The Needs of the Nation and the Technology of Tomorrow: The Illinois Coal Industry, 1941–1969

By
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During and after the Second World War, Illinois coal industry leaders expanded the scale, advanced the controls, and systematized the components of machine mining. Due to wartime energy demands, most coal mine and preparation plant operators accelerated the already rapid pace of prewar mechanization. Then, after the war, they worked with researchers, engineers, and manufacturers to further develop technologies for continuous mining, longwall mining, bucket-wheel excavator surface mining, and preparation plant systems. In part, the centralization and automation of equipment controls made this possible.

Meanwhile, research on the conversion of coal into synthetic liquid and gaseous fuels grew at a hurried rate. Advanced coal research expanded in both project scale and conceptually, as researchers envisioned new ways for utilities to generate and distribute power in the future. Those efforts grew in response to energy market competition, but also to a growing movement to mitigate air pollution.

More and more, members of the Illinois Mining Institute (IMI), an industry association focused on mining research, took part in the national discourse about coal. Before the war, IMI members primarily met with researchers from the Illinois State Geological Survey and the University of Illinois, yet after the war they frequently worked with the Office of Coal Research in the U.S. Department of the Interior, the U.S. Bureau of Mines, and the semiprivate firm Bituminous Coal Research, Incorporated. This outward-looking perspective among leaders in the Illinois coal industry had some precedent. Many had focused on their part in meeting national energy demands during World War I, federal labor regulations during the New Deal era, and competition in the prewar U.S. energy market. In general, however, the movement to preserve the

Illinois coal industry emerged from the generation of ideas concerning state-level issues.

That trend shifted during and after the war. In 1941, John Battle, executive secretary of the National Coal Association, discussed the Illinois coal industry's role in the looming war effort with IMI members. He explained that other fuel industries had promoted their interests as "national interests." Battle believed that Illinois coal insiders had a moral obligation to do the same: "We all know that in unity there is strength. . . . We must therefore, all who claim to be good, associate ourselves together in a common cause for our country and our industry."[1]

IMI members took Battle's words to heart, and increasingly focused on the needs of the nation. When the federal government positioned reserve troops to protect Illinois coal mines during World War II, it amplified their notion of playing a key part in national defense. Many Americans identified with the nation after the war, too, even as the relief of victory meshed with the anxieties of the emerging cold war.[2]

In 1951, William McGovern, a professor of political science at Northwestern University, informed Illinois coal industry insiders of their importance. During the war, McGovern had served as a member of the Joint Intelligence Committee, which had assigned him the task of estimating enemy capabilities. At an IMI meeting, he considered who had since become the enemy of the United States: "To my mind," he asserted, "wherever we find a country under the control of the [*sic*] communist dictatorship there is a secret enemy of the American people." In terms of their capabilities, he believed that "in some ways the enemy is far stronger than we are."

He explained that the Soviet Union and its satellites, combined with Communist China and Korea, held almost 800 million people compared to 150 million individuals in the United States. "But, there are certain things in which we are definitely ahead of the enemy," he assured his listeners. "We are, and they know we are, which is quite important. Among those things are strategic raw materials and the technological know-how to put those raw materials to use." The members of the IMI and their associates agreed with those sentiments.[3]

Despite its significance, historians have shed little light on the Illinois coal industry's response to competition in the energy market, the challenges generated by the clean air movement, and how its leaders transformed their industrial culture during and after the war. The majority of scholars investigating this period of the state's coal business have focused on coal miners' health and safety. That issue dominated public discourse and media attention around mid-century, and rightfully so, as two major Illinois coal mine disasters pushed President Harry Truman to sign into law the Federal Coal Mine Safety Act of 1952.[4]

Historians have also produced scholarship on national energy policy during the postwar years. Richard Vietor, for example, argues that the Second World War accelerated the shift from coal to the cleaner and more easily transported fuels natural gas and oil. Martin Melosi explains that the end of the Second World War created a watershed between wartime scarcity and postwar abundance in the U. S. energy market. Yet scholars have not highlighted the changes to the Illinois coal industry as it faced a new set of postwar challenges.[5]

While industry leaders continued to view developments as being modern and up to date, as they had for many decades, they increasingly identified their industry's interests as linked to the nation's security, espoused a faith in technology, and merged their ideas of modernity with ones of futurity, envisioning what their industry would look like in the years ahead. They sought to develop cleaner, more uniform, and less expensive fuels to compete with natural gas and oil. In general, that change was not particular to the industry. Many Americans shifted their outlooks at the onsets of the so-called "nuclear age" and "space age."

Nor did the coal industry's actions go unchallenged. The movement to regulate air pollution grew from the municipal and state levels to centralize at the federal level during this period. To better understand the Illinois coal industry's engagement during the late-twentieth century with events such as the global energy crises of the 1970s and the expansion of federal clean air laws, one must consider how the Illinois coal industry's attempts to preserve itself transformed during the postwar period.[6]

Large-Scale Mechanization and Automation

In the postwar years, developments in continuous mining increased the efficiency of underground mines in the Illinois coal industry. Scientific management, design of large-scale equipment systems, and haulage with trucks and conveyers on rubber tires and belts inspired forward-looking experts to develop machines to do a complete mining job. From 1939 through 1942, coal output in the United States increased almost fifty percent in response to wartime demand. National annual coal mine output continued to rise, setting a record of more than 630 million tons in 1947. The skyrocketing need for energy, first to fight the war and then to catch up with the demand for consumer goods in the postwar years, led to a windfall for the coal industry despite increased competition from oil and natural gas.

As a result, leaders of the Illinois coal industry continued to modernize coal mines and preparation plants. By 1948, the continuous mining machine had become commercially available in the United States, revolutionizing mechanical coal mining. A *Mechanization* magazine article explained that "these machines are designed to replace the present sequence of the separate steps of cutting, drilling, shooting and loading with a single continuous process whereby the unit takes coal from the solid face and transports it through the machine into separate transportation facilities for removal to the surface." Clayton Ball, author and IMI member, warned of high up-front costs, but promised that the new systems would create substantial reductions in total operating costs over time. By 1950, many Illinois coal industry leaders had accepted the continuous mining machine as an integral part of mechanized coal mining (Figure 1).[7]

While the continuous miner brought the principles of a totally mechanized mining system into mines designed for the "room and pillar" mining method, some operators applied those principles to "longwall" mining. Historically, the Illinois coal industry had used both methods of coal extraction, but stopped using longwall methods around the turn of the twentieth century, when mechanization made room and pillar mines more productive. In time, however, the development of automated conveyers, longwall plows and shearers, and hydraulic roof-support chocks revitalized the practice of longwall mining and revolutionized underground coal mining.

In 1965, mining engineer and consultant M. Albert Evans described the development of longwall mining and its potential in the Illinois coal industry. He noted that around 1955 a Soviet engineer had developed the powered roof support. Since then, Evans explained, "west of the Iron Curtain there are in excess of 400 operating longwall faces fully equipped with hydraulically lowered supports." His reference to what Churchill famously called the "iron curtain" reflected the fact that Soviet miners had first modernized longwall mining, but it also displayed a growing awareness of the Illinois industry's role in the Cold War.

According to Evans, at first engineers made little progress in roof support for long walling from the technique of pulling chocks forward with cables. Advancements in automation, however, led to a surge in innovations. British and German engineers improved these techniques, and then companies in the United States adopted them. Several mines had begun longwall operations in the coalfields of West Virginia and Pennsylvania. In Illinois, the Old Ben Coal Corporation oper-

Figure 1. Continuous mining machines, such as the Lee-Norse CM37, boosted coal mine productivity during the postwar years, yet they also increased impurities in mined coal and the need to clean it in surface preparation plants. (From Proceedings of the Illinois Mining Institute*, 1958, 35.)*

ated the state's first modern longwall mine near Sesser, starting in the early 1960s. Freeman Coal Company of Benton, Illinois, began operating a longwall system in 1965.[8]

The postwar automation of large-scale equipment systems also enabled surface-mine operators to increase production and efficiency. In the 1950s, companies developed ever larger "super shovels and draglines," such as the sixty-yard Marion Mountaineer. Bucyrus Erie followed with its River Queen shovel, and, in 1959, announced the sale of a truly gigantic machine to the Peabody Coal Company. The monster Model 3850-B swung a 115-yard dipper on a 210-foot boom. The machine weighed about fourteen million pounds, making it the largest land-based machine in the world.[9]

Compared to a dragline and shovel, however, the bucket-wheel-excavator system increased cubic yardage per month and also the distance that the equipment transported the material. In 1944, United Electric Coal Company introduced the radically different Kolbe Wheel Excavator into its Cuba Mine in Fulton County, Illinois. One excavating wheel had ten digging buckets capable of scooping overburden while it gradually moved through an arc set by the boom operator. The bucket wheel had a diameter of fifty-two feet and could dig at the rate of thirteen thousand cubic yards per hour. Crawler-mounted belt conveyers could dispose overburden at a rate of about six thousand cubic yards per hour. The entire mine-face operation flexed to shift its main haulage belts when needed. A crawler-mounted loading station continuously filled 180-metric-ton railroad cars. The system proved extremely effective in areas with the favorable mining conditions in all types of overburden. Despite the enormous capital investment, the system cost considerably less than underground mining in the long run.[10]

Advancements in automation with remote and central controls enabled all of these large-scale coal mining methods to operate efficiently. In 1958, Gerald Von Stroh, who served on the Mining Development Committee at Bituminous Coal Research, Inc., explained the purposes of automation to IMI members. These included quality control, replacement of human decisions with automatic responses, systemized maintenance through standardization and centralization of operations, and increased productivity per unit of investment.

Von Stroh believed that the coal industry should emulate the U.S. military, which had made important advancements in the automation of mobile equipment. According to him, the Illinois coal industry needed sensing devices, electric controls, and servo valves. He explained that "a means to convert electrical energy into a control system is usually called a computer." With an eye on the future, he suggested that "as individual coal operators, if you have not already done so, reconsider your organization in the light of these things to come." Coal mine system computerization promised to reduce demand for central systems operators, and move the industry into the future.[11]

The development of large-scale, automated coal mines necessitated similar advances in coal preparation plants. In 1962, a *Mechanization* magazine article stated that "modern preparation plants being built today are costing up to ten million dollars each—the cost of such an installation often is approximate to the cost of opening and equipping the underground mine that it serves." At that time, operators used several basic types of cleaning equipment, including air tables, wet tables, sand-flotation cones, launders, jigs, hydrotators, calcium chloride washers, froth flotation cells, and hydroseparators. Mechanical cleaning had grown from processing 15 percent of coal mine production in 1937 to 66 percent in 1961.

According to the article, "the year 1937 marked an important turn of events for the preparation plant operator. Several new plants were built with more modern equipment and a new era was started." Advances in mechanical cleaning slowed during the war, however, with operators cleaning only twenty-six percent of coal produced. But in the postwar years coal preparation increased, and by the 1950s multi-million-dollar preparation plants overshadowed their predecessors. They required only one-fourth to one-half of the manpower of earlier plants. An automated central station controlled major plant operations, and the use of coal flotation grew in importance with the introduction of new cell designs and chemical agents (Figure 2).[12]

Preparation plant engineers often discussed the state and future of technology at IMI meetings. In 1952, John A. Garcia, of the Allen and Garcia Company, presented his designs for the preparation plant at the Chicago, Wilmington, and Franklin Coal Company's Orient No. 3 Mine near Waltonville, Illinois. The plans resulted in one of the largest coal cleaning plants built at the time. It combined both wet and dry cleaning, and removed fine mesh coal by prior treatment to reduced sludge problems. Electronic panel boards controlled the units. Fine screening in the portal house alleviated dust problems in the cleaning plant. Three railroads served the new plant: the Chicago, Burlington, and Quincy; the Missouri Pacific; and the Illinois Central. In appearance, the plant looked large yet compact and functional. The main slope conveyor gallery ran into the portal house, and from there another belt conveyor gallery ran up and into the main preparation plant. Garcia used equipment from prominent manufacturers, such as Link Belt, Allis Chalmers, and Jeffrey.[13]

Emery Milligan, a preparation engineer at the Freeman Mining Corporation, described the "new modern preparation plant" at the company's No. 4 mine in southern Illinois. An inclined belt with a capacity of five hundred tons per hour fed the plant from underground and discharged onto a feeder that conveyed coal to a combination screen and picking table. From there, the coal either went into a Jeffrey single-roll crusher or into an Allis-Chalmers screen operation, which, in turn, fed a Dutch State Mines Heavy Media Vessel or a Roberts and Schaefer Super-Airflow Cleaner. The Dutch State equipment used fine magnetite, coal, and water, mixed and then fed into a magnetic separator that divided course material containing more magnetite from fine material holding less. After cleaning, the plant rescreened the coal and treated some sizes with stabilizing oil. A General Electric control center operated the equipment.[14]

While many mining system and preparation plant engineers thought of their work as updating facilities and designing new operations to include the most modern equipment and controls, others pushed that vision of modernity into one of futurity. William G. Carnegie, Jr., chief electrical engineer at the Roberts and Schaefer Company, for instance, understood the importance of electronic controls in a modern coal preparation plant, and even imagined where they might take the industry in the future.

At an IMI meeting in 1959, Carnegie explained that facilities required automation due to their size, complexity, and capacity. As mechanized mining and energy market demand had led to the development of centralized operation, Carnegie predicted that an "industrial television" would greatly improve future mining and preparation systems. In other words, he envisioned that computerized monitoring systems would revolutionize the industry. He conceded, however, that at that time costs prohibited their use. Likeminded individuals involved with the IMI during the postwar era updated the Illinois coal industry's technology, making it more modern, yet they also began to think ahead to the industry's computerized and remotely monitored future (Figure 3).[15]

Advanced Coal Research and the Future of Fuel

While coal mine and preparation plant owners expanded their operations, others interested in preserving the Illinois coal industry looked toward converting coal into products capable of transforming energy production and distribution. The conversion of coal into liquid or gaseous fuels

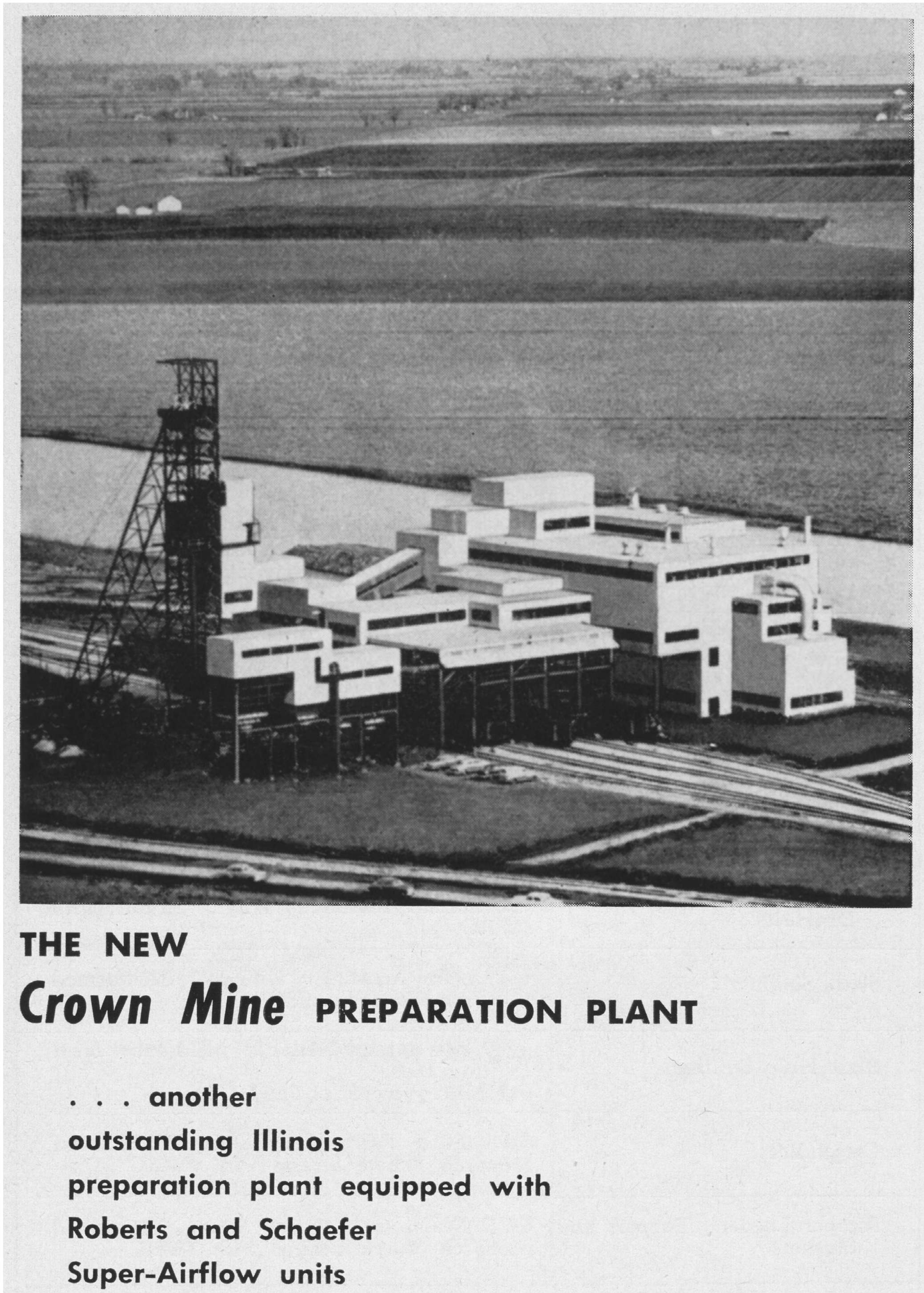


Figure 2. William G. Carnegie, Jr., chief electrical engineer at the Roberts and Schaefer Company, helped to design modern coal preparation plants, such as the one depicted in this artist's rendering of the Crown Mine Plant in Macoupin County, Illinois. (From Proceedings of the Illinois Mining Institute, *1952, 100.)*

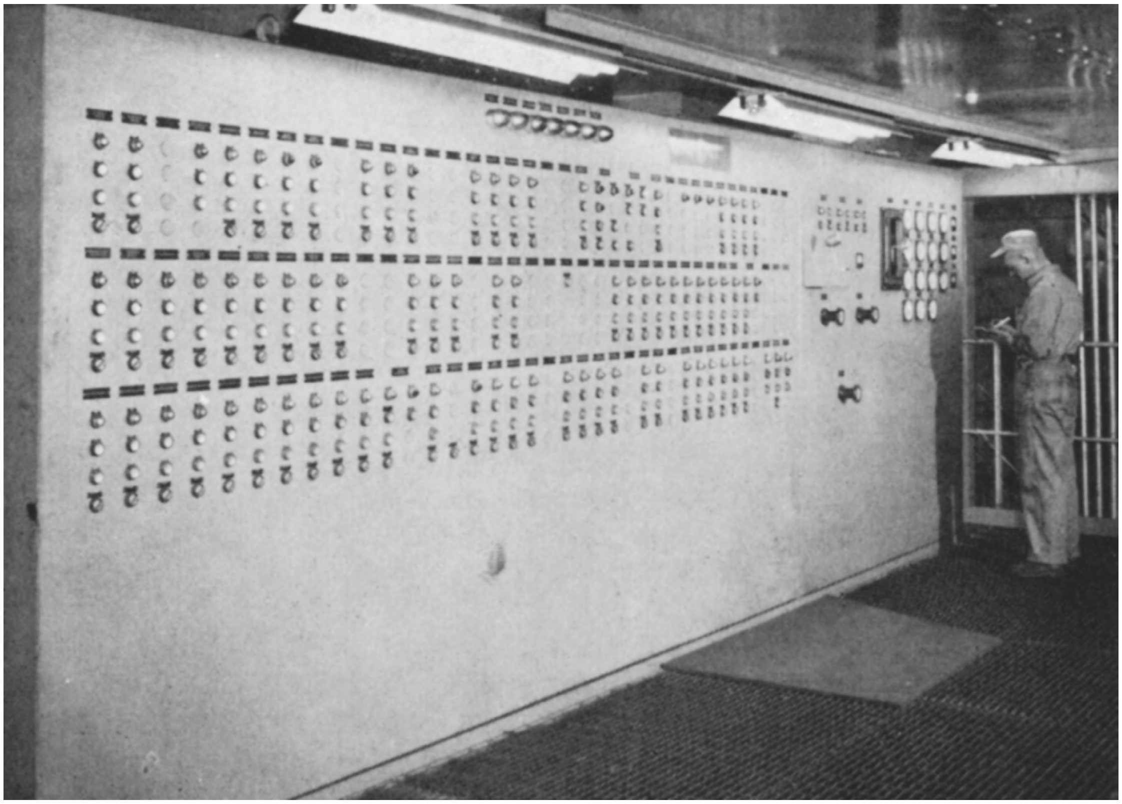


Figure 3. With modern preparation plant controls, a single operator monitored and adjusted multiple pieces of coal washing equipment with the touch of a button. (From Proceedings of the Illinois Mining Institute*, 1962, 127.)*

required the addition of hydrogen, or hydrogenation, and the simultaneous removal of oxygen. Chemists had achieved that objective with two processes: The Bergius process, or direct hydrogenation, and the Fischer-Tropsch synthesis, or indirect hydrogenation. Although chemists could convert natural gas into synthetic gasoline more economically than they could coal, analysists predicted that limited natural gas reserves would make the difference temporary.

Policymakers held similar beliefs. Congress passed and President Franklin Roosevelt signed the Synthetic Liquid Fuels Act of 1944, which appropriated twenty million dollars for the U.S. Bureau of Mines' laboratory and pilot-plant investigations. At that time, however, there was nothing revolutionary about making oil and gas from coal.

Experiments on hydrogenation dated back to about 1910 in Germany, and processes for distilling oil from coal went back to the mid-nineteenth century, when innovators first made coal oil to replace whale lamp oil. Coal oil plants operated in Germany and England before the Second World War at a cost several times greater than similar products produced from petroleum, but they helped make those nations less dependent on petroleum imports during that unstable period. Friedrich Bergius developed the first commercial-scale hydrogenation process in Germany. The Bergius process provided aviation fuel for Adolf Hitler's Nazi war machine. In 1936, German officials commissioned the first commercial Fischer-Tropsch plant, which contributed to production of diesel fuel and chemical products for the German military.[16]

Illinois coal industry insiders imagined themselves taking part in the future of synthetic fuels as they learned about coal conversion processes. At an IMI meeting in 1947, Joseph Pursglove, Jr., vice president of research and development at the Pittsburgh Consolidation Coal Company, anticipated great possibilities for the conversion of coal into liquid and gaseous fuels. Pursglove believed in what he envisioned to be this "inevitability in the future role of coal." His company, in conjunction with the Standard Oil Development Company, had announced research plans in the fields of coal gasification and liquefaction, and had contracted for the building of a large-scale pilot plant near Pittsburgh, Pennsylvania.

Pursglove described this installation as the "refinery of the future." He explained the plant's processes: crushers reduced the coal to a fine size and then fed it into a gas generator that converted it into carbon monoxide and hydrogen gas. Equipment next cleaned the gas, removing dust, sulphur, and other impurities. It then entered the synthesis reactor, in which a catalyst turned it into a variety of liquid and gaseous fuels. Pursglove concluded that "coal seems destined for the role of the most reliable base for the whole energy world." He not only imagined coal's role in the future of fuels, but also believed that fate had sealed it, given its natural abundance. Many IMI members came to share his faith in technological solutions.[17]

Around mid-century, chemical engineers began promoting the process of "underground gasification," as well as larger-scale facilities that would combine synthetic fuel manufacturing with electrical generation at the mine mouth. Soviet engineers first experimented with underground gasification, which involved injecting oxidants and steam into coal seams while extracting the product gas through wells. After the war, however, the Missouri School of Mines and Metallurgy made the most substantial efforts to advance the process.

In 1950, a copy of a speech on underground gasification circulated among IMI members. When Erich Sarapuu, a Ph.D. candidate from the Missouri school, delivered that speech, he predicted that American coal deposits would provide enough raw material to supply the nation with liquid fuels for several hundred years. He stated: "I believe that the first economical result can be obtained by a combination of electric power plant and underground gasification unit." Sarapuu anticipated that the Fischer-Tropsch method, in combination with underground gasification and a gas-fired electric generation plant near a coalfield, would improve the economics of synthetic fuel production. He also envisioned an automated and remotely controlled future: "We can keep the idea in our mind that one of these days the coal miner will not need to go underground, but will instead execute his duties in surface plants using the underground gas." Beyond mining and preparation, the concept included electrical generation at the mine mouth and therefore the elimination of railroad transportation, as operators could transmit electricity via wire and ship excess fuel via efficient pipelines. Sarapuu concluded that "the progress of underground gasification in this country depends largely on the attitude of the coal industry." Most operators agreed that the industry needed technological advancement.[18]

Those concerned with national defense played the largest part in driving the development and demonstration of synthetic fuels. In 1948, Frank H. Reed, chief geochemist at the Illinois State Geological Survey, wrote that "the greatest problem facing the United States today in preparing for a possible Third World War is that of the assurance of an adequate fuel supply." He and other Illinois coal insiders increasingly believed that it was their duty to meet the needs of the nation. In 1951, Charles Connor, a former administrator at the Defense Solid Fuels Administration, informed IMI members that coal constituted about 98 percent of the nation's mineral fuel reserve. He promoted the use of coal in order to conserve other fuels. He explained: "Paradoxically, the trend in fuel consumption has been advancing with the greatest rapidity in those fields in which our reserve position is relatively weak in terms of sustained productivity."[19]

Those limits, together with the uncertainty of oil and natural gas imports, seemed to solidify the importance of coal. Given those circumstances, the Truman administration supported the Department of the Interior's synthetic fuels program, and by 1951 the Bureau of Mines had completed a hydrogenation demonstration plant at Louisiana, Missouri, to produced fuel for military tests. According to Connor, recoverable coal deposits in Illinois, suitable for conversion, equaled thirty-four billion barrels of synthetic liquid fuels—substantially more than the total estimated domestic crude oil reserve of twenty-five billion barrels. He believed that the success of a pilot coal hydrogenation plant under construction by Union Carbide in West Virginia, a Bureau of Mines underground coal gasification project near Gorgas, Alabama, and the Louisiana, Missouri, plant would be important steps toward future developments in Illinois (Figure 4).[20]

Although a Republican-led Congress cut federal funding for the Synthetic Liquid Fuels Program in 1953, Illinois coal industry leaders continued to intertwine their movement with national coal research and development trends. They received a boost in 1964, when President Lyndon Johnson announced that "the challenge of a modern society is to make the resources of nature useful and beneficial to the community." George Fumich, Jr., director of the Office of Coal Research (OCR) in the Department of the Interior, informed IMI members that the Johnson administration sought "to make the great resource of coal more useful and beneficial to our society . . . by rapidly increasing our knowledge of coal and of the technology for its use."[21]

That national effort came with a significant financial endowment. Congress appropriated $6,836,000 for the OCR in fiscal year 1965 for research on coal conversion, combustion, purification, transportation, and byproducts. Fumich told the Illinois coal insiders that the OCR would "ensure that coal makes its optimum contribution to the nation's economic growth."[22]

Meanwhile, IMI members came to understand that they could potentially ally with the natural gas industry. The OCR and the American Gas Association formed a cooperative program to lead the engineering of a prototype plant for producing synthetic pipeline gas from coal. Henry R Linden, a director at the Institute of Gas Technology, predicted that if that plant succeeded, "a decision could then be made to build one or more commercial plants to begin operation around 1975." According to Linden, Illinois stood out as an ideal candidate to get one of the projects.[23]

Private institutions, often funded with a combination of private and public dollars, also played a role in developing coal conversion. Bituminous Coal Research, Inc. (BCR), of Pittsburgh, Pennsylvania, studied coal gasification and pollution control under contract with the Office of Coal Research. BRC investigated coal gasification from two standpoints: First, the development of a better process for making electricity from coal, where a power plant itself converted the coal into a gas before combustion. Second, BCR looked into the production of a synthesis gas suitable for methanation into a pipeline gas.

At an IMI meeting in 1965, BCR's president, James R. Garvey, recalled, "when I started in the coal business, the prediction was for a decline in available natural gas reserves within ten years. . . . Twenty-five years later, we are still using the ten-year figure." He explained why he believed that research should continue, nonetheless: "We must give some weight to predictions by the so-called experts. . . . They are people connected with the natural gas industry. They conclude that the need for gas from coal is imminent." Garvey thought that, despite the flawed timeline, in the end, that prediction would come true. Coal petrography, the study of organic and inorganic materials in coal, made it possible to identify the useful properties of coal and its industrial applications. Garvey advised that companies must use petrographic analysis when planning mines in order to prepare for the future of coal conversion.[24]

In 1969, Neal P. Cochran, chief of the OCR's Division of Utilization, updated IMI members on the potential for a processing plant in their state: "Illinois is important to the OCR because of [its] large reserve of coal suitable for use in the manufacture of synthetic fuel, chemicals, and power." Cochran described the division's objectives: "We produced a balanced program seeking ways and means to transform coal into high-quality liquid fuel, either refined petroleum products or high-quality crude oil. Equally important, we are carrying out a systematic investigation of the possibility of producing a 'synthetic natural gas' if you will."

In the end, though, generating electricity at lower cost from coal than from other fuels remained Cochran's primary goal. He admitted that the OCR opposed the Atomic Energy Commission in that regard. Nevertheless, Cochran believed that a coal processing plant in Illinois could produce synthetic fuels in the future. "Such a plant located in central or south-central Illinois," he imagined, "would mean jobs, a continued market for coal, clean air, satellite industries, and the best utilization of our national energy sources." Over time, the idea of future coal conversion technology in Illinois merged into the IMI's culture of industry preservation and its vision of steering

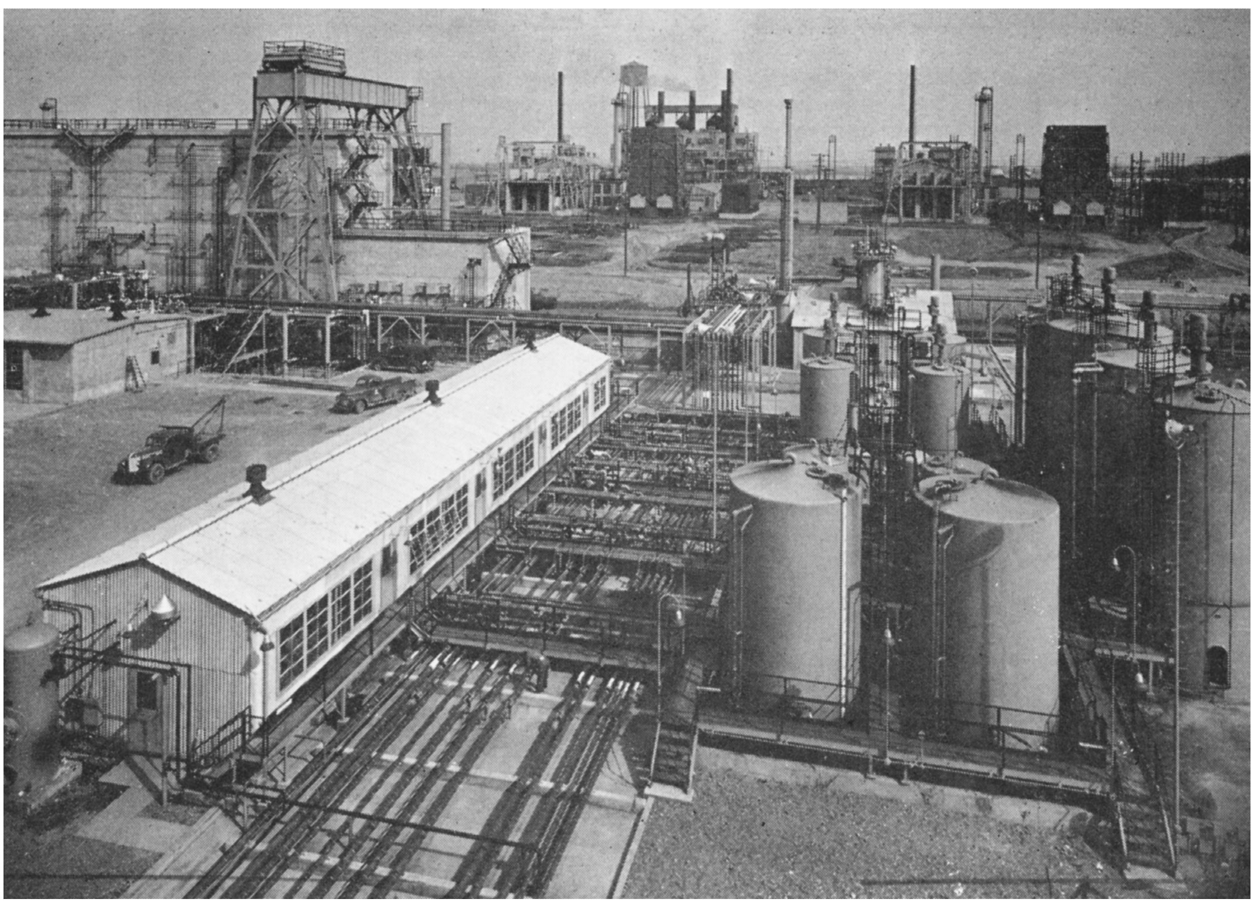


Figure 4. The U.S. Bureau of Mines' hydrogenation demonstration plant in Louisiana, Missouri, converted Wyoming coal into liquid fuel and provided a model that leaders of the Illinois coal industry hoped to replicate. (From Proceedings of the Illinois Mining Institute*, 1950, 84.)*

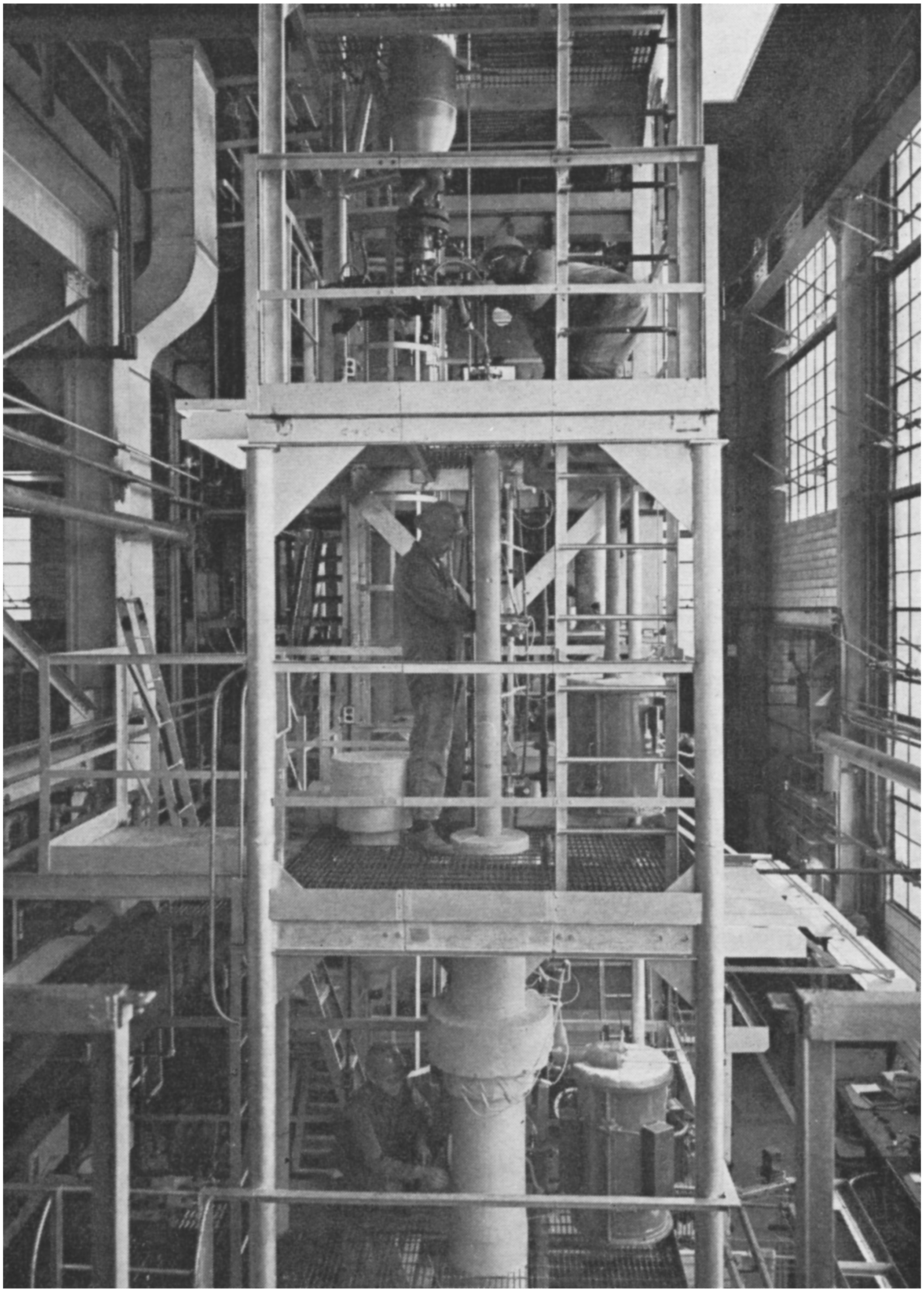


Figure 5. Interior view of a coal gasification plant with pipefitters assembling equipment systems. Members of the Illinois Mining Institute hoped that the U.S. Office of Coal Research would locate such a plant in their coal-rich state. (From Proceedings of the Illinois Mining Institute, *1969, 32.)*

modern coal mining into a more ideal future (Figure 5).[25]

Coal Utilization and Inter-fuel Competition

During the postwar period, leaders in the Illinois coal industry faced a set of changing circumstances and challenges: They had to accept that their residential and commercial customer bases had almost completely shifted from coal to oil and natural gas. Early on, some argued that supply rather than demand had driven coal's decline in the market. Howard Herder of the Sahara Coal Company believed that stoker coal use had declined as a result of low coal production. At the time, Illinois coal producers still distributed their fuel in a ten-state region that included the metropolitan areas of Chicago, Saint Louis, Minneapolis-Saint Paul, Kansas City, Omaha, Milwaukee, and the Quad Cities of western Illinois and eastern Iowa.[26]

While coal producers pushed to increase supply, stoker (coal burner) manufacturers did their part to generate demand, too. In December 1953, Automatic Solid Fuels Equipment, Inc., of Indianapolis, released the low-priced Campbell Automatic Bituminous Coal Stoker. The company had tested the unit in several homes and businesses in Indianapolis, and Bituminous Coal Research had extensively tested a unit and reported good results. Automatic features included a worm-drive feeder and an electric ignition and electric thermostat. According to a spokesman for Automatic Solid Fuels, "no piece of burning equipment has ever been more fully tested in performance prior to production."[27]

Despite those efforts, consumers increasingly switched to natural gas and oil to heat their homes. In response, many industry leaders refocused on two areas: electrical generation, and coal conversion research and development. A challenge arose, however, when utilities began to demand low-sulfur coal. The centralization of the movement to control air pollution pushed utility leaders to demand a higher-grade coal product. As a result, members of the IMI and their associates once again looked to a potential future technology as a means of preserving their industry. They envisioned emissions post-combustion sulfur dioxide removal, or "scrubbing," as the innovation that could secure their future.

In spite of the coal industry's push to preserve its share of the residential and commercial heating markets, around mid-century some of its leaders started to understand that they needed to focus more on the electric utility industry. In 1953, M. B. Covell, a superintendent at the Union Electric Company of Missouri in Saint Louis, held that the Illinois coal industry and the electric utility industry should consider one another partners. The utility industry demanded a sound, long-range fuel supply from the coal industry. "During these recent difficult recent years," he conceded, "the rapid expansion of the use of other fuels has caused considerable concern to many coal people. . . . But from the viewpoint of the electric power utility industry, coal is the basic fuel and will remain the basic fuel."[28]

In a presentation to IMI members, Covell explained that electric utility expansion led to continued coal demand. A one-room air conditioning unit, for example, used the same amount of power as the average household in 1940. Only 1 percent of the homes in the United States had an air conditioning unit in 1953, but sales soon skyrocketed. Covell anticipated that in the near future the demand for electricity would grow substantially, as homes and businesses added air conditioning units. The demand for power had surged in the industrial sector, too. Still, he recommended that the coal industry takes steps in order to compete with other fuels.[29]

A good portion of the market for coal had dwindled by the 1950s. Since 1927, the coal industry had lost 90 percent of its sales to railroad companies to diesel fuel, about one-third of its market for heating homes and businesses to oil and natural gas, and about 9 percent of coal's industrial users had likewise switched fuels. (The high cost of atomic energy, however, had limited the growth of nuclear power since its inception.)[30]

However, in 1959, electric utilities offered coal companies a solution to the issue of residential users switching from coal to natural gas and oil for home-heat generation, promising to give the coal businesses an upper hand in the competitive energy market. W. A. Raleigh, Jr., an associate editor of *Coal Age* magazine, informed IMI members that electric utilities had decided to push electric heating as a key to growth in residential and commercial sales. At that time, their success had already played a major role in boosting coal-fired utility growth in the United States.

Raleigh explained that electric heating "could also be the coal industry's best hope for recapturing big losses in retail sales during the past fifteen years, and for preventing further conversions to gas and oil." He concluded: "I do not consider it too optimistic to say that this [electric heat] program will soon take the place of our competitors' cry that oil and gas are cheaper and more convenient." An industry slogan and a major sales pitch for promoting electric heating had emerged: "Coal by wire." As more and more Americans brought conveniences like air conditioning into their homes, the idea of electric heating similarly promised to further expand the market for Illinois coal.[31]

Even with the utility industry's "coal by wire" campaign, the Illinois coal industry maintained a watchful eye on advances in atomic energy. At an IMI meeting in 1955, Arthur S. Griswold, assistant to the president of the Detroit Edison Company, discussed the state of atomic energy as a competitor of coal. In the late-1940s, he explained, some individuals had expressed skepticism regarding the production of electric power with atomic energy. Nevertheless, the technology progressed rapidly, and in 1955 developers began constructing several large atomic power plants in the United States.

In 1950, Detroit Edison Company and the U.S. Atomic Energy Commission began building a large demonstration reactor. The company also continued to consume large quantities of coal in order to serve its one million customers in southeastern Michigan. As a result, Detroit Edison concerned itself with the interests and vitality of the coal industry, while at the same time it looked toward a future of atomic fuels. Many utilities in the United States would face a similar dilemma. Milligan believed that if developers could resolve cost issues, atomic energy would dominate the inter-fuel competition for the electrical utility market. As a result, he advised, the coal industry should develop gas and liquid fuels. He encouraged IMI members with the idea that "an alert and well-informed coal industry will be able to meet the challenge of the time."[32]

In 1960, Hubert E. Risser, principle mineral economist at the Illinois State Geological Survey, assessed the "future of coal" in the energy market. He explained that a five-fold increase in the consumption of energy had occurred in the United States in the sixty years since 1900. Over the same period, the population had increased to 2.5 times its former level. Per capita consumption of energy had risen to the equivalent of more than nine tons of coal for every person. Still, due to the growing consumption of other fuels, the coal industry had declined even though total energy consumption had increased.

Risser predicted that the Illinois coal industry would move forward, nonetheless. On one hand, he thought, competition would prevent growth in the residential and commercial markets, but on the other hand he anticipated growth in coal use. He believed that the use of coal by utilities generating electric power would bring a significant increase in total coal consumption through the mid-1970s. That would help to strengthen the coal industry and enable it to face the last quarter of the twentieth century, when Risser thought that the declining availability of oil and gas would reopen old markets to coal. He suggested that "instead of being producers of oil, gas, or coal, firms engaged in the production of these fuels have in a broader sense become suppliers of energy and must compete on that basis." In other words, he advocated for a movement of horizontal integration across the energy industries. That advice reflected the general post-1945 industrial trend of expanding scale while centralizing control, and anticipated the future establishment of energy conglomerates.[33]

While leaders of the Illinois coal industry shifted their attention from the waning stoker market to the waxing utility market, they had to acknowledge that the high sulfur content of Illinois coal caused problems. In 1958, John Koopman, a vice president of Electric Energy Inc., presented a paper to IMI members titled "Fuel Requirements for Modern Power Plant Operation." His company's plant in Joppa, Illinois, had experienced boiler corrosion issues. The Joppa Steam Electric Station in Massac County, Illinois, sat approximately twelve miles down the Ohio River from Paducah, Kentucky. It supplied electric power to the Paducah Gaseous Diffusion Plant, which the U.S. Department of Energy had built in 1952. The station consisted of six sets of boilers and turbines, and at peak generating the plant produced about one megawatt. It consumed over three million tons of coal in 1957.

Engineers had designed the plant to burn coal from southern Illinois. After investigating corrosion problems in the plant's boiler systems, company officials determined that high-velocity airflow blew soot that abraded protective coatings and exposed raw metal to corrosive sulfur dioxide in flue gas. The equipment manufacturer and the utility worked together to experiment with anti-corrosive coatings for the equipment. They used X-ray images to view the results of their laboratory tests on the metal. While equipment innovations helped reduce the rate of corrosion, the company concluded that "it is only good sense to attempt to reduce known harmful constituents to a low or minimum value. In some cases, this can be done by the coal suppliers' care in coal preparation where rigid control of washing conditions is exercised." More and more, utilities would demand coal products more suitable for their use, but ultimately the movement to control air pollution would drive the change from high-sulfur to low-sulfur coals.[34]

The Air Pollution Control Movement

Throughout the 1960s, those in the movement to preserve the Illinois coal industry increasingly discussed the entanglement of their interests with the growing movement to control air pollution federally. Shifting the blame from coal combustion to other sources of air pollution became a common response among industry insiders.

In 1961, for example, Louis C. McCabe, a private researcher, presented his views on air pollution control at an IMI meeting. He explained that "sources of air pollution are many and varied, that is the reason there are difficulties in control." He believed that individuals supporting air pollution control tended to oversimplify the issue: "An individual experiencing one of the air pollution problems in one area," he said, "is inclined in think that the cause and the solution are the same in another area." He noted that natural sources of air pollution, such as volcanic emissions, dust storms, and forest fires, continually put organic compounds into the air.[35]

McCabe did not deny that burning coal caused pollution, yet he reduced the impact of manmade sources and amplified the role of natural ones. Further, he reminded IMI members that their industry had taken the brunt of the responsibility for the smoke pollution issues of the first half of the century. He argued that individuals needed to realize air pollution did not consist of coal smoke alone. The chemical industry, aluminum industry, petroleum industry, and trash incinerators had all required pollution control. McCabe concluded that industrial and commercial sources, in combination with natural ones, contributed to sulfur dioxide pollution, and that coal only played a minor role.

Nationally, Congress addressed the issue with the Clean Air Act of 1963. Building on the Air Pollution Control Act of 1955, which had authorized research, the 1963 Act gave the federal government the authority to appropriate $95 million for state programs, and authorized federal administrators to act against interstate air pollution. While many in Illinois opposed the federal regulation of coal burning, some helped push the issue onto the national stage.

Laura Fermi, for example, helped found one of the Chicago's first effective anti-pollution organizations. In 1959, Fermi and a small group of women met in Hyde Park, Illinois, the South Side neighborhood housing the University of Chicago, and formed the city's first citizens' organization against air pollution. Calling itself the "Cleaner Air Committee of Hyde Park" (CACHP), the group started locally by distributing literature, educating the public, and organizing a network of two hundred volunteers. The committee claimed a major local success when, after being the target of one of its campaigns, the University of Chicago announced that it would switch from coal to natural gas by the year 1971. The committee also kept constant pressure on the City of Chicago's administrators, from Mayor Richard J. Daley to the leaders of the Department of Air Pollution, resulting in revision and strict enforcement of the city's smoke ordinances.[36]

Fermi and fellow CACHP member Edith Harris then expanded their movement beyond Chicago to address state and national air pollution. In 1964, Harris delivered a testimony, which Fermi had prepared, at a U.S. Senate field hearing. Democratic U.S. Senator Edmund Muskie of Maine held the hearing prior to the federal government's implementation of the Clean Air Act. Fermi had sent inquiries to Muskie regarding air pollution, and in return he invited a committee member to speak before his subcommittee.

At the hearing, Harris explained that smoke pollution had covered their South Side neighborhoods in soot, posed a risk to their health, and discouraged people from moving into the area. She identified coal and outdated furnaces as the causes of the problem. The solution, she believed, had to come from the federal government. She pleaded to Muskie and his associates, arguing that "technical advances in the way of smokeless fuels . . . are probably beyond the resources of a city or state to develop. We wonder whether this might not be an area where the federal government could encourage research." Muskie and his committee praised Harris for her testimony, and added it to the growing record of those in support of federal air pollution control. Fermi and Harris' testimony, the only statement made by nonprofessional women, paved the way for others to do the same in other venues.[37]

At the state level, CACHP members involved themselves in the air pollution issue by writing letters to Illinois legislators and by testifying at the meetings of the Illinois Pollution Control Board (IPCB). To comply with the federal Clean Air Act, the Illinois legislature passed, and Governor Otto Kerner Jr. signed, the 1963 Illinois Air Pollution Control Act. This created the IPCB, and vested in it the power to control air pollution.[38]

With the federal and state governments moving to regulate air pollution more strictly and effectively, Fermi, Harris, and the Cleaner Air Committee began to take on the Illinois coal industry. One of the committee's campaigns sought to repeal the 1937 Illinois Mined Coal Act, which required all state institutions that burned coal to purchase coal mined in the state unless its cost exceeded 110 percent of that of imported coal. In 1967, the committee lobbied Illinois state representatives Water McAvoy and John Wall to introduce a bill that would only require state institutions to burn fifty percent Illinois coal, while also burning fifty percent low-sulfur coal mined in other states.[39]

Although this fifty-fifty compromise bill did not become law, the awareness it brought to the issue culminated in Illinois Attorney General William Scott advising the legislature that the 1937 Act could be unconstitutional. He believed that the law was "in conflict with the commerce clause of the federal Constitution . . . and [that] the Illinois legislature has no power to regulate commerce between states." The Illinois legislature sustained that advice in 1970 by repealing the 1937 Illinois Mined Coal Act.[40]

As the issue of clean air tethered together local, state, and national efforts to mitigate air pollution, discussions about sulfur dioxide emissions became more frequent between leaders of the Illinois coal industry and the national coal lobby. IMI members met with representatives of the National Coal Association (NCA) to strategize their responses to the Clean Air Act. James R. Jones, an engineer with Peabody Coal Company, spoke at one of those meetings in 1966. He explained that while researchers had developed equipment to collect particulate matter from coal combustion emissions, they had not yet marketed devices to capture sulfur dioxide. Research efforts had begun, but none had proceeded beyond the pilot stage.

Jones explained that "one of our objectives in working with air pollution control agencies is to develop regulations that do not precede the technical knowledge for compliance." The Clean Air Act of 1963 had directed the U.S. Department of Health, Education, and Welfare to establish ambient air-quality goals. Yet, when Jones spoke in 1966, HEW had not yet set those standards. The Illinois Pollution Control Board, however, had worked out a comprehensive set of rules. "Fortunately," Jones explained, "Illinois law states that the board must give consideration to the technical practicability and economic reasonableness. It is a difficult problem to determine what is economically reasonable."[41]

In 1967, George Sall, the National Coal Association's associate director of government relations, reminded IMI members that in 1962 President John F. Kennedy had established a precedent at a White House conference on conservation: Instead of addressing environmental problems as a set of separate issues, Kennedy's speech had drawn attention to conserving the entire environment as a whole. "From then on," Sall warned, "anti-pollution measures have become one of the favorite subjects of legislation." He urged his audience to persuade lawmakers to use logic rather than emotion in finding solutions.[42]

While industry organizers focused on lobbying, federal agencies scrambled to advance the technologies that could enable the continued use of Illinois coal. In 1967, for instance, Richard Corey, research director at the U.S. Bureau of Mines' Coal Research Center in Pittsburgh, offered a solution to sulfur dioxide emissions in urban areas. He suggested remote generation, writing that "combining power generation at the mine mouth in rural areas with extra high voltage transmission concentrates the sulfur dioxide pollution near the mine mouth rather than near large population centers." Yet Corey also acknowledged the limits of that answer, that "this could be only a short-term expedient. Ambient sulfur dioxide from huge power plants could spread over large geographical areas in time."[43]

Corey wrote that the utility industry favored tall smokestacks as a means to disperse sulfur dioxide and reduce its ground-level concentration. He believed that scrubbers would defeat themselves, as liquid scrubbing cooled plant emissions, thus reducing the buoyancy of the gas and raising ground-level concentrations. The U.S. Public Health Service sponsored a pilot scrubbing plant at the Bureau of Mines' research lab in Pennsylvania. Despite his skepticism, Corey hoped that the project would demonstrate the commercial viability of emissions scrubbing technology. In 1969, IMI members learned of the dry-limestone emissions scrubbing method scheduled for testing at the Tennessee Valley Authority's Shawnee Plant near Paducah, Kentucky. Plant operators would also test a wet-limestone scrubbing process on an identical boiler. They predicted that engineers would publish reports on the dry limestone injection process in 1971, and on the wet limestone process in 1973.[44]

Meanwhile, the U.S. Bureau of Mines also pushed the idea of coal utilization research into the IMI's discussion about air pollution. In 1969, William L. Crentz, director of coal research at the bureau, informed Illinois coal insiders of his role. "Our responsibility," he told them, "is to assure that the country utilizes its coal resources in the best possible way. Primarily our program is aimed to provide for an adequate supply of energy, under healthful conditions, at the least possible cost." He explained that the bureau's priorities, in order of importance, were air pollution control, conversion of coal to synthetic gaseous and liquid fuels, the use of coal to generate electricity, and, finally, the non-energy uses of coal.

In addition to the post-combustion removal of sulfur dioxide from stack gases, the bureau's air pollution abatement efforts concentrated on the pre-combustion removal of pyrite (iron sulfide) from coal. With the enactment of the Air Quality Act of 1967, the federal government designated air quality control regions, and informed state governors that airborne sulfur dioxide of 0.1 part per million over twenty-four hours harmed human health. Crentz explained that "new technology will be required to meet standards of this level."

The bureau developed a scrubbing system using pellets of alkalized alumina as one solution. According to Crentz, the sorbent had excellent properties for absorbing sulfur dioxide, but the bureau had failed to prepare it at a sufficient strength. He said that "we are hopeful that our efforts will be marked with further success in the near future." The bureau's researchers explored the production of elemental sulfur as a marketable byproduct of the dry emissions scrubbing technology, a revenue which could offset the cost of some of the equipment, installation, operations, and maintenance. IMI members and their associates welcomed those ideas into their culture of industry preservation and their vision of a future in which technological advances would enable them to overcome all challenges and fulfil the needs of the nation. The technology of tomorrow stood as a beacon of hope for Illinois coal leaders (Figure 6).[45]

An Industrial Culture

By the onset of the 1970s—an era defined by its national environmental policy reforms and by global energy crises—the leaders of the Illinois coal industry had forged a culture of industry preservation through the generation and circulation of ideas at meetings of the Illinois Mining Institute. The group helped the industry sustain itself and even thrive during times of national prosperity and growth. It modernized the production of its commodity, at first through piecemeal mechanization, and then by large-scale mechanization, systemization, and automation during and after World War II. Forward-thinking engineers and designers looked to a future in which computerization and remote monitoring would allow miners to control autonomous coal extracting systems from the surface. Meanwhile, industry leaders made advancements in coal preparation plants along a similar path of development.

Consumer choice and demand, in combination with competition in the energy market from natural gas and oil, pushed Illinois coal industry insiders to focus also on national research and development trends. The concept of converting coal into gaseous and liquid fuels and marketable byproducts galvanized coal producers to imagine a future of fuels in which technology would propel their business back into a dominant position in the energy market. Similarly, ideas for future technologies offered theoretical solutions to greater control of sulfur dioxide air pollution.

The movement to preserve the Illinois coal industry had existed for many decades, but after the Second World War it expanded in scale and complexity. Illinois coal insiders forged links with technological movements and the national industry, gained a growing sense that the nation's needs depended upon them, and developed a firm belief that technological advancements would continue to provide solutions to any and all future challenges. Some energy analysists predicted (correctly so far) that coal conversion technologies, despite subsidies, could not compete with cleaner, more easily transported, and less expensive natural gas and oil in the gaseous and liquid fuels markets.

Nonetheless, the U.S. government funded coal conversion research for many years. Although private investors increasingly chose not to inject their capital into that enterprise, public administrators continued the fight for one reason above all: national security through energy independence. Americans had a voracious appetite for energy in the postwar years, and the nation's leaders wanted to hedge against potential energy dependence on foreign oil and natural gas from the unstable Middle East. As a result, coal, one of America's most abundant energy resources, remained a key part of the nation's research and development agenda. When the federal government stepped back from funding coal conversion projects, Illinois coal industry leaders continued to promote the transformation of coal into synthetic natural gas and petroleum, especially during the 1970s, by which time fears about the nation's dependence on foreign fuels had come true.

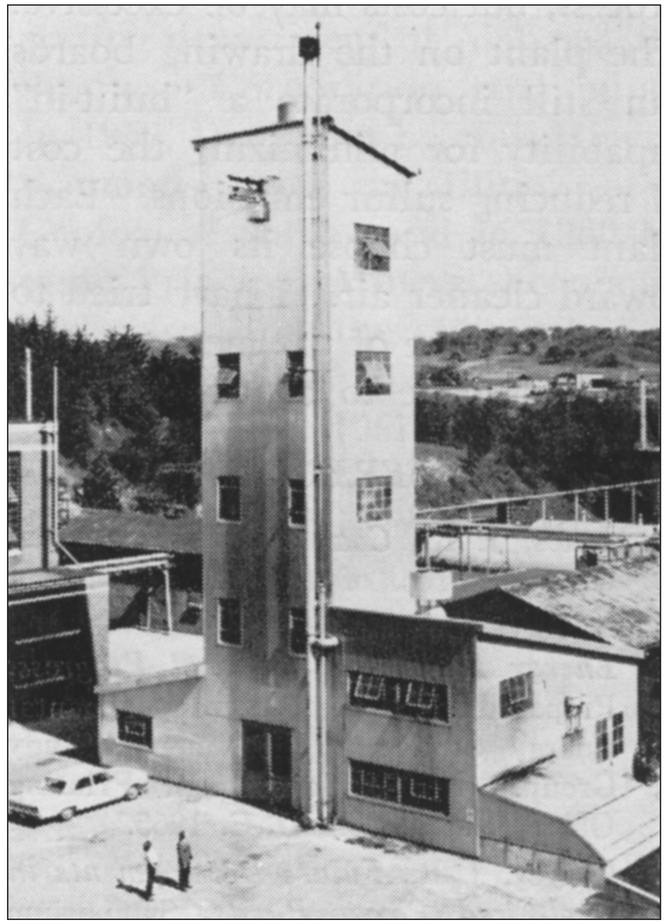
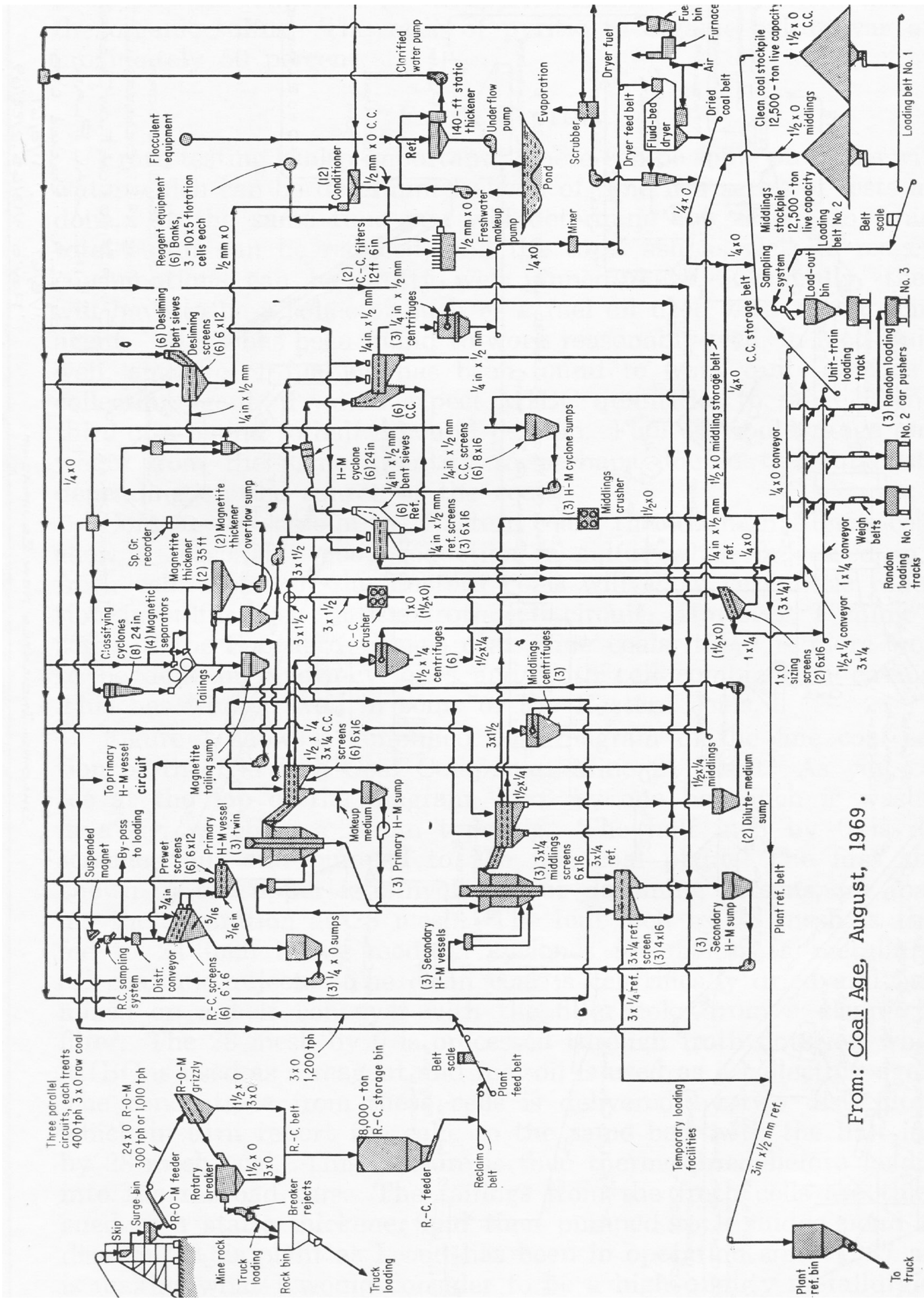


Figure 6. A U.S. Bureau of Mines prototype alkalized-alumina desulfurization unit, commonly called a "scrubber," located near Pittsburgh, Pennsylvania. As federal air pollution regulations began affecting the Illinois coal industry, its leaders looked to emissions-control technology as one possible solution. (From Proceedings of the Illinois Mining Institute*, 1967, 81.)*

In 1993, the Illinois coal industry's efforts to sustain itself began to fail. The 1990 Clean Air Act Amendments (CAAA), signed into law by President George H. W. Bush, severely restricted the amount of sulfur dioxide that utilities could emit from coal-fired power plants. Because Illinois coal is relatively high in sulfur, most utilities switched to burning low-sulfur coal from Wyoming. Utility leaders chose that path rather than installing expensive emissions scrubbers to mitigate sulfur dioxide pollution, a precursor to acid rain.

When the 1990 Amendments' mandates came into effect in 1993, Illinois politicians could not agree on how to address their negative impacts on the state's economy. Eventually, the industry saw a resurgence when Illinois coal leaders integrated their product into the world coal export market. In the 2000s and early 2010s, Asian markets, China and India in particular, began consuming



This line diagram, originally published in Coal Age, *reveals the relative complexity of modern coal preparation plants.* (*From* Proceedings of the Illinois Mining Institute, *1969, 70.)*

substantial quantities of Illinois coal. As a result, the Illinois coal industry survived the aftermath of the 1990 CAAA, but only as a fraction of its former self.[46]

In 2021, Illinois Governor J. B. Pritzker signed the Climate and Equitable Jobs Act, requiring the state's remaining coal-fired plants close by 2030. The law allowed exceptions for two plants, however, both of which must shut down by 2045. One of these, the Prairie State Plant, generated almost one-third of the state's total power production in 2020. Opened in 2012 by Peabody Energy and its partners, the utility burned Illinois coal and stood out as one of the largest coal-fired plants in the United States.

By 2020, however, nuclear power topped energy production in the state, generating over one-half of its energy needs. The state had subsidized the nuclear industry, as it had the coal industry, and had even bailed it out on two occasions when decades-old facilities needed repair. Coal produced 24 percent of the state's power, followed by natural gas at 12 percent, and wind at 10 percent. In 2021, Illinois led the country in nuclear production, and as a result of the 2021 Act it may come to lead the nation in renewable energy as well.[47]

On 30 June 2022, the U.S. Supreme Court announced a ruling restricting the federal Environmental Protection Agency's power to regulate air pollution, shifting jurisdictional authority back to the states. Leaders of some coal-rich states, West Virginia for example, have already announced plans to move back to coal. Recent news also reveals that Germany, a champion of renewable energy, may shift back to coal-fired power generation as a means of conserving natural gas during the 2022 escalation of the Russo-Ukrainian War.

These developments come as little surprise, however, as energy production and use have long had a complex relationship with shifts in political power. Time will tell if the movement to preserve the Illinois coal industry has truly lost the battle. At least the lessons learned from this historical episode can inform future responses to the seemingly inevitable future contests over energy, the environment, resources, and mining industries.[48]

Geoff Lybeck earned his Ph.D. in historical studies from Southern Illinois University, Carbondale in 2022. His dissertation describes the Illinois Coal Industry's struggles on two interrelated fronts during the twentieth century: economic competition from the natural gas an oil industries, and the regulatory pressures galvanized by the clean air movement.

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