] A Navajo Nation Council delegate said:

> *You're talking about 900 of the highest paying jobs that will be lost. We will have to cut a lot of programs. Health programs, it includes our security programs, even the law enforcement area. All programs will be affected*[30].

One Navajo laid off from the mine described what it was like to relocate to a new job off the reservation in Logan, Utah:

> *I wanted to stay on the Navajo Nation. That is one of my main goals, to stay on the reservation. It's home. Out here [Logan], it's not home. We're like tourists here… This [the reservation] is where we want to retire, this is where we want to build a house. This is where our heart is.*[31]

fte town of Page, Arizona, and its 7,500 inhabitants would also be impacted. Many of the NGS workers lived in Page. Besides NGS, tourism was the mainstay for the local economy. Page's location near the Grand Canyon, Lake Powell, the Colorado River, and slot canyons drew many visitors.

Decommissioning and New Coal Investment

SRP estimated that more than 90% of the decommissioned plant would be recycled, from core generating equipment down to the cement. Assets to be salvaged or sold included 141 transformers, 1,900 tons of copper, 105,000 tons of steel, and more than 650,000 gallons of diesel fuel. SRP planned to spend about $100 million on the land cleanup. Peabody would manage the mine site reclamation. ftere was no requirement to do any reclamation work on the aquifer.

In October 2019, the Navajo Transitional Energy Company (NTEC) acquired the Spring Creek coal mine in Montana and the Cordero Rojo and Antelope coal mines in Wyoming. NTEC also owned the Navajo Mine, located south of Fruitland, New Mexico. NTEC's mission was "to be a reliable, safe producer of coal, while diversifying the Navajo Nation's energy resources to create economic sustainability for the Nation and the Navajo people." NTEC was 100% owned by the Navajo Nation but not controlled by the Nation. NTEC was now the third largest coal producer in the United States.

Renewable Energy

With the closure of the NGS, the energy future of the reservations appeared to be renewable energy (RE). fte Navajo Tribal Utility Authority already had invested in solar—two fields of photovoltaic panels called Kayenta I and Kayenta II. fte two fields combined generated 55 megawatts, enough to power 15,000 homes across the Navajo Nation. Kayenta I was developed by the tribal authority and constructed by a Spanish renewable energy firm, the Isolux Corsán Group. It was completed in May 2017. Kayenta II was completed in 2019. A third solar project located in San Juan County, Utah, was underway. And although wind energy was a very real opportunity for both the Navajo and Hopi peoples, nothing had passed beyond the discussion phase. fte Hopi Tribe had no RE energy projects. Unfortunately, neither solar nor wind would ever generate the jobs the tribes were losing from the closure of NGS.

Although the vast sun-drenched windy expanses of the Navaho Nation looked perfect for more renewable energy developments, various challenges existed, as the following study found:

> *We believe obstacles to energy and economic development will persist unless the conventional model of RE development is reworked. That is, how will Navajo people and other stakeholders be engaged by Navajo Nation leadership? The challenges are clear: how to remedy chronic energy poverty, how to regain the trust lost in implementation of past energy projects, and how to catalyze social and cultural awareness of Navajo RE development. In the end, the most vexing challenge is how to reap the benefits of RE development without compromising Navajo value.*[32]

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