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Errata: page 189 of the April 2015 issue of *PMHB* contains several inacurracies regarding the biography of John Cadwalader that have since been brought to the editors' attention. John Cadwalader married twice. His first marriage was in 1768 to Elizabeth "Betsy" Lloyd, of Wye, Maryland. Betsy had three daughters, Anne, Elizabeth, and Maria, but died of complications eleven days after Maria's birth, in February of 1776. John remarried in 1779 to Williamina "Willy" Bond (1753–1837). Together the couple had three children: two sons, Thomas and John (who died in infancy of smallpox), and a daughter, Frances. An updated description for the John Cadwalader Estate Volume (Collection 3831) can be found online at http://discover.hsp.org/Record/ead-3831.

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Editorial

The history of Pennsylvania is inextricably linked to the history of energy—from the forests and waters of Penn Woods, to the anthracite and bituminous coal fields of the northeast and southwest corners of the state, to the natural gas trapped in the state's Marcellus Shale formation. Today, Texas may be the nation's leading energy producer, but it was Pennsylvania energy that powered much of America's industrial revolution. In the twenty-first century, energy production and consumption remain central to the state's economy. Over the last few years, according to the US Energy Information Agency, Pennsylvania has been the second-largest producer of natural gas and nuclear energy in the nation and the fourth-largest producer of electricity and coal (as well as the only state that mines higher heat–producing anthracite). Nationally, Pennsylvania is ranked third in total energy production. It is also, unfortunately, ranked third in total carbon dioxide emissions.[1]

Energy—its production and consumption and its role in development and in devastation, both human and environmental—is central to Pennsylvania's history, present, and future. It is therefore appropriate that we dedicate this special issue to the history of energy in the commonwealth, in the hope that by better understanding this important past, we can make more informed decisions about our future.

[1] US Energy Information Administration, Independent Statistics & Analysis: Pennsylvania, http://www.eia.gov/state/overview.cfm?sid=PA, accessed Sept. 28, 2015.

Guest editors Brian Black and Donna Rilling bring their combined expertise to this issue. Brian Black is professor of history and environmental studies at Penn State, Altoona, and he has written extensively on the history of oil, gas, and the environment. Donna Rilling, professor of history at Stony Brook University, focuses on the history of early American work, business, and the economy; she is currently working on a project on early industrial pollution in the Delaware Valley. They have selected articles that comment on a wide range of Pennsylvania energy sources—from water and animal power to electricity and natural gas—and that examine these sources' creative as well as destructive potential. This issue does not, however, attempt to be comprehensive—and, as the essays make clear, there are many subjects in need of further study.

Beyond the importance of the topic, this issue of the *Pennsylvania Magazine of History and Biography* is significant for other reasons. As regular readers of *PMHB* will have noticed, there was no July issue this summer. This year *PMHB* moved to a new production schedule, publishing three issues per year, in January, April, and October, with the October issue being a double issue on a special topic. Readers can expect future special issues on the history of immigration and ethnicity, education, and more.

Finally, this is my last issue as editor of *PMHB*. With this issue I finish thirteen years of editing this journal. With you, I have learned a lot of fascinating history through its pages. I leave the journal in the very capable hands of its new editor, Christina Larocco, and managing editor, Rachel Moloshok. Christina received her PhD from the Department of History at the University of Maryland, College Park, and her research has focused on the culture and thought of twentieth-century social movements. Rachel, who received her MA in history from Northeastern University, has been the assistant editor of *PMHB* for the past four years. I look forward to watching *PMHB* grow under their stewardship.

Tamara Gaskell
Editor

Introduction

"Fracking Means Jobs"; "New Well Severance Tax Would Stifle Job Growth and Economic Benefits of Pennsylvania's Energy Development"; "Methane Emissions from Oil and Gas Sector Found to be Much Greater than Expected." What newspaper reader in Pennsylvania today hasn't regularly encountered such headlines? From developing new pipelines and cracker plants that break down petrochemical and fracking residue to defining standards for the allowable toxicity of fluids used or created in the conversion of shale into natural gas, Pennsylvania remains one of the nation's hot spots for energy development as it continues its historical practice of extraction and expansion into other forms of energy.

For more than a century, fossil fuels have defined the lives of every American, and few states have contributed more to this bounty than Pennsylvania. The commonwealth's diverse energy resources have been repeatedly connected to markets and converted into power and commodities. Pennsylvania has been a place where innovators attempted pioneering techniques and developed new technologies. Although its energy history has exerted a significant toll on Pennsylvania's environment and citizens, it has also enabled the state to lead the nation into and through the industrial age. Today, as yet another energy frontier emerges—natural gas mined from shale—investigating ways that various energy forms were developed in Pennsylvania is particularly compelling. Thus, a special issue of the *Pennsylvania Magazine of History and Biography* on Energy in Pennsylvania is timely.

The following pages offer some historical context for our current gas boom as well as for other energy opportunities that will emerge in the twenty-first century. The flexible nature with which energy winds its way through everyday human life has inspired the editors to choose essays that represent various stops on the life cycle of energy use. In the first essay, Frederick Quivik examines Philadelphia's Point Breeze petroleum refinery and storage site to reveal the tensions between oil production and hazards to humans and the environment. Louis Carlat and Daniel Weeks, in the second selection, show how Thomas Edison and his managers and partners approached technological, structural, financial, and human barriers to bring electrification to residents of towns in middle Pennsylvania in the late nineteenth century. In the third contribution, Joel Tarr and Karen Clay find in early natural gas development in Pittsburgh a precursor for much of what we see unfolding today in the Marcellus Shale and in other parts of the United States, though the experiences and environmental consequences of nineteenth- and early twentieth-century gas drilling have been largely ignored by today's producers and regulators. A review essay by Brian Black, Ann Greene, and Marcy Ladson surveys exciting new literature on energy history while also noting opportunities for further investigation. Allen Dieterich-Ward provides a close review of three recent important scholarly works in the field. Finally, a selection of short essays on "Hidden Gems" for those interested in further exploring Pennsylvania's energy history highlight energy sources such as wood, charcoal, water, and coal that were critical to colonial Pennsylvanians and the state's early industrialists. The gems also point to some of energy's cultural dimensions, be it in singular creations of models of automobile America or in ideas about abundance that supported profligate use of the region's vast sylvan lands.

Whether it is gathered from turbines atop our ridges or layers of shale buried deep below, there can be little doubt that energy will continue to play an important role in life in Pennsylvania. While the historical stories are full of personal drama and fascinating technical innovations, the true imperative for historians derives from the need for us to draw from past patterns and practices to inform this current and future development.

Penn State Altoona Brian C. Black
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REVIEW ESSAY

Energy in Pennsylvania History

ENERGY REPRESENTS A LENS through which some of the most unique and compelling insights about human life in the commonwealth may be viewed. Every type of American prime mover—the power to do work—has been harvested and used in Pennsylvania and, in the process of its use and management, has defined entire regions of the state. Exciting new scholarship—as well as new readings of existing literature—is teaching us much about this important history while also pointing us to promising areas for future inquiry.

In his recent book, *Routes of Power: Energy and Modern America*, Christopher Jones provides new terminology to allow us to organize Pennsylvania's energy history. He urges us first that each energy regime—an identifiable period of predominant reliance on a specific source of power—"was neither natural nor inevitable." Coining the term "landscapes of intensification," Jones continues:

> In conjunction with the activities of energy entrepreneurs, economic incentives, and new consumer behaviors, these material alterations of the environment transformed the nation's energy practices. The roots of America's energy transitions can be found in the building of routes along which coal, oil, and electricity were shipped.[1]

In short, energy development has a physical impact on its surroundings, and moments of change (such as intensification or take-off) are particularly revealing. Any investigation of such corridors and transitions, of course, pulses through and from Pennsylvania history—possibly making the commonwealth the single most significant site of energy "intensification" that our nation has seen.

[1] Christopher F. Jones, *Routes of Power: Energy and Modern America* (Cambridge, MA, 2014), 2. This book is discussed at length, alongside Sean P. Adams's *Home Fires* and Andrew Arnold's *Fueling the Gilded Age*, in a review by Allen Dieterich-Ward in this issue.

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Pennsylvania's landscape is a text containing each of Jones's regimes and transitions; indeed, historians who write about energy from a national or global perspective frequently use Pennsylvania as a case study. Fossil fuels have defined much of its energy story since the early 1800s, as the commonwealth led the nation into regimes organized by, successively, coal, petroleum, and natural gas. Although Pennsylvania ceased to be a major source of oil in the twentieth century, it was the birthplace of the first commercial industry and many of the modern-day corporations that have led the global quest for crude. Coal and natural gas continue to shape the state's history and terrain today.

In addition to towns, canals, and pipelines, the landscapes of energy encompass old mine tunnels, culm banks, acidified streams, long-wall surface mine scars, gas well derricks, pipeline alleys, coal slurry and fracking fluid holding ponds, and other physical manifestations of the extraction process. They also contain the coal company patch towns and other built landscapes that testify to the defining role of human labor in energy extraction. In a sometimes overlooked connection between environmental history and labor history, the exploitation of people often parallels the exploitation of the environment in the commonwealth. Working people have used and shaped the landscape as an ally in struggles with the power of industrial capitalism even as some of the greatest fortunes of the industrial era grew from the resources drawn from the mountains of Pennsylvania.

Energy history is an essential aspect of the role Pennsylvania has played in our nation's past and will continue to play in its future. Our goal in this essay is to identify key works in the scholarship about Pennsylvania's energy history and to suggest promising areas for future study. In the spirit of the work of Jones and others, any such overview must explore the definition of energy. When we do so, we find that landscapes of power are also marked by complex connections between mining, processing, and transmission. Even our idea of landscapes must expand as we consider means of transferring energy that preceded the harvest of fossil fuels. In short, we find that human life in the commonwealth has, from its beginning, been built around various methods of transforming energy into work and that future histories may assist in telling this story more completely.

Early Patterns of Energy: Water, Timber, and Animal Power

The efforts of industrialists to develop Pennsylvania's energy resources began with the land's ubiquitous waterways. Native peoples and European settlers had often created their communities on the banks of rivers and streams; it made sense to apply in the commonwealth the milling technologies modeled in New England and elsewhere. The first element of the landscape to be regarded an energy commodity was very likely these rivers and streams.

Some of the earliest industrial historians have emphasized waterpower, among them Louis C. Hunter, who wrote the seminal work *A History of Industrial Power in the United States, 1780–1930*. Hunter's study, combined with newer titles such as Donald C. Jackson's *Pastoral and Monumental*, provide the necessary context for approaching the preeminent work in the field.[2] Anthony F. C. Wallace's *Rockdale: The Growth of an American Village in the Early American Revolution*, a bedrock study for many students of material culture, provides a careful anthropologic enumeration of the cultural impact of early industrialization in the Philadelphia region.[3] Of course, the real story of industrialization is that the early patterns of energy use will be overwhelmed by the scale and scope of expansive fossil fuel. This distinction, however, makes *Rockdale* a superb primer for understanding different levels of industrialization.

Canals—particularly those in Pennsylvania, such as the Main Line—have received scarce historical consideration. Sources on neighboring (and competing) canal systems, such as Carol Sheriff's *The Artificial River: The Erie Canal and the Paradox of Progress, 1817–1862,* may provide a template for future scholars to apply to the canals of Pennsylvania. At present, readers should consider Robert J. Kapsch, *Over the Alleghenies: Early Canals and Railroads of Pennsylvania*, or Ronald E. Shaw, *Canals for a Nation: The Canal Era in the United States, 1790–1860*. Other historians such as Donna Rilling and Joel Tarr have used the era of waterpower and canals to explore larger, related questions such as industrial pollution and sewage technology.[4]

[2] Louis C. Hunter, *A History of Industrial Power in the United States, 1780–1930*, 3 vols. (Charlottesville, VA, 1979–86, and Cambridge, MA, 1991); Donald C. Jackson, *Pastoral and Monumental: Dams, Postcards, and the American Landscape* (Pittsburgh, 2013).

[3] Anthony F. C. Wallace, *Rockdale: The Growth of an American Village in the Early American Revolution* (New York, 1978).

[4] Carol Sheriff, *The Artificial River: The Erie Canal and the Paradox of Progress, 1817–1862* (New York, 1996); Robert J. Kapsch, *Over the Alleghenies: Early Canals and Railroads of Pennsylvania* (Morgantown,WV, 2013); Ronald E. Shaw, *Canals for a Nation: The Canal Era in the United States, 1790–1860* (Lexington, KY, 1990). See for instance, Joel A. Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron, OH, 1996).

Forest use has received little specific treatment by historians of Pennsylvania; readers are likely best served to refer to Michael Williams's general work *Americans and Their Forests: A Historical Geography*.[5] Efforts to convert Pennsylvania's expansive forests into fuel have, similarly, received minimal historical consideration. The use of timber for charcoal, particularly in the iron industry, provides a crucial model of the intensification of industrialization in the commonwealth. Historians have yet to create literature that properly places timber harvest and iron—subjects superbly interpreted at historical sites such as Hopewell Furnace—as an important crossroads—or site of intensification—in our use of energy.

In the instructive work, *The Texture of Industry*, Robert B. Gordon and Patrick Malone catalogue the material culture of early industrialization in North America. In addition, Gordon's *A Landscape Transformed*, which studies the iron industry in Salisbury, Connecticut, provides a wonderful example of what a similar study of Pennsylvania could follow.[6] Each of these studies grows from the field of industrial archaeology, which is well represented in many of the historically preserved sites of industry in Pennsylvania. However, these focused studies often overlook the larger context of energy use represented by such industrial sites.

The major prime mover of early settlement in Pennsylvania and elsewhere lived and labored among the human community. The work animal population, consisting primarily of horses, mules, and oxen, expanded sixfold during the nineteenth century and continued to increase into the second decade of the twentieth century. (During this same period, by contrast, the human population merely tripled.) As Dolores Greenberg shows in her essay "Energy Flows," the majority of power used by Americans came from animal sources until the 1870s.[7] At the turn of the twentieth century, animal energy still accounted for one-third of energy consumed. And even as the percentage of energy from animal power declined relative to all energy consumed, the amount of energy from work

[5] Michael Williams, *Americans and Their Forests: A Historical Geography* (Cambridge, 1989); Donna J. Rilling, "Sylan Enterprise and the Philadelphia Hinterland, 1790–1860," *Pennsylvania History* 67 (2000): 194–217.

[6] Robert Boyd Gordon and Patrick Malone, *The Texture of Industry: An Archaeological View of the Industrialization of North America* (Oxford, 1994); Gordon, *A Landscape Transformed: The Ironmaking District of Salisbury, Connecticut* (Oxford, 2000).

[7] Dolores Greenberg, "Energy Flow in a Changing Economy, 1815–1880," in *An Emerging Independent American Economy, 1815–1875*, ed. Joseph R. Frese and Jacob Judd (Tarrytown, NY, 1980), 28–58.

animals continued to increase until 1930. It is safe to say that until World War I it would be difficult to find a product in the United States that did not involve animal power in its production, processing, transport, or marketing at some point in its life cycle. There was no separate animal energy economy; animal energy was embedded in the economy.

In addition to Greenberg, a number of scholars have studied animal power. Clay McShane and Joel Tarr, for example, focus on the urban horse, arguing that as "living machines," horses were indispensable to the nineteenth-century city and that urban history cannot be understood without understanding the role of horses. Horses shaped and were shaped by urban environments. In focused chapters addressing horse markets, regulation of horse use and behavior, mass transit, recreation and leisure activities with horses, stables and the built environment, nutrition, and health, McShane and Tarr provide a comprehensive view of the city as a world of both horses and humans.[8]

Most recently, Ann Norton Greene's *Horses at Work: Harnessing Power in Industrial America* disputes the conventional narrative of industrialization—"machine replaces muscle"—by demonstrating that, contrary to popular and scholarly belief, the first wave of industrialization had quite the opposite effect on the use of animal energy. She explores the cultural and biological choices that defined the American workhorse population and traces the rising use of animal energy through the transportation and market revolutions, the Civil War, and postbellum urban and agricultural expansion. Greene argues against deterministic explanations for the decline of animal power that occurred after 1915, exploring the social, cultural, and political factors that favored automotive technologies and tracing the gradual, complicated decline of animal power across the first half of the twentieth century [9]

Coal and Industrial Intensification

Scholars have carefully considered the commonwealth's primary energy source, coal, from a number of angles. Thomas Dublin and Walter Licht's *The Face of Decline: The Pennsylvania Anthracite Region in the Twentieth Century* remains the crucial initial reading for the pattern of extraction

[8] Clay McShane and Joel A. Tarr, *The Horse in the City: Living Machines in the Nineteenth Century* (Baltimore, 2007).

[9] Ann Norton Greene, *Horses at Work: Harnessing Power in Early America* (Cambridge, MA, 2008).

and decline that has proven to be the legacy of anthracite mining. Sean Patrick Adams's *Old Dominion, Industrial Commonwealth: Coal, Politics, and Economy in Antebellum America* analyzes the political importance of coal to the entire mid-Atlantic region in the 1800s.[10]

Historians have produced a number of excellent works on the history of coal that are specific to Pennsylvania and the surrounding Appalachian region.[11] Studies by Janet MacGaffey and Karen Metheny examine Pennsylvania's history of energy extraction on very local scales, one focusing on the eastern anthracite coal fields, the other on the western bituminous region. Both scholars have personal connections to coal miners in Pennsylvania's landscape of extraction. These works, in common with other histories from below, draw on the tools of social science, anthropology, and historical archaeology as well as more conventional archival research. Among other similarities, they both investigate why place matters so much to the residents of these areas now that mining jobs are mostly gone.

In *Coal Dust on Your Feet: The Rise, Decline, and Restoration of an Anthracite Mining Town*, Janet MacGaffey draws on her personal contacts in Coal Township to highlight the importance of community in the hard coal region of northeastern Pennsylvania.[12] She recounts the experiences of miners and their families, beginning with their southern and eastern European origins and continuing through their early struggles as new immigrants during the anthracite boom, the eventual decline of the regional mining industry, and the current challenges their children and grandchildren face to keep the town alive. Immigrants drew on survival skills initially learned from the dangerous and oppressive conditions that drove them from Europe to the mining towns. They forged strong communities based on broad ethnic identities formed after they reached America. The resultant community solidarity and mutual help enabled the miners to support strong labor unions and to resist (to some extent) their exploitation by mine company owners.

[10] Thomas Dublin and Walter Licht, *The Face of Decline: The Pennsylvania Anthracite Region in the Twentieth Century* (Ithaca, NY, 2005); Sean Patrick Adams, *Old Dominion, Industrial Commonwealth: Coal, Politics, and Economy in Antebellum America* (Baltimore, 2004).

[11] In addition to the works discussed here, see Chad Montrie, *To Save the Land and People: A History of Opposition to Surface Coal Mining in Appalachia* (Chapel Hill, NC, 2003); and Shirley Burns, *Bringing Down the Mountains: The Impact of Mountaintop Removal on Southern West Virginia Communities* (Morgantown, WV, 2007).

[12] Janet MacGaffey, *Coal Dust on Your Feet: The Rise, Decline, and Restoration of an Anthracite Mining Town* (Lewisburg, PA, 2013).

Landscape and place, MacGaffey stresses, continue to impact the inhabitants of Shamokin and Coal Township. The countryside is scarred with old mine pits and culm waste banks, juxtaposed with gold church cupolas. These markers of place record the history of hard rock mining, labor struggles, ethnic heritage, and human endeavor and perseverance. Miners partnered with the landscape in their labor struggles; when out of work or on a prolonged strike, they depended on food they grew and gathered, animals they raised, and fuel they scavenged for subsistence. The attachment to place that was fostered continues to exert a powerful influence, even on those many inhabitants who have moved away or eventually retired in the town.

Karen Metheny likewise studies Pennsylvania's landscape of extraction and the relationship between people and place. In *From the Miner's Doublehouse: Archaeology and Landscape in a Pennsylvania Coal Company Town*, she combines environmental and social history and material culture methods to demonstrate the landscape's cultural meaning during the nineteenth century.[13] Metheny examines the agency of miners and their families who inhabited the coal-patch company town Helvetia, Clearfield County, a product of the Rochester and Pittsburgh Coal Company located in the soft coal region of western Pennsylvania. The company town and its infamous company store have long been treated by historians as symbols of capitalist domination and corporate paternalism. But in recognizing working-class resistance only in the disruptive activities of labor movements and unionization, Metheny argues, scholars have neglected to see the empowering force of community stability and cooperation and the reciprocal exchange of influence between capital and labor. Metheny finds that despite the exploitation and dominance exercised within this order, mining families constructed a physical and cultural landscape that gave them a measure of control over their lives.[14]

In Helvetia, as in Shamokin, people used the landscape to improve the quality of their lives, particularly to gain a measure of food independence. Helvetians also shaped their environment to compensate for the ugliness of the mined landscape, planting trees and flowers and distinguishing Helvetia among company towns for its attractive, well-kept appearance. The company owners also participated, underwriting the installation of

[13] Karen Bescherer Metheny, *From the Miners' Doublehouse: Archaeology and Landscape in a Pennsylvania Coal Company Town* (Knoxville, TN, 2007).

[14] Ibid., xvii–xviii.

tidy cement walkways and giving substantial cash prizes to winners of gardening contests.

Pennsylvania is important in energy studies of large cities as well as small mining towns. In *Energy Capitals: Local Impact, Global Influence* contributors examine the importance of place and fossil fuel extraction in urban centers, including Pittsburgh.[15] Editors Joseph Pratt, Martin Melosi, and Kathleen Brosnan, citing historian Alfred Crosby, characterize modern civilization as the result of an "energy binge" based on coal, petroleum, and natural gas. In this sense, all urban spaces are shaped by fossil fuel use.[16] However, in the places described as "energy capitals," energy extraction and consumption has had a particularly profound and long-term effect on the environment as well as on social conditions, including local economies, infrastructure, labor markets, educational opportunities, public health, and political and cultural climates.[17] The cities examined in this volume—Pittsburgh; Houston; Los Angeles; Perth, Australia; Stavanger, Norway; Calgary, Canada; Tampico, Mexico; Port-Gentil, Gabon; and various locations in Louisiana—exemplify the close and self-reinforcing interconnections between expanding energy use, urban growth, and environmental degradation that are so integral to the modern world.

As these sources demonstrate, studies of coal frequently emphasize the social implications of energy extraction. In *Coal: A Human History*, Barbara Freese provides a concise overview of both the creative and destructive power of coal as a shaper of civilization on a grand scale.[18] Freese examines three areas of the world: Great Britain, China, and the United States, where her discussion focuses primarily on Pennsylvania. Freese provides a thorough accounting of coal's role in nineteenth- and twentieth-century energy transitions and in establishing "routes of power." Pittsburgh, situated over the wide soft coal formation at the forks of the Ohio River, was uniquely positioned to develop as a major industrial center. As "the smokiest city in the western hemisphere," it followed an accelerated version of the British switch to mechanized steam-powered manufacturing.[19] In eastern Pennsylvania, the discovery of anthracite hard coal at the turn of the nineteenth century

[15] Joseph Pratt, Martin Melosi, and Kathleen Brosnan. eds., *Energy Capitals: Local Impact, Global Influence* (Pittsburgh, 2014).

[16] Ibid., xiii.

[17] Ibid., xi.

[18] Barbara Freese, *Coal: A Human History* (Cambridge, MA, 2003).

[19] Ibid., 109.

initiated the shift away from the widespread use of wood fuel, as well as dependence on waterpower in the textile mills of the northeastern United States. Philadelphians began to heat their homes with anthracite coal in the late 1700s; although difficult to ignite, it burns cleaner than soft bituminous coal or seasoned firewood. The first canal in Pennsylvania, the Schuylkill Canal, linked the state's hard coal regions of the Northeast with consumers (and exporters) in Philadelphia, and other canals soon followed that expanded this network throughout the mid-Atlantic region. The transportation of coal stimulated the construction of railroads as well.

During the nineteenth century, the magnates of "King Coal" and their associated railroads accumulated enough wealth, power, and political influence to arouse public outrage. Even more disturbing were the violent labor disputes between management and miners' groups as laborers attempted to gain some control over the difficult and dangerous conditions of their lives. One such group was the Molly Maguires of the anthracite fields. The use of soft coal, which led to badly polluted air in cities such as Pittsburgh, also prompted citizen activism. Nevertheless, Freese's synthesis shows that until the 1920s, it would have been difficult for anyone to envision a modern industrial economy that did not depend primarily on coal. Pennsylvania's history supports this claim.

Petroleum and the Boomtown Model

Landscapes of intensification involve a shift in priorities and ethics that can often be observed in land-use patterns. The concept of the ethic of extraction evolves in Brian Black's *Petrolia: The Landscape of America's First Oil Boom*.[20] His analysis grows partly from the work of cultural geographer John Brinckerhoff Jackson, who contends:

> no group sets out to create a landscape. . . . What it sets out to do is to create a community, and the landscape as its visible manifestation is simply the by-product of people working and living, sometimes coming together, sometimes staying apart, but always recognizing their interdependence. . . . It follows that no landscape can be exclusively devoted to the fostering of only one identity.[21]

[20] Brian Black, *Petrolia: The Landscape of America's First Oil Boom* (Baltimore, 2003).

[21] John Brinckerhoff Jackson, *Discovering the Vernacular Landscape* (New Haven, CT, 1984), 12. The natural environment bears little pertinence in Jackson's landscape hierarchy unless it is set off by human boundaries for some cultural reason, such as preservation or conservation.

Under this logic, it would seem that a community organized under a single motivation is incapable of sustaining itself. No built landscape better exemplifies this logic than the boomtown, particularly one so completely dependent on the single commodity for which it has been organized that it ceases to exist when that commodity is exhausted. Although many extractive communities fit into this category, the oil boomtown—as exemplified by a Pennsylvania town known as Pithole—may best demonstrate the transience of a place based on the ethic of extraction.

Pithole developed in a backwards fashion. Although it had the trappings of a regular community, Pithole was essentially a large oil camp, entirely dependent on laborers and the crude that they would generate for lubrication and refinement into kerosene. At the peak of Pithole's production in October 1865, it supplied at least six thousand of the nine thousand gallons produced in the entire Pennsylvania oil region. Of this supply, over half came from just two wells. In a place where the product was the only rationale for development, these two wells sustained the largest town in the oil region, and yet few voiced concern about wells running dry. The town of Pithole, similar to many energy boomtowns, existed only for oil.

But supply would be only one of the problems confronting Pithole. As Black describes in *Petrolia*, from December 1865 through January 1866, Pithole experienced one fire per week. Throughout the rest of 1866, Pithole experienced one fire after another. But Pithole had no ability to cope with a large fire or even to notify its occupants in the event of one's occurrence. In the end, local apathy and the inability to rally any sort of community sentiment thwarted attempts to stabilize the town. By January 1866, the population had fallen to barely four thousand. Then the oil supply began giving out as well. In February 1867 another fire destroyed almost all of the remaining businesses in Pithole. Under the model of the ethic of extraction, this was a job well done.[22]

From this specific case study of oil in Pennsylvania, energy historians have traced the global dimensions of petroleum in books such as Black's *Crude Reality* and the emergence of the field of petroleum geology in studies such as Brian Frehner's *Finding Oil* and Paul Lucier's *Scientists and Swindlers*. Jones's *Routes of Power* also includes a fascinating chapter on the corporate and industry systems that were introduced through Pennsylvania's experience with crude. Finally, working from an angle of business history, Jon Wlasiuk's work on the history of Standard Oil, "A Company Town

[22] Black, *Petrolia*, 234.

on Common Waters," was recently published in *Environmental History*.[23]

As Black's *Petrolia* demonstrates, extraction of petroleum—unlike coal or natural gas—expanded from Pennsylvania to the farthest reaches of the earth, including the deep ocean. By the 1990s, even the corporate headquarters of the industry—for companies such as Quaker State and Pennzoil—left their roots in the commonwealth for new destinations, such as Houston. The legacy of Pennsylvania crude, therefore, became almost entirely the domain of historians.

The Emergence of Natural Gas

Such energy transitions, of course, have not necessarily meant that patterns of development, such as boom, also left the commonwealth. New drilling technologies and higher energy prices fueled a twenty-first-century boom in natural gas that continues to play out in the present; however, history can contribute mightily to the resource's development by providing lessons and guidance from past episodes.

In the chapter on Pittsburgh in *Energy Capitals*, Joel Tarr and Karen Clay argue that energy capitals that persist in the long term are those that make successful transitions between energy regimes.[24] For Pittsburgh, the most significant transition has been between coal and natural gas. Coal initially fueled the development of industrial Pittsburgh, but it also produced the air and water pollution that motivated city leaders to look for cleaner alternative fuel. In the late nineteenth century the city experienced a short-lived transition to natural gas. The skies cleared, and people enjoyed a cleaner environment and better health—until the shallow local gas wells were exhausted and the smoke returned. Then, in the mid-twentieth century, pipelines transported natural gas from the southwestern United States to Pennsylvania, contributing to the success of the Pittsburgh Renaissance urban renewal project.

[23] Brian C. Black, *Crude Reality: Petroleum in World History* (Lanham, MD, 2012); Brian Frehner, *Finding Oil: The Nature of Petroleum Geology, 1859–1920* (Lincoln, NE, 2011); Paul Lucier, *Scientists and Swindlers: Consulting on Coal and Oil in America, 1820–1890* (Baltimore, 2008); Jones, "Pennsylvania's Petroleum Boom," in *Routes of Power*, 89–122; Jonathan Wlasiuk, "A Company Town on Common Waters: Standard Oil in the Calumet," *Environmental History* 19 (2014): 687–713.

[24] Joel A. Tarr and Karen Clay, "Pittsburgh as an Energy Capital: Perspectives on Coal and Natural Gas Transitions and the Environment," in *Energy Capitals*, 5–29. Joel Tarr has written extensively on Pittsburgh's environmental history. On urban air, water, sewage, and mining pollution, see Joel A. Tarr, ed., *Devastation and Renewal: An Environmental History of Pittsburgh and Its Region* (Pittsburgh, 2003). In addition, Joel A. Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron, OH, 1996), draws heavily on case studies from Pennsylvania and the Ohio River valley.

Tarr and Clay primarily describe the uses and effects of natural gas in the late nineteenth and early twentieth centuries, during a boom in gas production from shallow wells. Tom Wilber addresses the Pennsylvania boom that began in about 2005 in *Under the Surface: Fracking, Fortunes, and the Fate of the Marcellus Shale*.[25] Wilber's work concerns the history of events dictated by local conditions in Dimock, Pennsylvania, on the New York border. However, he connects those events with larger issues of global warming, environmental sustainability, energy independence, land use, public policy, and the effects of poverty and wealth. Wilber frames his narrative of the Marcellus Shale gas boom by arguing that there is a parallel between the geological forces that produced the formation and the social forces that shape the destiny of the people who live above it:

> In all these shale gas regions, the relationships people have with the land, and with their neighbors, are as complicated and multidimensional as the topographical and geological terrain. Here, too, there are cracks. They are created by forces that sometimes pull in opposite directions, at other times collide with great force, and often are buried from view.[26]

Drawing on the findings of Penn State University geosciences professor Terry Engelder, Wilber presents detailed information on the extent and potential reserves in the Marcellus Shale formation and explains the new extraction technologies of horizontal drilling and hydraulic fracturing, or fracking. He describes the physical effects of this method of gas drilling—the damage to land and water supplies, the noise, dust, and danger of explosions, and the fragmentation of forests and roads—and also examines the characters and actions of the residents of Dimock, who live in a region with relatively few economic opportunities but a long history of resource extraction, beginning with timber. Nevertheless, some local people who would never have self-identified as environmentalists have become "accidental activists" as they learned the extent of the impact that fracking caused. Histories of events concerning natural gas in the Marcellus Shale have a way of turning into something more like journalism, because fracking there is so recent and so controversial. Yet the conditions Wilber describes, during the first frenzied rush by gas companies to secure drilling leases, have already changed as efforts galvanize to resist development.

[25] Tom Wilber, *Under the Surface: Fracking, Fortunes, and the Fate of the Marcellus Shale* (Ithaca, NY, 2012).

[26] Ibid., 8.

Energy in a National and Global Context

The commonwealth's role in each of the fossil fuel industries has drawn the state's economy into a national and global context that is organized by humans' growing reliance on inexpensive energy. For many of these micro-histories of the commonwealth or region, energy's broader considerations fall outside of the author's purview. Including these specific stories within a wider lens offers a promising avenue for future scholarship. For instance, Freese's *Coal* begins with an elementary discussion of the way plants transform and store solar energy and the geological processes by which plants became coal. Her effort to connect this well-known resource to its organic roots provides a context that similarly allows us to see all energy use as an organic portion of the human existence; variations in use and transitions between sources, as Jones and others have pointed out, then extend an understanding of energy use that is informed by environmental history.

Even though petroleum became the most important fuel during the twentieth century, coal interests still possessed significant wealth and political power. These interests were and are able to resist efforts to combat climate change caused by the greatly increased levels of atmospheric carbon dioxide from fossil fuel combustion. Freese's narrative of coal consumption in China focuses primarily on the problems inherent in China's use of coal to modernize industry and stimulate economic growth. Chinese leaders have recently become more aggressive in dealing with their nation's extremely high level of air pollution and greenhouse gas emissions. However, their pollution problems, combined with those of other industrialized and industrializing nations, are truly a global concern. As a product of coal use, these larger implications become a portion of Pennsylvania's energy legacy that is worthy of exploration by historians who wish to understand Pennsylvania's place in the larger world.

In *The End of Energy: The Unmaking of America's Environment, Security, and Independence*, Michael Graetz provides a valuable overview of these interdependent factors concerning energy production and consumption in the last forty years.[27] Despite the complex and contingent nature of fossil fuel usage, Graetz claims, there is one simple underlying thread: the artificially low price. He argues that American energy producers and consumers have never paid the actual cost of the energy that fuels the modern world

[27] Michael Graetz, *The End of Energy: The Unmaking of America's Environment, Security, and Independence* (Cambridge, MA, 2011).

and that the most effective way to address the current state of energy-related environmental and political crises is to pay the real price of energy.[28]

Graetz puts oil at the center of his narrative, but he also demonstrates how coal and natural gas are essential to the story. The 1970s oil shocks prompted a renewed interest in domestically produced energy. Coal was an important component, despite the difficulties and hazards of extraction, transportation, and environmental degradation associated with its extraction and use. American policy makers of the time referred to the United States as the "Saudi Arabia of coal," suggesting that developing such a resource trumped other considerations.[29] For a few years Pennsylvanian and other eastern coal companies profited from the increased demand and relaxed regulation designed to encourage the use of coal. However, a number of factors—including labor activism in the unionized eastern coal fields, legislation such as the Surface Mining and Reclamation Act, and amendments to the Clean Air Act that created demand for low-sulfur western coal—combined to favor coal production in western states.

Similar to oil, natural gas was in short supply in the late 1970s. The winter of 1977 was unusually cold, and natural gas shortages prompted factory layoffs and school closings in the Northeast and the upper Midwest. The southwestern oil fields were producing plenty of gas, but a complicated system of federal price regulation designed to protect consumers had discouraged interstate gas sales. Gas is in many ways a more desirable and less polluting fuel than oil or coal, but it is more difficult to transport. The infrastructure of pressurized pipelines required to move it caused the federal government to regulate natural gas as a public utility and natural monopoly. Graetz summarizes the subsequent legislative battles that resulted in the Natural Gas Act of 1978, which did not deregulate gas prices but encouraged production sufficiently to cause gas surpluses, while also encouraging deep-well drilling.

Natural gas produced in Pennsylvania has been an important part of the nation's energy supply for a century, and the Marcellus boom has generated public and scholarly interest. The social and environmental impact of the twenty-first-century gas boom currently receives a high level of popular and scholarly attention. In recent years, major newspapers have dedicated special sections for coverage of gas drilling. Josh Fox's 2010 documentary film *Gasland*, in which the resident of a Pennsylvania gas field famously

[28] Ibid., 7.
[29] Ibid., 79.

set the water coming from his kitchen tap on fire, has aroused considerable controversy.[30] Authors of popular books explore the impact of the new drilling boom on people in Appalachian regions.[31] Scholarly researchers study the social effects of new fracking technologies.[32] However, less attention has been paid to the history of drilling for natural gas in Pennsylvania in earlier decades. As in Graetz's work, nearly all the existing political and economic history of natural gas is concerned with what happened after gas left the wellhead. Little has been written about what was happening on the ground, in the countryside, as gas companies and landowners negotiated gas exploration and extraction.[33] Yet, the experiences of rural residents who were affected by the energy extraction process in the 1970s and 1980s would be well worth examining as important context for the Marcellus Shale boom.

Conclusion

Energy transitions, writes Jones, "are reorientations of how people live, work, and play."[34] Particularly in the commonwealth, energy landscapes clearly represent history worth preserving. They provide evidence that mutability is a leading characteristic of energy acquisition and use. Equally mutable is the wealth that derives from energy. In the nineteenth century, under the leadership of J. Edgar Thomson, the Pennsylvania Railroad was the largest publicly traded corporation in the world. A quarter of a million people worked for it, and it had a bigger budget than the United States government. Part of its success came from Thomson's willingness

[30] *Gasland*, directed by Josh Fox (New York, 2010).

[31] For well-received examples see Wilber, *Under the Surface*; and Seamus McGraw, *The End of Country: Dispatches from the Frack Zone* (New York, 2011).

[32] See, for example, Jeffrey Jacquet, "Boomtowns and Natural Gas: Implications for Marcellus Shale Local Governments and Rural Communities" (NERCRD Rural Development Paper no. 43, Northeast Regional Center for Rural Development, Pennsylvania State University, Jan. 2009), http://www.nercrd.psu.edu. This study examines the impact on jobs, community infrastructure and services, and quality of life. See also Simona L. Perry, "Using Ethnography to Monitor the Community Health Implications of Onshore Unconventional Oil and Gas Developments: Examples from Pennsylvania's Marcellus Shale," in "Scientific, Economic, Social, Environmental, and Health Policy Concerns Related to Shale Gas Extraction," ed. Robert E. Oswald and Michelle Bamberger, special issue, *New Solutions: A Journal of Environmental and Occupational Health Policy* 23 (2013): 33–53.

[33] Environmental historian Joel Tarr comments on the lack of good historical treatments of twentieth-century natural gas drilling in Julie Grant, "Historian Makes Case for Tougher Fracking Laws in PA," *Allegheny Front*, Jan. 31, 2014, http://www.alleghenyfront.org/story/historian-makes-case-tougher-fracking-laws-pa.

[34] Jones, *Routes of Power*, 20.

to embrace innovation, as when he had the railroad switch from wood- to coal-powered locomotives.[35] When Bernard DeVoto wrote in the 1930s and 1940s about resources and conservation in the western United States, he saw Pennsylvania as representative of the controlling, eastern, big-money interests that plundered the natural resources of the West.[36] Such wealth, though, has proven transitory for the region. Forty years later, the Pittsburgh region struggled to reinvent itself after the bulk of its heavy industry closed.

In the histories of energy sources reviewed here we see common themes as well as promising directions for future scholarship. The stories of energy use and development in the commonwealth reveal connections between the local and the global, the importance of adaptability for sustainability, and the inseparability of protecting the environment and protecting the citizen. In sum, these stories reveal the costs of energy that are externalized to the environment and the people who live and work there. The human stories are critical; however, the landscape created and left behind also becomes an essential text that illustrates energy priorities and transitions.

In the past, the relative scarcity or expensiveness of a particular energy source was the most common reason for transitioning to another type. Now, the impetus for change may be a scarcity of sinks for the disposal of waste products rather than a scarcity of the energy resource itself. Clearly, pollution has long been a cause of public concern, and the problem of peak oil is still an issue. However, the acceleration of climate change is the primary global environmental danger. Climate change is driven by increasing levels of carbon dioxide in the atmosphere from the combustion of fossil fuel—a result of using the atmosphere as a sink for emissions. The questions prompted by climate change are less about what we will do if oil, coal, or gas runs out, but rather what we will do about the consequences of using the abundant supplies still in the ground.

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[35] James A. Ward, "Power and Accountability on the Pennsylvania Railroad, 1846–1878," *Business History Review* 49 (1975): 37–59.

[36] Bernard DeVoto, *DeVoto's West: History, Conservation, and the Public Good*, ed. Edward K. Muller (Athens, OH), 2005.

Abundance, Dependence, and Trauma at Philadelphia's Point Breeze Petroleum Refinery: A Mirror on the History of Pennsylvania's Oil Industry

Catastrophic fire struck the Atlantic Refining Company petroleum refinery at Point Breeze on June 11, 1879. Lightning sparked this first conflagration at the plant, and it was devastating. The blaze destroyed twenty-five thousand cases of petroleum stored at Atlantic's Schuylkill River docks, as well as five foreign ships. Six other ships were towed away before they ignited. Fire destroyed virtually every structure at the works, including the office and the superintendent's house, the cooperage, the tin shop (which made cans for shipping oil), and refining equipment. Fueled by oil that saturated the ground, the fire continued to burn long into the night. Two days later, lingering flames from one of the burning ships at the wharf spread under increasing winds to more of the oil company's waterfront property. In total, about a half mile of Philadelphia's waterfront was destroyed. Amazingly, firemen, sailors, workmen, and nearby residents escaped injury, but an estimated two thousand men were thrown out of employment, most sailors lost all their belongings, and some houses were destroyed.[1] Rather than marking an exception, however, this fire highlights Pennsylvania's often traumatic relationship with the commodity that it introduced to the world in 1859.

Crude oil gains value only with refinement and transshipment. Although far from oil wells, locales such as Point Breeze, where petroleum and its products are transported and processed, mark important cogs in the creation of the commodity petroleum and are revealing sites of historical inquiry. As a commodity, of course, petroleum becomes valuable when it has been moved and processed into the products that are now integral

[1] "Acres Blaze," *Philadelphia Inquirer*, June 12, 1879, 8; "Half a Mile of Ruins," *Philadelphia Inquirer*, June 14, 1879, 2; "Struck Oil: A Great Fire at Point Breeze," *Philadelphia North American*, June 12, 1879, 1.

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Fig. 1. Aerial view to the northwest of the Point Breeze refinery in Philadelphia, 1926. Atlantic Refining's south yard is at the center of the photo, and the Passyunk Avenue Bridge crosses the Schuylkill River. The Philadelphia Gas Works is along the north side of Passyunk Avenue on the east side of the river, and Atlantic Refining's north yard is beyond the gas works on the bend of the river. The arrow at the lower center of the photo points to a black dot, which is the location of the 1962 sewer explosion that killed four construction workers. Photo no. 70.200.02453, Dallin Aerial Survey Company Collection, Hagley Museum and Library, Wilmington, DE, used by permission of the Hagely Museum and Library.

to human society. Most petroleum processing occurs at refineries, such as the Point Breeze facility, which separate crude into several constituent components called fractions. Refineries remove impurities and chemically reconfigure some fractions into diverse marketable products. But the business of refining oil is full of danger.

Today's refineries process millions of gallons of flammable, hazardous materials daily, and they pose significant risks to workers, neighborhood residents, and the environment. Events such as the 1879 fire, as well as oil leaks, explosions, accidents, and environmental damage at Point Breeze demonstrate the hazardous nature of refining. Point Breeze supplied the market with significant volumes of petroleum products, but the transportation, storage, and processing of oil there has had dire consequences for people and the environment throughout the facility's existence. The history of the Atlantic Refining Company at Point Breeze demonstrates that the oil industry embarked on a long trajectory of technological and organizational change to make the most economical use of crude oil, given changing market conditions. Point Breeze's history also shows that, despite efforts by industry and government to improve the safety and environmental impacts of oil refining, transporting and processing crude oil and its products continue to be sources of trauma for both people and environments (Fig. 1).

That crude oil both brings great benefit and is by nature a volatile commodity is now a basic reality of humans' relationship with the substance. On one hand, it is often celebrated, more than other fossil fuels (i.e., coal and natural gas), for liberating Americans from limitations on consumption imposed by their bodies and environmental conditions. Oil holds its distinct place in Americans' hearts because it has been the fuel that made relatively long-distance and high-speed personal mobility seem so effortless, thanks to the automobile and its gasoline-fueled internal-combustion engine. But as environmental historian Bob Johnson writes, oil has a darker side that Americans often don't want to contemplate. It has given rise to some of the largest corporations, which wield inordinate control over political and economic life in the United States and throughout much of the world. Its extraction, transport, processing, and use can sometimes lead to catastrophic accidents that result in maimed bodies and the loss of lives. And oil has dire consequences for the environment when it leaks or spills and when the byproducts of its combustion are discharged into the atmosphere. Johnson calls Americans' two-sided relationship with oil—profound dependence combined with safety and environmental disasters—*traumatic*, and like other traumas, oil's disasters have had long-term consequences for both individuals and society.[2] The history of refining at Point Breeze exemplifies this Janus-faced interplay of dependence and environmental consequences and places Philadelphia on the front line of this traumatic relationship.

[2] Bob Johnson, *Carbon Nation: Fossil Fuels and the Making of American Culture* (Lawrence, KS, 2014), xxv–xxvii, 134–62.

From its beginning, America's petroleum industry has featured serious losses of oil to the environment.[3] Production from oil fields, first in Pennsylvania, then in Ohio, West Virginia, and New York, and eventually elsewhere in the nation and throughout the world, led to local discharges on land, into waterways, and, often thanks to fires, into the atmosphere. Cross-country pipelines leaked. Loading and unloading ships with crude oil and petroleum products polluted the nation's harbors. Refineries near population centers posed threats of fire and explosion to their neighbors. Each of these forms of environmental degradation led to calls for regulation of the oil industry, but the industry was able to keep legislatures at bay until well into the twentieth century by arguing that, rather than fettering the industry with the costly apparatus of regulation, the engineering ideals of efficiency offered the solution to the problem. Engineers were professionally driven, so the argument went, to find ways to eliminate waste. It was in the economic interest of the oil companies to enable engineers to do just that. Because the elimination of waste would yield the additional benefit of reducing pollution, industry advocates urged legislatures to be patient.[4]

The Point Breeze refinery exemplifies self-regulation by the industry during its first decades. Its engineers and managers focused on improving the efficiency of the refinery's operations and thereby its profitability. Oil output at Point Breeze and by the industry overall grew tremendously, but at the same time, companies continued to discharge pollutants. Serious pollution continued because the engineering ideal of efficiency only went so far in abating losses of hydrocarbons to the environment. If a technological innovation that could reduce waste (and, therefore, reduce loss to the environment) did not also yield a financial return to a company (either in recovered marketable material or in savings due to fewer lawsuits) that was greater than the cost of implementing the innovation, then the innovation simply would not be adopted. Particularly in the refinery industry, growth without stringent regulation often worsened pollution problems.

Beginning in the 1920s and especially after World War II, legislatures finally realized that the efficiency ideal would not abate the problem and

[3] For environmental hazards in Pennsylvania's early oil extraction and transport, see Brian Black, *Petrolia: The Landscape of America's First Oil Boom* (Baltimore, 2000), 26, 84–91.

[4] This and the next paragraph are a brief synopsis of an excellent book on the subject: Hugh S. Gorman, *Redefining Efficiency: Pollution Concerns, Regulatory Mechanisms, and Technological Change in the US Petroleum Industry* (Akron, OH, 2001).

that governments had to regulate the oil industry. Regulation placed new importance on measuring and monitoring losses of material, especially contaminants, to the environment. Since the introduction of regulatory regimes, engineering expertise has been employed in part to help the oil industry remain profitable by finding ever more efficient ways to comply with environmental regulations.[5] At Point Breeze, management finally acceded to new government regulations in the 1920s and 1930s and began measuring and monitoring leaks and other losses. The refinery has nevertheless continued to be a source of loss to the environment up to the present century, in part because a refinery like the one at Point Breeze processes such large volumes of material on a continuous basis. Some of the loss has been through evaporation and flaring, and much has been a result of leaks into the ground. Leaks were and continue to be hard to detect, but a conservative estimate suggests that with a capacity to treat 160,000 barrels of petroleum daily in 1972, for example, Point Breeze, an old refinery, could have been losing 1,600 barrels of oil or product to the environment each day without raising alarm. Some 800 barrels per day, or 290,000 barrels (12 million gallons) yearly, could well have leaked to the subsurface without managers being aware that a slowly developing catastrophe was underway. As described below, slow-moving catastrophes did occur at Point Breeze.[6]

Prior to investigating such long-term implications, this essay first discusses the business and technological developments at Point Breeze in the context of a nascent industry, ownership and managerial developments, and the struggle for engineering efficiency in a regime of self-regulation. Developments at Point Breeze align with the rapid increase in demand for oil products, underscoring one side—the side of increasing dependence on the resource and its products—of the traumatic relationship Johnson describes. Next, the article explores the costs of this dependence for the safety of workers, residents, and the Philadelphia environment.

[5] This shift in the understanding of efficiency is the basis for Gorman's title, *Redefining Efficiency*.

[6] Hugh Gorman estimates that nearly 20 percent of the petroleum extracted from the ground at the turn of the twentieth century was lost to the environment by the oil industry before it made it to market. One hundred years later, that loss had dropped to less than 1 percent, due to a combination of government regulation and improved efficiency by the industry; see Gorman, *Redefining Efficiency*, 3–5. A loss of less than 1 percent might seem insignificant, but it can still be a huge amount, because of the vast volume of hydrocarbons a refinery such as Point Breeze processes daily. A 1972 article in *Oil & Gas Journal* about tools for conserving resources makes the point. The article describes mass-balance calculations, which compare the mass of material charged to the refinery with the mass yielded by the refinery processes. The article reported that, in that era, mass balances for new oil refineries could be

Beginnings of Oil Dependency and Abundance at Point Breeze

The Point Breeze area of Philadelphia lies along the east bank of the Schuylkill River a couple of miles above its confluence with the Delaware River (Fig. 2). Point Breeze forms a portion of a larger area of the city called South Philadelphia, which is that part of the city between the two rivers and south of the original southern boundary of Philadelphia at Cedar, now South Street. The area south of South Street was comprised of small colonial settlements and farms. Today's Oregon Avenue runs east from the Point Breeze area. Much of the area south of Oregon Avenue, historically called the Neck, was marsh and wet meadow. Most of the east bank of the Schuylkill River in South Philadelphia was tidal mudflat, the exception being a section south of Point Breeze called the Passyunk Bank, which sat about twenty feet above the river. The high ground along Passyunk Bank became an attractive location for early shipping and industrial facilities.[7]

The oil industry was not America's first fossil fuel industry. Nor was it the first fossil fuel industry in the Point Breeze section of Philadelphia; that distinction belonged to the Philadelphia Gas Works (PGW), which manufactured gas from coal. The City of Philadelphia chartered a private gas company to manufacture and distribute gas in 1835, and the next year the company built a plant on the north side of Market Street near the Schuylkill River to do so. Discord between the city council and the company's stockholders led the city to take possession of the gas works in 1841. Demand for gas grew, and the city constructed a second gas manufacturing plant on the east side of the Schuylkill River at Point Breeze. Like the original gas works, the site at Point Breeze was chosen to facilitate deliveries of coal by ship or barge. The Point Breeze works went into operation in December 1854. PGW still occupies its Point Breeze site, but it ceased manufacturing gas there in 1964.[8]

as close as 99.5 percent, the remaining 0.5 percent being lost through leaks, flaring, evaporation, and other means. Mass balances for older refineries would only be as close as 99 percent, meaning that 1 percent of the material charged to the refinery could be lost, without the managers knowing how it was being lost. O. A. Kozeny and E. J. Stanton, "Energy and Material Conservation in Refineries," *Oil & Gas Journal*, Nov. 6, 1972, 82. On the Point Breeze refinery's capacity in 1972, see "U.S. Refineries: Where, Capacities, Types of Processing," *Oil & Gas Journal*, Mar. 27, 1972, 152.

[7] Mary Maples Dunn and Richard S. Dunn, "The Founding, 1681–1701," in *Philadelphia: A 300-Year History*, ed. Russell F. Weigley (New York, 1982), 3–10; Martin P. Snyder, *City of Independence: Views of Philadelphia before 1800* (New York, 1975), figs. 26, 45–50, 59–60, and 66, and color plate 4.

[8] Oscar E. Norman, *The Romance of the Gas Industry* (Chicago, 1922), 42–44; "Our Gas Works Started in 1836," *Philadelphia Evening Bulletin*, Feb. 5, 1964; "Phila. Gas Works Created by Council 125 Years Ago," *Philadelphia Evening Bulletin*, Mar. 27, 1960, 3; W. Van Dusen, "Early History of the Point Breeze Plant of the Philadelphia Gas Works," *U.G.I. Circle*, Aug. 1922, 8.

Fig. 2. Detail from US Geological Survey topographical map of Philadelphia. Note the Point Breeze area and the underdeveloped lands of "the Neck." The Atlantic Refining Company's south yard is the development just west of the label, "Point Breeze." The Atlantic Refining Company's north yard is the development on the north curve of the river, just northwest of the south yard. US Geological Survey, "Pennsylvania—New Jersey, Philadelphia Sheet" (Washington, DC, 1898).

The business that would grow to become the Point Breeze petroleum refinery set up operations south of the gas works in 1866. As soon as oil wells in western Pennsylvania went into production beginning in 1859, entrepreneurs tried to find the most competitive system for refining, transporting, and marketing petroleum and its products. A group of Pittsburgh entrepreneurs, Charles Lockhart, William Frew, and William G. Warden, formed the Atlantic Petroleum Storage Company in 1866 to capitalize on Philadelphia's market and shipping facilities, hoping thereby to take control of some of western Pennsylvania's petroleum output. Lockhart, the new company's president, was a Pittsburgh businessman who, since the mid-1850s, had been selling petroleum from a saltwater well to Sam Kier, an early distiller of petroleum. Lockhart and Frew bought wells in the oil region and then quickly built a refinery at Pittsburgh. Shortly after Warden joined Lockhart and Frew, he moved to Philadelphia to begin marketing their crude oil and petroleum products. In 1866, the group formalized their business with the incorporation of Atlantic Petroleum Storage. The new company's storage and shipping facility was located on the east side of the Schuylkill River along Passyunk Bank, which offered a convenient wharfing location for transatlantic ships, as Liverpool had developed into a major market for new oil products. Atlantic Petroleum Storage Company featured two departments: Empire Stores, for storing and shipping crude oil, and Atlantic Stores, for storing and shipping products refined in Pittsburgh.[9] Still another entrepreneur, Philadelphian B. J. Crew, established a one-still refinery on land just south of the Empire Stores, which he called the Atlantic Petroleum Refinery.[10]

[9] "100 Years of Progress," centennial issue of *ARCO: The Magazine of the Atlantic Richfield Company*, Nov.–Dec. 1966, 5–10, and reprint of promotional brochure and map, 1866, for the Atlantic Petroleum Storage Company (copy held by the Hagley Museum and Library, Wilmington, DE); Ron Chernow, *Titan: The Life of John D. Rockefeller* (New York, 1998), 163.

[10] "100 Years of Progress," reprint of promotional brochure and map; "B. J. Crew's Atlantic Petroleum Refinery," *Hexamer General Surveys*, vol. 2 (Philadelphia, 1866), plate 105, Map Collection, Free Library of Philadelphia. B. J. Crew was a chemist who started a small petroleum refinery in Philadelphia with his brother, J. Lewis Crew, in 1862. Since 1849, they had been in business together manufacturing chemicals. B. J. left his brother a few years after 1862 to pursue his own business, first refining oil near Atlantic Petroleum Storage's warehouses and then manufacturing pharmaceuticals in Philadelphia. Meanwhile, Lewis Crew partnered with Lewis Levick to continue refining oil; see *Medical and Surgical Reporter* 18 (May 2, 1868): 397; *Pharmacist and Chemical Record*, Oct. 1869, 114; *The Biographical Encylopaedia of Pennsylvania of the Nineteenth Century* (Philadelphia, 1874), 615; and "London View of Crew-Levick Deal," *Petroleum Gazette*, Sept. 1916, 10. The nature of B. J. Crew's exact relationship with Atlantic Petroleum Storage is not known.

By the end of the 1860s, the owners of Atlantic Petroleum Storage Company had found that, with limited refining capacity in Philadelphia and with most of its finished product coming from Pittsburgh and the oil region, it could not compete with enterprises that had refineries along the Atlantic Coast, because it was more costly to ship packaged finished products than to ship crude oil in bulk. Lockhart, Frew, Warden, and some other associates reorganized their business as the Atlantic Refining Company, with Lockhart as president and Warden as general superintendent. Crew's little refining operation disappeared, and the reorganized company located its own refinery just north of the storage warehouses and south of the Philadelphia Gas Works' Point Breeze facility. The new refinery had greater capacity, with four stills and extensive facilities for processing distillates and packaging finished products.[11] This arrangement allowed Atlantic Refining to move crude oil in bulk to Philadelphia and then to ship packaged products to nearby and foreign markets.

Similar to other early refiners, the Atlantic company needed to meet the technological challenges of the industry. Petroleum had to be treated before it was ready for the consumer market. Crude oil is a liquid comprised of an assortment of hydrocarbon molecules, some with small numbers of carbon atoms and some with many. Hydrocarbon molecules with between one and four carbon atoms are gaseous at ambient temperatures and pressures. Molecules with more carbon atoms are liquid at ambient temperature and pressure, and the more carbon atoms they have, the higher their boiling point and the more viscous they are. In fact, hydrocarbon molecules with more than twenty-five or thirty carbon atoms are so viscous that they are barely liquid at all; they have to be heated so they can flow. The largest molecules are asphalt. All the varieties of hydrocarbon molecules are mixed together in crude oil, much the way alcohol and water are mixed together in a bottle of whiskey. Distillation, the first step in refining crude oil, uses the different boiling points of the hydrocarbons to evaporate them and then condense them at different temperatures, thereby separating them into useful fractions. For example, hydrocarbons with between five and twelve carbon atoms are said to be in the gasoline range. (Pentane, with five carbon atoms, boils at ninety-seven degrees Fahrenheit and is typically too volatile to be included in gasoline fuel.) Hydrocarbons with between

[11] "100 Years of Progress," 10–11, and reprint of promotional brochure and map; "Atlantic Refining Company," *Hexamer General Surveys*, vol. 7 (Philadelphia, 1872), plates 562–63, Map Collection, Free Library of Philadelphia.

eight and sixteen carbon atoms are said to be in the kerosene range. Larger hydrocarbon molecules comprise oils useful for lubricating, furnace fuel, and asphalt, among other uses. In the early years of the oil industry, the most important marketable fraction was kerosene, used as illuminating oil. Refining amounted to little more than distillation of the crude oil and then treatment of the distillates, first with sulfuric acid and then with caustic soda and then with several water washes after each treatment.[12]

The oil industry had a very fluid and volatile structure at its outset, as numerous entrepreneurs like Warden and Lockhart had rushed to capitalize on new opportunities to generate wealth. Some speculators had gone directly to the oil regions of western Pennsylvania to drill wells, hoping to strike the liquid, black gold. Boomers pumped more oil into the nascent market than it demanded in the first few years, but then demand surged to meet supply, as more potential customers learned the benefits of kerosene as an illuminant and of heavy oils as lubricants. Other entrepreneurs had rushed into the downstream segments of the industry: transportation, refining, and marketing. No one knew yet the most effective means to transport a bulk liquid commodity across long distances. And no one was sure how the vertical structure of the industry should be organized or where best to locate refineries. Should they be located in the oil regions, or in Pittsburgh, or near customers?[13]

Point Breeze and the Standard Oil Trust

The Point Breeze facility that Lockhart and Warden were developing grew in capacity because they had chosen to cooperate with the monopolistic ambitions of John D. Rockefeller. The initial years of the oil industry attracted a competing collection of producers, refiners, shippers, and investors; this free-for-all encouraged too much pumping and too much refining. As a result, consumers were enjoying prices so low that refiners could not make a profit.[14] Seeing the excessive refining capacity in the country, Rockefeller set about consolidating that segment of the industry in 1870, beginning in Cleveland,

[12] Harold F. Williamson and Arnold R. Daum, *The American Petroleum Industry: The Age of Illumination, 1859–1899* (Evanston, IL, 1959), 215–27; William L. Leffler, *Petroleum Refining in Nontechnical Language* (Tulsa, OK, 2000), 9–13, 50–55.

[13] Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York, 2008), 10–18, 21–22; Brian Black, "Oil Creek as Industrial Apparatus: Re-Creating the Industrial Process through the Landscape of Pennsylvania's Oil Boom," *Environmental History* 3 (1998): 214–23.

[14] Yergin, *The Prize*, 10–18, 21–22.

where he established the Standard Oil Company of Ohio. At the start, Rockefeller's refining company had about 4 percent of the refining capacity in the United States. By 1871, Rockefeller owned nearly all the refineries in Cleveland, giving him control of about a quarter of the nation's refining capacity. He next set his sights on refineries in Pittsburgh and Philadelphia, each also home to about a quarter of US refining capacity. Rockefeller's strategy was to bring the largest refiners in each city into Standard Oil, and that meant bringing in Lockhart and Warden. In 1874, they accepted Rockefeller's invitation to sell their Pittsburgh and Philadelphia operations to Rockefeller's Standard Oil Company in exchange for Standard Oil stock and the opportunity to be part of Standard's management structure. Lockhart and Warden then turned their attention, with Rockefeller, to the smaller refiners in Pittsburgh and Philadelphia, either acquiring them or forcing them out of business through cutthroat pricing. Rockefeller used a similar method to take control of the refining industry in New York. By 1879, Rockefeller and his Standard Oil Trust controlled over 90 percent of the nation's refining capacity.[15]

The Atlantic Refining Company (still a distinct corporate entity within the Standard Oil Trust) acquired the Philadelphia Refining Company's refinery on the north side of the Philadelphia Gas Works in 1878. Atlantic integrated the two facilities into a single refinery, despite their being separated by the gas works. The Philadelphia refinery came to be known as Atlantic's Philadelphia yard and eventually as Atlantic's north yard (with the Atlantic refinery known as the Atlantic yard and then the south yard). The north yard came to specialize in treating heavy oils, such as asphalt, paraffin, and lubricating oils, and the south yard treated light fuels, such as gasoline and kerosene (Fig. 3). Atlantic also acquired some smaller refineries in the Philadelphia area and took them out of operation. In 1892, Standard Oil placed all of its interests in Pennsylvania and Delaware in Atlantic's hands. That included the Philadelphia properties as well as a refinery in Pittsburgh and a refinery at Franklin in western Pennsylvania's oil region.[16]

[15] "100 Years of Progress," 10–11; Elizabeth Granitz and Benjamin Klein, "Monopolization by 'Raising Rivals' Costs': The Standard Oil Case," *Journal of Law and Economics* 39 (1996): 1–2, 8–9; Chernow, *Titan*, 162–63; Yergin, *The Prize*, 23–24. Note that Granitz and Klein claim that Pittsburgh and Philadelphia each had about a quarter of the nation's oil refining capacity when Rockefeller began to make his play for their refineries, but Williamson and Daum, *Age of Illumination*, table 12:1, p. 291, show Pittsburgh with about a fifth of the nation's capacity and Philadelphia with only about 4 percent.

[16] "100 Years of Progress," 10–11, 15; Indenture between the Philadelphia Refining Company and the Atlantic Refining Company dated Oct. 30, 1878, Deed Book DHL 206, pp. 79–84, Philadelphia City Archives; G. M. Hopkins, *Atlas of the City of Philadelphia, 1st, 26th, 30th Wards*, (Philadelphia,

Fig. 3. Atlantic Refining Company's south yard, ca. 1920. This view to the east shows Atlantic Refining's shipping wharf along the Schuylkill River in the lower portion of the photo, the crude distillation stills (each still with its own stack) along the right edge of the photo, the light-fuels treatment area in the left portion of the photo, and petroleum storage tanks in the background. Photo no. P.8990.1861, Aero Services Collection, Library Company of Philadelphia. By permission of the Library Company of Philadelphia.

Although Atlantic was a distinct corporate entity in the Standard Oil enterprise, it operated as a refinery department of the Standard Oil organization. Other elements of the Rockefeller enterprise supplied the Point Breeze refinery with crude oil and marketed the refinery's product, and Standard Oil managers in New York directed overall operations. Thus Standard Oil was able to transfer two of its top refinery managers from Lima, Ohio, to Philadelphia in 1903. J. W. Van Dyke was made manager

1885), plate 12; "Ladenburg, Thalmann & Co's Oil Shipping Yard," *Hexamer General Surveys*, vol. 20 (Philadelphia, 1885), plates 1884–85; George W. and Walter S. Bromley, *Atlas of the City of Philadelphia*, vol. 7, *22nd Ward* (Philadelphia, 1889), plate S; Herman LeRoy Collins, *Philadelphia: A Story of Progress* (Philadelphia, 1941), 94–95; Chernow, *Titan*, 162–63.

of the Point Breeze refinery and W. M. Irish his assistant. In terms of capacity, the Point Breeze refinery was second only to the plant at Bayonne, New Jersey, among Standard Oil's refineries (third largest was the refinery at Whiting, Indiana, near Chicago).

Led by Van Dyke and Irish, Atlantic became a pioneer of improved refining technologies, including distillation methods. For example, Atlantic's Max Livingston was the first American to develop a practical method for continuous distillation, in which a series of connected stills brought the charge of oil to successively higher temperatures, each still evaporating a different fraction of hydrocarbons. In a different approach, Irish and Van Dyke developed a tower still in 1904 and received a patent for it in 1913, and Atlantic built some of them at Point Breeze. A tower still brought the charge to a temperature high enough to evaporate most of the hydrocarbons. Vapors then passed through successive condensers, which distilled different fractions of hydrocarbons. These technological improvements aimed to make operations more efficient and therefore more profitable; if they reduced losses of hydrocarbons to the environment, that improvement would have been incidental. Within a few years, Standard Oil had converted many of its other refineries to use tower stills.[17]

The Point Breeze refinery continued as an integral part of the Standard Oil empire until 1911, when the US Supreme Court ruled that the giant trust was in violation of the Sherman Antitrust Act of 1890 and had to be dissolved. The trust refined more than 75 percent of the crude oil in the United States; it transported more than 80 percent of oil produced in Pennsylvania, Ohio, and Indiana; it sold more than 80 percent of the kerosene in the country; and more than 80 percent of US kerosene exports were Standard Oil's. US railroads bought more than 90 percent of their lubricating oils from Standard Oil. In July 1911, the trust announced its dissolution plan, which specified that each of its major subsidiary operating companies, including Atlantic, would become an independent corporation, conducting its business independently of the others. Although

[17] Charles F. Wilner, *J. W. Van Dyke: The Story of a Man and an Industry, Correlated with a Short History of the Atlantic Refining Company, 1870–1936* (Philadelphia, 1936), 4–8; J. W. Van Dyke and W. M. Irish, Process of and Apparatus for Distilling Petroleum, US Patent 1,073,548 (filed Oct. 4, 1909, and issued Sept. 16, 1913), US Patent 1,095,438 (filed Apr. 18, 1911, and issued May 5, 1914), and US Patent 1,143,466 (filed May 16, 1914, and issued June 15, 1915); "Largest Refinery Center in World Got Its Start in Third Era," *Oil & Gas Journal*, Aug. 21, 1934, 104–6, 146; "Grew in Oil Atmosphere," *Oil & Gas Journal*, Aug. 20, 1936, 141; "100 Years of Progress," 56–57; Paul H. Giddens, *Standard Oil Company (Indiana): Oil Pioneer of the Middle West* (New York, 1955), 61; Harold F. Williamson et al., *The American Petroleum Industry: The Age of Energy, 1899–1959* (Evanston, IL, 1963), 124–28.

Atlantic and the other companies, such as Standard of New Jersey (now the Exxon of ExxonMobil), Standard of New York (now the Mobil of ExxonMobil), Standard of Indiana (now Amoco, which has merged into BP), and Standard of California (now Chevron), did not compete in each other's territories in the early decades after the dissolution, the breakup of Standard Oil nevertheless introduced a degree of competition into the US oil industry that had been lacking since the end of the 1870s.[18]

At the time of the trust's dissolution, Van Dyke was president of the Atlantic Refining Company, and Irish was his vice president. Restructuring presented Atlantic's leaders with several immediate problems. Although the company owned three refineries in Pennsylvania—the one at Point Breeze as well as refineries in Pittsburgh and Franklin—the company did not have its own source of crude oil. In the short term, Atlantic had to bid against competitors to acquire petroleum on the open market, but Van Dyke quickly assembled an organization to find and acquire oil-producing properties in Kentucky, Texas, Louisiana, and Arkansas. Atlantic's other major problem concerned marketing. Atlantic sent 60 percent of its output, including 80 percent of the Point Breeze refinery's production, to overseas markets, and yet Atlantic had no export organization. That, too, had been handled by Standard Oil. In the short term, Atlantic sold its product to Standard companies that had foreign sales organizations, but Atlantic quickly developed its own marketing offices in Paris, Copenhagen, and elsewhere, and it entered a partnership with Anglo-American Oil Company to conduct sales in England.[19]

Refining Technologies and the Transition to the Automobile Era

The dissolution of the Standard Oil Trust occurred as markets for petroleum products were rapidly shifting and stimulating profound changes in the ways oil companies, including Atlantic, refined petroleum. Throughout the nineteenth century, kerosene had been the industry's most important product, with lubricating oils comprising most of the rest of the market. During the oil industry's first several decades, gasoline, which might comprise about 18 percent of the hydrocarbons available in a typical crude oil, had largely been a waste product of the distillation process. The

[18] Yergin, *The Prize*, 91–94. Since the dissolution, several of the Standard Oil subsidiaries that became independent in 1911 have merged. For example, Exxon and Mobile are now part of ExxonMobil, and Amoco and Atlantic (which would later become Atlantic Richfield) are now part of BP.

[19] "100 Years of Progress," 17–18, 55–57.

advent of the age of electricity, however, began to have a severe impact on kerosene sales, as people came to prefer the incandescent light bulb to the kerosene lamp. Although kerosene sales continued to grow into the twentieth century, sales of gasoline grew even faster, beginning in the 1890s, with the development of the automobile, powered by the internal-combustion engine and fueled by gasoline. Gasoline sales accelerated in the early twentieth century, as Henry Ford introduced the Model T and the assembly line, making low-priced cars attractive to masses of Americans. Revenue from gasoline sales surpassed those from kerosene in 1914, and the volume of gasoline sold surpassed that of kerosene in 1919. This stimulated technological improvement in the oil industry to make more efficient use of the hydrocarbon molecules available in crude oil.[20]

Because the gasoline fraction typically comprised only about 18 percent of crude oil, refiners worried that production of crude oil could not keep pace with accelerating demand for gasoline. A technical solution lay in a process that made it possible to break apart the larger molecules of a fraction of crude oil, called gas oil, into the smaller molecules of the gasoline range. Gas oil, with molecules having between fourteen and twenty-three carbon atoms, is the fraction between kerosene and the heavier lubricating and fuel oils, and there was little market for it. Prior to the 1910s, refiners had been using very high temperatures and ambient pressures, in a process called destructive distillation or "cracking," to break gas-oil molecules into kerosene molecules, thus increasing the supply of the kerosene fraction when illuminating oil was the industry's principle product. In the early twentieth century, researchers began looking for practical means to use high temperature and high pressure to break gas-oil molecules into molecules in the gasoline range, thus increasing the proportion of crude oil that could be marketed as gasoline. The most significant commercial breakthrough occurred at Standard of Indiana's Whiting refinery, where William Burton developed and patented a process for thermal cracking that quickly became the industry standard. By 1920, several former subsidiaries of the Standard Oil Trust and some previously independent refining companies had obtained licenses from Standard of Indiana to use the Burton process. This was a period of rapid technological change, however, and several other innovators were also developing thermal-cracking methods and equipment.[21]

[20] Williamson and Daum, *Age of Illumination*, 485, 615; Williamson et al., *Age of Energy*, 111–12; Yergin, *The Prize*, 94–96.

[21] Williamson and Daum, *Age of Illumination*, 218–21; Williamson et al., *Age of Energy*, 132–50; Yergin, *The Prize*, 94–96.

The first cracking stills Atlantic Refining installed may have been for the Burton process. When the American Chemical Society (ACS) met in Philadelphia in September 1919, its members toured several industrial facilities in the city, including Atlantic's Point Breeze refinery. A description of the tour in the October 15 issue of *Chemical and Metallurgical Engineering* features two photographs of stills at the Atlantic refinery, one labeled as "high pressure horizontal Burton process stills" and one as "high pressure vertical Burton stills."[22] The horizontal stills may well have been Burton cracking stills, but the vertical stills were those developed and patented by Atlantic's Joseph W. Lewis, who followed Irish's and Van Dykes's example of technological innovation at the Point Breeze refinery.[23]

Lewis had long been superintendent of the Point Breeze refinery, and for several years his process was Atlantic's sole method for cracking heavier oils to make gasoline-range distillate at Point Breeze as well as at Atlantic's other refineries. Unlike Standard of Indiana, however, which licensed the Burton process to competitors, Atlantic kept the Lewis process proprietary and did not attempt to license it.[24] Atlantic boasted of its unique vertical pressure stills for cracking heavier oils into gasoline. The caption for a drawing of the cracking units in the company's *Story of Gasoline* describes the vertical stills as "original and exclusive Atlantic equipment that assists The Atlantic Refining Company in keeping up with the increasing demand for good, uniform gasoline" (Fig. 4).[25] This indeed was the purpose of cracking: to convert a higher percentage of crude oil into motor fuel. Atlantic's promotional booklet on gasoline includes a drawing of a second set of vertical stills under construction. Aerial photos from the mid-1920s show both sets of Lewis stills in the north yard, helping Atlantic supply Americans' increasing thirst for motor fuel.[26]

As with so much other equipment, however, the vertical pressure stills exhibited the Janus-faced nature of oil refining. Not only did the Lewis

[22] Williamson et al., *Age of Energy*, 148; "Industrial Excursions," *Chemical and Metallurgical Engineering*, Oct. 15, 1919, 488–89.

[23] J. W. Lewis, Method of and Apparatus for Treatment of Petroleum, US Patent 1,364,443 (filed Apr. 19, 1917, and issued Jan. 4, 1921).

[24] Eugene H. Leslie, *Motor Fuels: Their Production and Technology* (New York, 1923), 381; C. O. Willson, "Install Process of Special Design," *Oil & Gas Journal*, May 21, 1925, 24.

[25] Atlantic Refining Company, *The Story of Gasoline* (Philadelphia, 1920), drawing inside front cover, Hagley Museum and Library, Wilmington, DE.

[26] Aero Service Corporation, photographer, "Atlantic Refining Company plant, 3314 Passyunk Avenue, Point Breeze, Philadelphia," photo P.8990.1138 (ca. 1920) and P.8990.6112 (1926), Aero Service Negative Collection, Print Department, Library Company of Philadelphia.

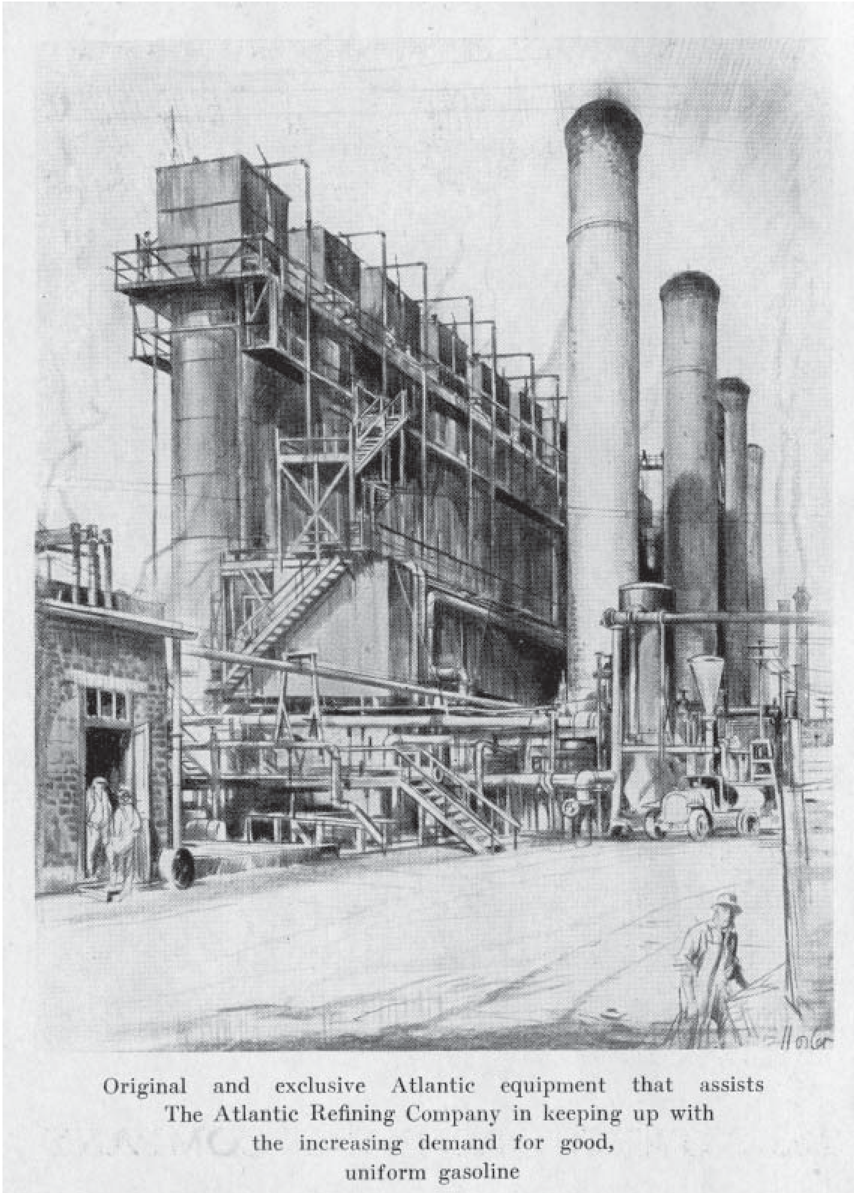

Fig. 4. Drawing of Atlantic Refining Company's Lewis stills, used in the north yard for thermal cracking of gas oil to produce a distillate rich in hydrocarbons in the gasoline range. Atlantic Refining Company, *The Story of Gasoline* (Philadelphia, 1920), Hagley Museum and Library.

stills help Americans acquire the mobility they desired; the vertical pressure stills were fraught with danger. In September 1921, a pipe in the initial set of vertical stills ruptured and the naphtha it was carrying exploded, killing twelve workers.[27] The 1921 explosion at the Lewis stills is just one of a number of catastrophic events at the Point Breeze refinery throughout its history that have led to loss of life and/or significant losses of oil and oil products to the environment.

Environmental Catastrophes at Point Breeze

Numerous catastrophic events have occurred at the Point Breeze refinery, the most widely publicized of which have been fires and explosions. Such disasters were widely reported by the news media when they were accompanied by loss of life. Several of the fires and explosions killed workers and also released large volumes of oil into the environment. Other catastrophes have been less spectacular, but they, too, resulted in large releases.

An early casualty of the development of facilities for processing fossil fuels at Point Breeze was the area's ground water. The earliest known reference to oil contaminating the water table is in the 1884 annual report of the Philadelphia Water Department (PWD). The Philadelphia Gas Works laid a ten-inch water line along Passyunk Avenue, from Broad Street to Schuylkill Avenue along the river, in order to deliver good water to the Point Breeze area, including the gas works. PGW turned the pipe over to the PWD upon completion of the project. The reason PGW made the expenditure was that soil in the Point Breeze vicinity was said to be saturated with "oil and other objectionable matters," making water pumped from shallow wells unfit to use.[28] The gas works had been in operation for thirty years by then, the refinery for almost twenty. The report did not speculate on the source of the oil contamination, but given the propensity of both manufactured gas and oil refining plants to leak hydrocarbons to the environment, the report of contamination is not surprising.[29]

[27] "Explosion of Naphtha Spells Death for Ten," *Philadelphia Record*, Sept. 15, 1921; "Former Blast Victim Explains This Tragedy," *Philadelphia Inquirer*, Sept. 15, 1921; "Blames None for Fatal Oil Blast," *Philadelphia Inquirer*, Sept. 16, 1921.

[28] *Annual Report of the Chief Engineer of the Philadelphia Water Department for the Year 1884* (Philadelphia, 1885), 2.

[29] Joel Tarr, "Toxic Legacy: The Environmental Impact of the Manufactured Gas Industry in the United States," *Technology and Culture* 55 (2014): 107–47.

The huge fire of June 1879 was neither the only nor the last such incident. On August 14, 1921, about a month before the explosion at the Lewis stills in the north yard killed twelve workers, catastrophic fire struck Atlantic's south yard. The fire started in the early morning hours when a steam still exploded, and it spread quickly to three storage tanks holding between 5,000 and 20,000 barrels of refined product. The fire engulfed agitators and about two dozen storage tanks holding a variety of refined and unrefined materials in the treating area of the yard. Within a short time a number of other installations of the refinery had been destroyed, including five steam stills, each containing between 1,500 and 4,000 barrels of oil; four lead-lined agitators, each containing about 1,000 barrels of oil; a concrete oil-water separator containing a large but unestimated volume of oil; five storage tanks, each containing between 5,000 and 20,000 barrels of oil; and four large pump houses equipped for pumping oil to and from ships. The fire threatened but did not reach the administration building on the Schuylkill River bank. Corporate officers organized numerous secretaries and clerks to move the company's books out of the building. Three steamships docked at the refinery were quickly moved away when the fire erupted. All of the damage was confined to what Atlantic called the light oils (naphtha, kerosene, benzine) section of the plant; there was no damage to the north yard. City officials complained that the fire had grown to catastrophic proportions because of Atlantic's policy of having employees try to extinguish refinery fires without calling the fire department. The fire killed six and injured many others.[30]

Dramatic fires and explosions at the Point Breeze refinery continued to take lives and release large volumes of hydrocarbons into the environment throughout the twentieth century.[31] Many other losses, including leaks and spills, went unnoticed for years. Although small at any given time, leaks

[30] "Many Firemen Hurt in Early Morning Point Breeze Blaze," *Philadelphia Inquirer*, Aug. 14, 1921; "4 Dead, 10 Injured by Blazing Oil at Point Breeze Fire," *Philadelphia Inquirer*, Aug. 15, 1921; "Cortelyou Demands Reports on Blaze," *Philadelphia Inquirer*, Aug. 16, 1921; "New Fire Starts at Point Breeze," *Philadelphia Inquirer*, Aug. 17, 1921; "$1,000,000 Blaze at Point Breeze Kills Four Men," *Philadelphia Record*, Aug. 15, 1921; "New Outbreak of Fire in Point Breeze Plant," *Philadelphia Record*, Aug. 18, 1921; "Six Die in Big Oil Fire; Million Dollars Loss," *Oil & Gas Journal*, Aug. 19, 1921, 78.

[31] Other fatal fires at the Atlantic refinery included an explosion and fire in April 1944 that killed three workers; see "Three Killed in Five-Alarm Refinery Fire," *Philadelphia Inquirer*, Apr. 13, 1944. Across a dozen years, from 1962 to 1976, there were four major fires at the Point Breeze refinery, including a fire that killed seven workers in May 1970 and a fire and explosion that injured Philadelphia's Mayor Rizzo in October 1975; see "Region Plagued by Refinery Fires," *Philadelphia Evening Bulletin*, Jan. 24, 1977.

can amount to large volumes if undetected or left unresolved. Such was the case in the early twentieth century, as oil refineries and other sectors of the industry failed to reduce losses to the environment they promised would accompany improvements in efficiency.

That began to change in 1924, when Congress passed the Oil Pollution Act, aimed at protecting the nation's harbors. The American Petroleum Institute formed a committee to study means—including measuring and monitoring—by which refineries could keep oil and oil products out of bodies of surface water. Atlantic's W. B. Hart served on the committee. A few years later, a journalist described what Hart said Atlantic was doing to protect the Schuylkill River from oil pollution. A principal tool at Atlantic and other refineries was the oil-water separator, which was little more than a settling basin that allowed oil and water to separate by gravity. The Point Breeze refinery used separators to treat waste water from processing as well as surface runoff collected in sewers on the property. The latter would otherwise be a significant source of discharge to the river because the ground surface of the refinery was often soaked with oil, and rainwater would carry some of that oil away. Crews skimmed oil from the surface of a separator and allowed water to drain from the bottom of the basin to the river. By the 1930s, Hart reported, keeping oil and refined material from leaking to the ground had also become an important undertaking for the Point Breeze refinery, which employed thirty-seven "leak detectives" who monitored the refinery's five thousand miles of pipe. When they found underground leaks, they reportedly dug out any oil-soaked earth and burned it. This was said to prevent seepage into the river. Hart claimed that separators at the Atlantic refinery recovered between six thousand and eight thousand barrels (between 252,000 and 336,000 gallons) of oil per month. Drip pans and other devices throughout the refinery collected another forty thousand to forty-five thousand barrels (1,680,000 to 1,890,000 gallons) per month. Recovered material was either burned at the refinery as fuel or cycled back into the process.[32]

The refinery remained a leaky operation, despite the regulatory regime. Considerable volumes of oil leaked into the ground, and some of that oil found its way into the city's sewers, with disastrous consequences in 1962. The city's sewer system had several sewer mains in the Point Breeze area

[32] Gorman, *Redefining Efficiency*, 102–17; W. B. Hart, "Disposal of Refinery Waste Waters," *Industrial and Engineering Chemistry*, Sept. 1934, 965–65; Stephen Spencer, [no title], *Philadelphia Evening Bulletin*, Aug. 10, 1936.

running from east to west. They were part of the combined sewer system in south Philadelphia, built in the late 1800s and early 1900s to convey both storm water and sanitary sewage to the Delaware and Schuylkill Rivers. In the late 1940s, the City of Philadelphia began constructing interceptor sewers to convey sewage to treatment plants, rather than allowing it to run raw into the Delaware River system. One of those interceptors, the Lower Schuylkill East Side Interceptor, was to convey storm water and sewage from Penrose Avenue on the south to a pumping station near University Avenue on the north. From there, sewage would be pumped under the Schuylkill River to the city's treatment plant in southwest Philadelphia. The Philadelphia Water Department awarded a contract to Driscoll Construction in March 1962 to complete the last section of the Lower Schuylkill East Side Interceptor, running along Twenty-Sixth Street (the east side of the refinery) from Penrose Avenue north to Shunk Street.[33]

The interceptor sewer had to pass under the existing sewers. The portion of the interceptor to be built in 1962 would be some forty feet below the surface, which put it at or below the water table. The construction scheme called for driving a series of twelve vertical shafts along Twenty-Sixth Street and then tunneling between the shafts, rather than excavating an open trench along the entire length of the sewer construction. Because the interceptor was to be installed below the water line, water had to be pumped from the construction site. At the commencement of construction, workers found that hydrocarbons, in addition to water, were seeping into the bottoms of the shafts. Those liquids also had to be pumped from the shafts. Initially the mix of water and hydrocarbons was allowed to drain directly to the river, but after a short time Atlantic Refining began allowing Driscoll Construction to pump the mix of liquids to oil-water separators at the Point Breeze refinery. At the underground work site, the contractor had to enhance ventilation in an effort to keep hydrocarbon vapors below safe levels. This safety measure was not accomplished satisfactorily, however, and on August 22, 1962, a series of explosions in the tunnels and shafts killed four workers—James C. Hennigan, Robert Wilson, John Riddick, and William Gregory—and injured several others working in shaft number five, just south of Hartranft Avenue (Fig. 1). Analysis by the refinery of hydrocarbon samples taken from the sewer excavation shortly after the

[33] "$2,421,442 Is Low Bid on Sewer Unit," *Philadelphia Evening Bulletin*, Oct. 19, 1947; "Sewer Project in Final Stage," *Philadelphia Evening Bulletin*, Mar. 14, 1962.

explosion showed that the material was mostly in the gasoline range.[34] Gasoline is the fraction that makes petroleum the highly sought resource it is, but gasoline that leaks to the environment can lead to traumatic events, such as the 1962 sewer explosion.

Widows of three of the four dead workers (Hennigan, Wilson, and Riddick) filed suit against Atlantic Refining and the City of Philadelphia. The trial took place in federal court before Judge A. Leon Higginbotham in November 1966. Various employees and officials of the Philadelphia Water Department testified about the design of the sewer and the precautions they had implemented during construction to keep workers safe in an underground environment harboring explosive vapors. Inspectors described working conditions at the construction site. James and Michael Driscoll, the brothers who owned Driscoll Construction, described conditions they and their workers encountered in the excavation along Twenty-Sixth Street. Chemists at the water department and the police department laboratory testified concerning samples that had been collected from the site at the time of the explosion. Officials from Atlantic Refining Company testified about conditions at the refinery and about the way the refinery handled liquids (including both water and hydrocarbons) that Driscoll construction pumped from the construction site and conveyed to the refinery. Finally, the three widows testified about the hardships they faced with their husbands dead. Before the end of the trial, however, Atlantic settled with each of the plaintiffs for $100,000 (with Atlantic's excess liability insurer paying half the settlement amount). The attorneys for the plaintiffs therefore asked that the court find only against the City of Philadelphia. In light of the settlement, plaintiffs' attorneys reasoned that even if Atlantic had been negligent in allowing hydrocarbons to leak into the soil (and they were not arguing that Atlantic had been negligent), the immediate cause of the explosion that killed the workers was the city's negligent design of the tunnel for construction of the sewer and its failure to provide a safe workplace. The jury found the city negligent under both theories.[35]

[34] "Blasts, Fire Kill 4 in Deep S. Phila. Pit," *Philadelphia Daily News*, Aug. 22, 1962; "Rescuers Battle Smoke, Fumes in Search for 4," *Philadelphia Evening Bulletin*, Aug. 22, 1962; "Air Forced into Tunnel in Probe of S. Phila. Blast," *Philadelphia Evening Bulletin*, Aug. 23, 1962; "4 Workers Killed as Explosions Rip Sewer Tunnel," *Philadelphia Inquirer*, Aug. 23, 1962; "Blame Explosion on Seeping Oil Refinery Fumes," *Philadelphia Tribune*, Aug. 25, 1962.

[35] "Sandhogs' Kin to File $-Million Suits," *Philadelphia Tribune*, Aug. 28, 1962; Gwendolyn Sharpe, testimony in the United States District Court for the Eastern District of Pennsylvania, Hennigan v. Atlantic Refining Company et al. (Civil Action No. 32433, hereinafter cited as Hennigan v. Atlantic), Nov. 3 and 4, 1966, pp. 359–61, 403–5, file 7, box 3484, file 9, box 3484, entry 42-E-56, Record Group

The verdict notwithstanding, testimony presented at the *Hennigan* trial offers insight into Atlantic's long knowledge that it had been leaking hydrocarbons into the subsurface and about the character and composition of hydrocarbons that caused the sewer explosion. For example, William Wakeley, the refinery's plant protection superintendent, testified about the refinery's tank farm that was adjacent to the site of the explosion. Although he tried to be vague about it, Wakeley testified that the refinery had about 1,300 tanks on the property and that some of the tanks along the eastern edge of the property were as large as 160,000 barrels (6,720,000 gallons). While admitting that some leaks from these tanks might go into the ground, he tried to focus attention on leaks that would vaporize or be captured by the refinery's surface sewer system. Nevertheless, when pressed, Wakeley admitted that at least some of the petroleum products that Driscoll had been pumping from its excavation were Atlantic's materials, and he estimated that petroleum had been sitting on the water table in that area for about one hundred years.[36] At the time of the trial in 1966, a refinery had been in operation at Point Breeze for exactly one hundred years.

Atlantic officials testified that, through evaluation of samples taken from test wells installed by the refinery, they were well aware that hydrocarbons were present on the water table along the refinery's eastern property boundary. Charles Stose, former manager of the refinery, also testified that Atlantic recovered hydrocarbons from those wells. He said that Atlantic had two purposes for pumping material from the recovery wells. One was to try to prevent the migration of hydrocarbons beyond Atlantic's property boundary. Another was, by monitoring the volume recovered, to be alerted to any increases, which might indicate some new leak or other problem that would need to be corrected. Stose testified that he was aware that an

21, Records of the United States District Court for the Eastern District of Pennsylvania, National Archives at Philadelphia (hereafter cited as RG-21). The following testimony is also in Hennigan v. Atlantic, RG-21: Samuel K. Wilson, Nov. 4, 1966, pp. 452–74, file 9, box 3484; Stewart James Nichols, Nov. 4, 1966, pp. 436–42, file 9, box 3484; James Dennis Holden, Nov. 4, 1966, pp. 446–50, file 9, box 3484; Richard Thompson, Nov. 4, 1966, pp. 497–99, file 9, box 3484; Edward J. Burke, Nov. 7, 1966, p. 766, file 10, box 3485; J. Howard Myers, Nov. 16, 1966, pp. 1526–31, file 14, box 3485; William J. Hume, Nov. 16, 1966, pp. 1671–84, file 15, box 3486; Charles S. Wolff, Nov. 18, 1966, pp. 1924–25, file 15, box 3486; see also James E. Beasley, closing argument in Hennigan v. Atlantic, Nov. 29, 1966, pp. 2277–78, file 19, box 3486, RG-21; Opinion of the United States Court of Appeals for the Third Circuit in the Appeal of the City of Philadelphia of the verdict in Hennigan v. Atlantic, file 2, box 3483, RG-21.

[36] Wakeley, testimony in Hennigan v. Atlantic, Nov. 14, 1966, pp. 1237–39, 1313, 1316, file 13, box 3485, RG-21.

excavation down to the water table along the alignment of the Twenty-Sixth Street sewer would encounter hydrocarbons and yield vapors that could be explosive. He stated his belief that the ground could not be decontaminated of liquid hydrocarbons, although he believed that vapors in the excavation could have been controlled.[37]

Construction of the Twenty-Sixth Street sewer resumed in late 1964, with the Philadelphia Water Department having awarded Driscoll Construction a contract to complete the work. The first task in preparing the site for construction was to test the shafts for liquid hydrocarbons and gases in the explosive range. On December 17, a measurement showed the "depth of hydrocarbon (oil, etc.)" to be "about 30 [inches] above [about] 5 [inches] of H_2O."[38] After continuous pumping for several weeks, however, the liquid at the face of the tunnel was still twelve to eighteen inches deep, so in early February 1965 the contractor installed five deep wells on the Atlantic side of the tunnel alignment. Within a few days, the contractor was pumping as much as two hundred gallons per minute from the five deep wells plus three sump pumps in shafts, discharging the liquids into Atlantic's waste oil and water system. Shortly after the middle of the month, pumping had lowered the apparent level of the hydrocarbons to below the tunnel floor. Extending the tunnel commenced, although work had to be suspended occasionally because of infiltration of liquids (water and hydrocarbons) into the work or unsafe concentration of gases in the underground atmosphere. On at least one occasion, the diaries reported that a worker became sick from breathing fumes in the work area.[39]

After the Twenty-Sixth Street sewer was completed, PWD began in late 1966 to notice infiltration of hydrocarbons into the sewer line near shafts six, seven, and eight (adjacent to and just east of the refinery's number two tank farm). The atmosphere in the line was tested, showing concentrations near the explosive level, and samples of liquids were taken for analysis. As PWD officials met at the site with contractors to discuss grouting of the line to prevent infiltration of hydrocarbons into the sewers, at least one Atlantic representative joined the discussion, in part because

[37] Charles Stose, testimony in Hennigan v. Atlantic, Nov. 16, 1966, pp. 1568–78, file 15, box 3486, RG-21.

[38] Twenty-Sixth Street Sewer Construction Diary for Dec. 17, 1964, drawer SD-250-SW to SD-320-SW, Delaware & Race Pumping Station, Philadelphia Water Department, Philadelphia (hereafter cited as PWD).

[39] Twenty-Sixth Street Sewer Construction Diary for Dec. 26, 1964, Feb. 9 and 10, Feb. 17 and 18, Apr. 12, 21, and 22, May 25, and Aug. 20, 1965.

Atlantic was granting permission for the grouting operation to access the sewer line from Atlantic property.[40]

One more problem associated with leaks of petroleum from the refinery into the surrounding environment merits mention. In 1987, the Defense Supply Center Philadelphia (DSCP, a military supply depot owned and administered by the US Department of Defense) discovered a large plume of liquid petroleum beneath its property east of the refinery's south yard while responding to a leak in a fuel line associated with the filling station DSCP operated at the depot. DSCP reported the leak to the Pennsylvania Department of Environmental Protection (PADEP). At first DSCP suspected that the plume of petroleum might have come from its own leak, but subsequent analysis led officials to conclude that the plume had originated from another source: the refinery. Nevertheless, under terms of the Pennsylvania Storage Tank and Spill Prevention Act, PADEP issued an order to DSCP in 1999 to remediate the plume, because of the proximity of the plume to DSCP's underground storage tanks for the filling station. Believing that the refinery, not DSCP, was liable for the plume, the United States filed suit against the refinery's current and previous owners in 2005. A federal judge ruled, however, that the United States could not bring the suit because the statute of limitations had run out on the government's right to do so. Although the United States appealed the judge's ruling, the parties settled the litigation before it was finally resolved.[41] Remediation of the plume continues.

Recent Changes at the Point Breeze Refinery Reflecting Changes in the US Refinery Industry and the Continuing Threat of Trauma

Atlantic's Point Breeze refinery continued to grow through the first two-thirds of the twentieth century. Entering the last third of the century, Atlantic Refining underwent a significant change in 1966 when it merged with the Richfield Oil Company, which had a refinery in California and established markets on the Pacific Coast. The two companies believed that their markets on the two coasts and their refinery locations were complimentary and that the size of the new Atlantic Richfield Company (ARCO) would be better able to compete in expanding and diversifying

[40] Twenty-Sixth Street Sewer Construction Diary for Dec. 10, 12, and 19, 1966.

[41] U.S. v. Sunoco, Inc., 644 F. Supp. 2d 566 (E.D. Pa. 2009). See https://casetext.com/case/us-v-sunoco-6.

markets. In 1973, ARCO reconfigured its Philadelphia refining operation, spending more than $60 million to convert the Point Breeze refinery from a full-product-line facility to one that concentrated on fuels and continued to produce lubricating oils and asphalt. Such products as wax, however, were eliminated. As part of the reconfiguration, ARCO removed processing operations from the north yard and consolidated all refining in the south yard.[42]

In 1985, ARCO sold its eastern refining and marketing operations, including the Point Breeze refinery, to John Deuss, a Dutch oil trader, who formed Atlantic Refining and Marketing Corporation. Three years later, Deuss sold the property, including the refinery, more than five hundred former ARCO service stations on the East Coast, and the Atlantic Pipeline Company (a network of more than a thousand miles of product pipelines in Pennsylvania and New York) to Sun Company (Sunoco). Sunoco already had a large refinery just downstream of Philadelphia, built along the Delaware River at Marcus Hook in 1902. In 1988, Sunoco decided to sell its exploration and production assets and focus its business in the areas of refining and marketing petroleum products. Its first new purchase that year was the Point Breeze refinery, which had the capacity to treat heavier, sulfur-laden crude oil (Sun's Marcus Hook refinery could only handle light, sweet crude). In 1994, Sunoco purchased the Girard Point refinery from Chevron (which had bought the facility from Gulf), consolidating it with the Point Breeze facility. Sunoco called the combined Point Breeze and Girard Point facility the Philadelphia refinery.[43]

A recent leak involving the Philadelphia refinery occurred in 2000, when an underground pipeline, running five miles from Sunoco's Hog Island marine terminal on the Delaware River to the Philadelphia refinery, developed a leak beneath the John Heinz National Wildlife Refuge near the Philadelphia International Airport. Sunoco received imported crude oil by ship at the marine terminal and conveyed it via the twenty-four-inch pipeline to the refinery. The February 2000 leak discharged an estimated

[42] Atlantic Refining Company, *Annual Report 1965* (Philadelphia, 1966), inside front cover, 38; Atlantic Richfield Company, *1966 Annual Report* (Philadelphia, 1967), 6; "Why Oil Companies Merge," *Oil & Gas Journal*, Apr. 18, 1966, 56–57; Ted Wett, "ARCO's Philadelphia Refinery System Restructured," *Oil & Gas Journal*, Apr. 9, 1973, 80–82.

[43] Idris Michael Diaz, "Sun Will Buy Atlantic Corp. for $513 Million," *Philadelphia Inquirer*, July 6, 1988; Daniel F. Cuff, "Oil Trader a Big Winner in Atlantic Sale to Sun," *New York Times*, July 7, 1988; Sunoco, "Our History, Our Community" (Philadelphia, ca. 2000, Sunoco brochure in possession of the author).

192,000 gallons of crude oil into a pond in the midst of the refuge. Sunoco paid for the remediation under an order from the US Environmental Protection Agency.[44]

In the last few years, the refinery has undergone further changes reflecting corporate restructuring of the refining industry. In September 2011, Sunoco announced that it was leaving the refining business and that it would either sell or close its Point Breeze and Marcus Hook refineries. The following May, Energy Transfer Partners, a Texas pipeline company, acquired Sunoco, stating that it would continue Sunoco's retailing and pipeline business and try to find a buyer for the refineries. In July 2012, the Carlyle Group, a private equity firm, entered an agreement with Sunoco to operate the refinery by means of a joint venture called Philadelphia Energy Solutions. Because the Philadelphia refinery is now the largest on the East Coast, officials from the White House and the City of Philadelphia worked to bring the Carlyle Group and Sunoco together in the undertaking. In announcing the deal, a Carlyle spokesperson said that the new venture would include a high-speed railroad unloading facility at the refinery so that it could treat increased volumes of low-sulfur crude oil from North Dakota's booming Bakken Shale formation. The refinery now receives 160,000 barrels per day (about half of its capacity) from the Bakken formation, most of it by rail. For decades, the refinery had relied primarily on crude oil imported by ship, which in recent years had become more expensive than domestic crude.[45]

Receiving Bakken crude by rail from North Dakota links the Point Breeze refinery to another dangerous feature of the oil industry: the possibility of railroad accidents involving tank cars filled with explosive materials—a potential that was realized in June 2013 when a train carrying

[44] Sandy Bauers, "Wildlife Refuge Cleanup Crew Were Working Nonstop after a Pipeline Ruptured," *Philadelphia Inquirer*, Feb. 8, 2000; "Restoring Habitat at John Heinz National Wildlife Refuge at Tinicum," US Fish and Wildlife Service newsletter, Aug. 2009, http://www.fws.gov/northeast/pafo/pdf/john_heniz_final.pdf; Environmental Protection Agency, "John Heinz National Wildlife Refuge: Current Site Information," last updated Mar. 2008, http://www.epa.gov/reg3hscd/super/PA/johnheinz/pad.htm.

[45] Andrew Maykuth, "Sunoco to Sell or Close Its Refineries in Philadelphia, Marcus Hook," *Philadelphia Inquirer*, Sept. 7, 2011; Maykuth, "Texas Pipeline Firm to Buy Sunoco Inc. for $5.3 B," *Philadelphia Inquirer*, May 2, 2012; Maykuth, "Deal Will Keep Sunoco's Philadelphia Refinery Operating," *Philadelphia Inquirer*, July 2, 2012; "Partnership Formed to Keep Philadelphia Refinery Open," *New York Times*, July 2, 2012; Ryan Dezember and Jerry A. Dicolo, "Carlyle Bets Big on U.S. Energy," *Wall Street Journal*, July 2, 2012; Luke Geiver, "Philadelphia Refiner's Bakken Rail Project Saves Company," *Bakken Magazine*, Oct. 2013; Ryan Dezember, "Carlyle to Sell Shares in Philadelphia Refining Equipment," *Wall Street Journal*, Sept. 22, 2014.

Bakken crude derailed and exploded in the Quebec town of Lac-Mégantic, killing forty-seven people. In December 2013, a train carrying Bakken crude through North Dakota exploded a mile west of Casselton, leading to an evacuation of the town. Although the accident had no casualties, the accident highlighted the possibility that such an event could again lead to loss of human life.[46]

In reporting the deal to keep the Point Breeze refinery in operation, an Associated Press article in the *New York Times* called the combined Philadelphia refinery "the oldest and largest refinery on the East Coast."[47] Oil refining began at Point Breeze in 1866, during the first few years of Pennsylvania's oil boom, and the refinery was an important cog in the monopolistic enterprise that John D. Rockefeller formed to rationalize the industry in its early decades. The technologies developed and employed at the Point Breeze refinery have helped it adjust to a variety of sources of crude oil supply and to changing market conditions for petroleum products, and the facility continues to provide Americans the fuels they demand to maintain lifestyles of ready personal mobility. That perhaps, is the side of the refinery's history that is easiest to contemplate. But refineries are messy operations, and the Point Breeze refinery has been no exception. It has created its share of human and environmental disasters, beginning in 1879 and continuing into the twenty-first century. This is the traumatic side of the refinery's history, and a history of trauma is likely to continue.

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[46] David George-Cosh, "After Lethal Crash, Quebec's Fears Return of Oil Trains," *Wall Street Journal*, July 4, 2014; David Schaffer, "As Oil Train Burns, 2,300 Residents of Casselton, N.D., Told to Flee," *Minneapolis Star Tribune*, Dec. 31, 2013.

[47] "Partnership Formed to Keep Philadelphia Refinery Open," *New York Times*, July 2, 2012.

"New and Untried Hands": Thomas Edison's Electrification of Pennsylvania Towns, 1883–85

Thomas Edison was directly involved with building and running pioneering electric power stations in Pennsylvania from the spring of 1883 until the late summer of 1884.[1] The story of Edison's Pennsylvania ventures, long a justifiable source of local pride, is briefly highlighted by Thomas Hughes as a crucial early step of electrification in the United States and Europe.[2] In Hughes's consideration, Edison's work in Pennsylvania does not rise to the level of a "reverse salient," a term for an unexpected battlefield reversal that Hughes so memorably applied to a sticking point or setback in the development of large technological systems, such as the electrical grid. But Edison, were he inclined to military metaphors, might have expressed his experiences in Pennsylvania in just this way. He was poised in early 1883 to break out of the metropolitan market of Manhattan, where his direct current (DC) system successfully

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[1] The Edison central stations in Pennsylvania completed during this period, with start dates and initial rated capacity [number of ten-candlepower lamps] were: Sunbury (July 1883 [500]); Shamokin (September 1883 [1,600]); Mount Carmel (January 1884 [500]); Bellefonte (February 1884 [800]); and Hazleton (February 1884 [1,000]). Lists of all Edison plants completed and planned during this period are in *TAEB* 7, appendix 2. Edison's extensive correspondence regarding these plants is arranged in several functional groups maintained at the archives of the Thomas Edison National Historical Park in West Orange, NJ (hereafter NjWOE). Incoming correspondence from or specifically about individual central stations is grouped there in a separate archival series arranged by state and town name (including Sunbury, Shamokin, Bellefonte, Mount Carmel, and Williamsport). These place-specific documents and the great majority of others related to central construction may be accessed in several ways on the Thomas Edison Papers website, such as by retrieving individual items (http://edison.rutgers.edu/singldoc.htm) or browsing folders (http://edison.rutgers.edu/sn03.htm#1883).

[2] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore, 1983), 431–33.

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lighted the Wall Street area, and start what he hoped would be a wave of power plants in less dense and more workaday communities across the United States. He opted to start in and around Pennsylvania's anthracite region, first in Sunbury and Shamokin, and soon enough in Mount Carmel, Bellefonte, and Hazleton. Several factors influenced his choice of this area: the relative ease of access from his New York laboratory and offices; local entrepreneurial networks formed semi-independently of mineral wealth; population density; and, ironically, the high cost or unavailability of illuminating coal gas. When he left the region some fifteen months later, Edison had achieved only qualified success at the cost of great aggravation and expense and some damage to his reputation as America's most successful inventor.

The problems Edison encountered in Pennsylvania were not only in the technical design of his system, or at least not exclusively so. He planned the Pennsylvania stations to meet a shortage of financial capital for constructing power plants and distribution networks. What he failed to anticipate fully was a shortage of human capital: the skills needed in each community to operate and oversee the plants. He seriously underestimated, first, the difficulty of transferring his own facility with the system to new hands and, second, the challenges of adapting the system in response to feedback that was often uninformed. Edison and his closest associates had four years of familiarity with the elements of electric lighting: the dynamo for generating electric power, the wiring scheme for transmitting it safely and economically, and the delicate incandescent lamp for converting it into light. Although basic knowledge of electricity was widespread due to the nationwide networks of commercial and railroad telegraphs, there was no analog for electric lighting in telegraphy's batteries, uninsulated iron wires, and sending keys. Much of the skill needed for the power plants would have to be imported or cultivated from the ground up. Edison and his intimates had no more experience doing this than the local plumbers or machinists had with electric lighting; all were untrained hands at their respective tasks. Edison coped by turning to his strength: devising technological solutions, even for problems that were only marginally technical. But despite his past experience as a proprietary capitalist, he could not easily master the administrative tasks of financing and managing the central stations. The plants—and the organizations developed to run them—proved to be fragile and almost ended up justifying the criticism of skeptics. In the end, the tightening financial noose of an unfavorable business cycle in 1884 helped to force Edison out of the business and nearly undid his work in the state.

This article places those local events in broad technological and organizational contexts and offers an evaluation of their significance to the larger project of electrification in the United States in the late nineteenth century. Edison's work in those fifteen-odd months was crucial to sorting out the technological, economic, and organizational arrangements necessary for his dream of constructing power networks in cities and towns across the country. By unwittingly demonstrating the limitations of his own system in eastern Pennsylvania, Edison kept the door open to a rival who would emerge at the other end of the state. George Westinghouse of Pittsburgh recognized the opportunity and, within just a few years, assembled a cadre of skilled engineers, secured the necessary patents, and devised a feasible business model to promote the more economical alternating current (AC) model of distribution.

Financial and Technical Context: London and New York

The signal event of Edison's presence in the state came on July 4, 1883, when the inventor personally inaugurated central station electric service in Sunbury. It was a festive moment. In addition to its nascent electrification, the town held a boat regatta to celebrate Independence Day and also opened a new rail line. Months of planning and building had gone into the station, and for several weeks Edison himself had intermittently left his New York office and laboratory to supervise the work at first hand.[3]

Edison's route to Pennsylvania went first through London and New York City, where he successfully planned and built generating stations and distribution networks in 1881–82. He was famous around the world as the "Wizard of Menlo Park," the New Jersey village where he had built a laboratory in 1876. The nickname, initially given to him in 1878 as the inventor of the first practical device for recording and playing back sound, carried over to his electric light work.[4] At Menlo Park, he invented not only the famous light bulb but a supporting cast of components all designed to operate together in what was quickly recognized as a coherent system: his dynamos, first and foremost, and also meters, regulators,

[3] Despite the fact that Edison and his associates generated and saved an extraordinarily large amount of documentation during this period, all details of these trips have been lost.

[4] "The Wizard of Menlo Park," *New York Daily Graphic*, Apr. 10, 1878.

fuses, insulated conductors, and a plan for apportioning electric current geographically according to anticipated demand.[5] The "Wizard" nickname stuck even after he left Menlo Park to set up laboratories and offices in New York City in 1881. From Manhattan, he oversaw the installation of a temporary demonstration generating station on London's Holborn Viaduct, a busy commercial corridor. When it opened in early 1882, the plant proved the technical feasibility of his system for the incandescent lighting of shops and offices clustered in a relatively small area—probably fewer than a thousand lamps along about a quarter mile of the viaduct.[6] The dynamos, which Edison had designed as "converters" of mechanical into electrical energy, worked as intended, as did the other parts—all operating to produce a pleasing light at a cost not greatly exceeding that of illuminating gas.

Characteristically confident of success, Edison was already moving in the winter of 1881–82 toward his next step: lighting New York City's financial district on a permanent, for-profit basis. Illuminating the area around Wall Street would be not only a technological achievement but also a possible public relations bonanza. That, in turn, could translate into investment in Edison lighting companies beyond what he already enjoyed from a coterie of financiers affiliated with the banking house of Drexel, Morgan & Company. Edison knew he needed money to put in the necessary electrical plant, of course, but he also wanted to expand his manufacturing capacity for the lamps, dynamos, switches, and meters he expected to use for the widespread electrification of the United States and much of the world.[7] From late 1881 to the next summer, Edison work crews dug trenches and laid down conductors—copper rods insulated inside iron pipes—under the streets of lower Manhattan. The conductors, some fifteen miles of them in a roughly half-mile-square area, were connected to

[5] See, for example, Robert Friedel and Paul Israel with Bernard S. Finn, *Edison's Electric Light* (Baltimore, 2010).

[6] "Electric Lighting (Holborn Viaduct)," *Electrician* 11 (July 21, 1883): 232–33. Regarding the design, construction, operation, and stage-managing of the Holborn installation, see *TAEB* 6.

[7] Edison and several partners provided their own working capital for the manufacturing carried on by the Edison Lamp Company, the Edison Machine Works (dynamos and other heavy electrical equipment), and the Electric Tube Company (underground conductors). Edison was also a partner in the New York firm of Bergmann and Company, which made switches, sockets, lamp fixtures, and other small items. The small and tightly overlapped web of Edison associates supporting and managing the four enterprises makes it possible (for the most part) to consider these entities a unified Edison manufacturing operation before their integration into the Edison General Electric Company in 1889. See "Edison's Manufacturing Operations," *TAEB* 6: Doc. 2343.

six large dynamos in a building on Pearl Street.[8] The Pearl Street station, as it came to be called, started operating in September 1882. Although press notice of the event was muted, the plant did what Edison intended: it illuminated without interruption the influential customers around Wall Street—in particular, banks, printing houses, shops, and a few prestigious residences.[9] The plant and the district it lighted became symbols of a new electrical age. Demand for electricity exceeded Edison's hopes, and the station was enlarged several times.

Although the Holborn and Pearl Street plants met Edison's expectations, they also revealed flaws that would make his design too expensive in areas of lower population density—that is, the great majority of the territory he hoped to electrify. Edison modified his system to meet the needs of these areas and anticipated a wave of construction in small cities and towns throughout the United States.

That wave failed to materialize in the winter of 1882–83, and the impatient inventor saw his "Edison system" of central station electric lighting at a crossroads by the early spring. In addition to London and New York, the system was a reality on a small scale in Roselle, New Jersey, but neither Edison nor the Edison Electric Light Company, to which he had sold his patents, had suitable arrangements—organizational, financial, or technical—for building or operating central stations elsewhere. Edison foresaw a large market in small cities and towns but feared that the prospective business "would go to ruin" in the Edison Electric Light Company's hands.[10] Believing "if the business is to be made a success it must be by our personal efforts and not by depending upon the officials of our Companies," Edison sought new sources of capital.[11] The year 1883 started auspiciously when financier Henry Villard proposed contracting with the light company for "lighting all the cities & towns along the main line & branches of the Northern Pacific" railroad. A conversation with banker George Ballou

[8] See "Pearl Street Central Station," *TAEB* 6: Doc. 2243, for an overview of the Pearl Street plant's design, construction, and operation.

[9] Partial lists of customers as of April and October 1883 are in the Edison Electric Light Company Bulletins 17:3 and 20:30, available through the Thomas A. Edison Papers digital edition (hereafter cited as *TAED*) at http://edison.rutgers.edu/singldoc.htm, document folders CB017 and CB020. A list of first-year customers itemized by type of business is in Payson Jones, *A Power History of the Consolidated Edison System* (New York, 1940), 183–87.

[10] On Roselle see *TAEB* 6: Doc. 2336; Samuel Insull to Edward Johnson, Apr. 3, 1883, Misc. Letterbook 3:120, NjWOE; available online as *TAED* LM003120.

[11] Thomas Edison (TAE) to Edward Johnson, Mar. 5, 1883, Letterbook 13:12, NjWOE (*TAED* LB013012; *TAEB* 6: Doc. 2407).

also lifted Edison's hopes for fresh investment, but neither Villard nor Ballou brought new funds in the short run.[12] Searching for another way to proceed, Edison sketched a partnership arrangement in late March with trusted associates Edward Johnson, Samuel Insull, and Charles Batchelor, but this plan, too, failed to materialize.[13]

Edison would eventually diagnose the apparent lack of entrepreneurship by the Edison Electric Light Company as symptomatic of the innate caution of its president, Sherburne Eaton, a lawyer accustomed to working with established firms like Western Union Telegraph. Whatever the inadequacies of its management, the light company did not stand in the way of efforts to sell the Edison system outside of New York. The firm allowed other companies, formed for the purpose, to build and operate local central stations under license for Edison's patents. This was practically the only option available to the cash-poor New York firm, whose chief assets were those patents. Licensing would preserve the value of the patents and generate income through fees. The company developed a shadowy network of promoters or sales agents, men from other business or professional endeavors who had some allegiance to and financial interest in the company's growth. These relationships were highly individual, and though they would later be somewhat standardized or at least affirmed on something stronger than a handshake, we are largely at a loss to know their terms in 1882 and early 1883.[14]

One of those agents was Phillips B. Shaw, a Williamsport merchant and manufacturer. Shaw must have been forward looking and well connected to the area's mercantile and professional men who had some money to risk. In 1882, he had tried unsuccessfully to broker the commercial use of Edison's patents for electric railroads.[15] He was inquiring about estimates for putting in Edison lighting systems about the middle of that year,

[12] Villard to Sherburne Eaton, Jan. 2, 1883, Letterbook 47:6, box 122, Henry Villard Papers, Baker Library Historical Collections, Harvard Business School; TAE to George Ballou, Mar. 13, 1883, Letterbook 15:465A, NjWOE (*TAED* LB015465A; *TAEB* 6: Doc. 2413).

[13] TAE memorandum for village plants, Mar. 29, 1883, NjWOE (*TAED* HM830172B; *TAEB* 6: Doc. 2417); Samuel Insull to Edward Johnson, Apr. 3, 1883, Misc. Letterbook 3:120, NjWOE (*TAED* LM003120; *TAEB* 7: Doc. 2420); Paul Israel, *Edison: A Life of Invention* (New York, 1998), 219–25.

[14] Licensing also promised to boost the manufacturing businesses, revenue streams for Edison into which the New York company was also trying to tap. For general discussions of licensing and the recruitment of potential licensees, see "Village Plant Construction" and "Thomas Edison Construction Department," *TAEB* 7: Docs. 2424 and 2437.

[15] *TAEB* 7: Doc. 2424 n. 1; "P. B. Shaw," Edison Pioneers biography, NjWOE.

well before Edison had settled on a fixed "village plant" design adapted to such locales, much less built and tested one.

Shaw likely was involved in a nascent Edison illuminating company in Williamsport. Not far geographically from the anthracite fields, Williamsport had little direct economic connection with mining, in part because the Susquehanna River at its doorstep flowed toward the Chesapeake rather than to the coal markets of New York or Philadelphia. Its money came from timber, and the thriving city enjoyed a concentration of personal wealth. The illuminating company there obtained a license from the Edison Electric Light Company of New York, the first such license issued, and it made a public demonstration in mid-March. The demonstration consisted only of one or two small generators and about sixty lights in a handful of stores, but it drew as many as five thousand spectators the first night.[16] Shaw became the Edison Electric Light Company's recognized agent for Pennsylvania about that time.[17]

Shaw had already been busy. Exercising considerable independence from the New York firm, he had in the previous year solicited interest in Edison lighting in Sunbury, a busy county seat of four thousand people down the Susquehanna, and in Shamokin, a larger town and a major railroad junction about a dozen miles to Sunbury's east. Both towns were within about fifty miles of Williamsport, and both were near the active western edge of the anthracite coal region, where fuel for steam power was plentiful and illuminating gas (made from bituminous coal) was expensive.[18] Shamokin's mineral wealth flowed to Philadelphia or New York, but there was enough

[16] Regarding transportation of anthracite coal, see Barbara Freese, *Coal: A Human History* (New York, 2003), 118–24. The Williamsport company was incorporated in May 1882, but construction there did not begin until the end of 1883. Thomas W. Lloyd, *History of Lycoming County, Pennsylvania* (Topeka and Indianapolis, 1929), chaps. 26–30; Edison Electric Light Co. Bulletins 17:19 and 18:36, Apr. 6 and May 31, 1883, NjWOE (*TAED* CB017, CB018); Michael Nash, John Rumm, and Craig Orr, *Pennsylvania Power and Light Company: A Guide to the Records* (Wilmington, DE, 1985), 47; Alfred Tate to William Rich, Dec. 27, 1883, Construction Dept. Letterbook 17:252, NjWOE (*TAED* LBCD4252).

[17] Insull to Johnson, Apr. 11, 1883, Misc. Letterbook 3:135, NjWOE (*TAED* LM003135).

[18] The 1880 federal census listed the population in Sunbury as 4,077 and in Shamokin as 8,184. Gas in Shamokin was about four dollars per thousand cubic feet and, according to one report, ten dollars in Sunbury. For a standard fifteen-candlepower gas jet burning five cubic feet per hour, the latter price meant about five cents per hour per lamp. Thomas Dublin and Walter Licht, *The Face of Decline: The Pennsylvania Anthracite Region in the Twentieth Century* (Ithaca, NY, 2005), 18–19; Francis Jehl, *Menlo Park Reminiscences*, 3 vols. (Dearborn, MI, 1937–41), 3:1096; William Hammer notebook as chief engineer of Edison Electric Light Co., 1885–86, series 1, box 13, folder 1, William J. Hammer Collection, Smithsonian National Museum of American History. On Sunbury see Herbert C. Bell, *History of Northumberland County Pennsylvania* (Chicago, 1891), 480–500. In towns without gas ser-

local interest to form an illuminating company in November 1882.[19] A similar company was organized for Sunbury in April 1883. Despite the Williamsport demonstration and a reported visit by Edison that spring, there was little financial support in Sunbury itself; the firm's capital was eventually raised in Williamsport, where the board met.[20]

Shamokin proved more receptive to Shaw's ideas. A local delegation traveled to New York sometime in the spring, when Edison provided an estimate to put up a plant, poles, and wires for about $25,000. The Shamokin investors agreed and promptly put up money for an initial payment, but they also had their own ideas. Shaw wired Edison from Shamokin on May 3: "Contract for installation of sixteen hundred light plant signed. Boiler

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vice, such as nearby Mount Carmel, prospective companies had to apply for a license from the Edison Company for Isolated Lighting, which controlled rights to the Edison system in non-gas territory (see *TAEB* 6: Doc. 2299 n. 4). The Edison Electric Light Company later published some limited retrospective information on the price of gas in fourteen towns and cities, including Bellefonte, Hazleton, York, and West Chester, Pennsylvania. Edison Electric Light Co. circular, p. 24, n.d. [1886?], NjWOE (*TAED* CA001D).

[19] Shaw was among the Shamokin company's directors. Most of the early investors were Shamokin residents; a notable exception was Francis Upton. The company also sold bonds, largely to its stockholders, to help meet its first expenses. Incorporation certificate, Nov. 29, 1882, personal collection of Richard Guth, Georgetown, DE, on loan to the Thomas Edison Papers; Hugh A. Jones, "Edison's Experiment in Northumberland County," *Northumberland County Historical Proceedings and Addresses* ([Sunbury, PA], 1984), 29:69–90; Bell, *Northumberland County*, 627–28; Edison Electric Light Co. Bulletin 18:11, May 31, 1883, NjWOE (*TAED* CB018); Edison Electric Illuminating Co. of Shamokin ledger (1883–99), 1–3, Northumberland County Historical Society.

[20] The close personal and business ties among investors mimicked the tightly interlocking directorates of the New York Edison companies. Among the Sunbury directors were two prominent Williamsport attorneys (Seth T. and Frank McCormick) and a young physician (Thomas Detweiler); another (Charles Story) was from New York. Jones, "Edison's Experiment," 70; Edison Electric Light Co. Bulletin 18:11, May 31, 1883, NjWOE (*TAED* CB018); Emerson Collins and John W. Jordan, *Genealogical and Personal History of Lycoming County, Pennsylvania* (New York, 1906), 293–96; Bill Beck, *PP&L: 75 Years of Powering the Future* (Eden Prairie, MN, 1995), 51; some occupational information derived from 1880 federal census manuscripts for Williamsport (Lycoming County), accessed through Ancestry.com.

In Shamokin, the officers included president William H. Douty (b. 1837), owner of W. H. Douty Dry Goods, who was also a mining operator (and future director of the Shamokin Board of Trade). John Mullen (b. 1838), vice president, owned both John Mullen & Co., which manufactured mining machinery, and the Anthracite Foundry and Machine Works. In a notable but hardly unique overlap of electric and gas lighting interests, Mullen was a director of the Shamokin Gas Light Co. Among other business ties, he was president of both the First National Bank in Shamokin and the Shamokin Coal and Coke Company of May-Beury, West Virginia. The Shamokin treasurer was William Beury, a local gunpowder manufacturer. Beury later became the founding treasurer of the Shamokin Arc Light Company and seems to have become involved with John Mullen in the Shamokin Coal and Coke Company. Andrew Robertson (b. 1831?), a former colliery operator who was active in Shamokin business affairs (including the introduction of water and gas services) had some unspecified role in the firm, perhaps as one of its investors. Bell, *Northumberland County*, 618, 627–28, 892–94, 906–7; "Black Diamonds," *Washington Post*, Aug. 2, 1889, 2; approximate birth years derived from 1880 federal census of Shamokin (Northumberland County), accessed through Ancestry.com.

stock poles building & few miner [*sic*] items cut out of estimate. you better come by penna road to sunbury tonight. I will meet you. answer quick."[21] Edison initially declined to make the trip, but when Shaw insisted, he and Samuel Insull, his secretary and personal business manager, left that night. The next day, they signed a two-page, handwritten contract committing Edison to set up a central station system of 1,600 lamps—ten candlepower each—for $19,209, the price having been reduced by the local company's wish to subcontract for the station building itself.[22] Then Edison and Insull turned around and went back to New York, taking advantage of the geographical proximity that would be so useful during the months of construction to come. At some point around this time, probably soon after this trip, Edison also came to an understanding with the Sunbury company to build a plant there, though the contract has not been found.[23]

Edison praised the Shamokin plan as a "new and successful idea."[24] The contract called for cash payments in three installments, the last to come after the station was in operation for thirty days. It also stipulated that "if from any cause P. B. Shaw fails to furnish the cash payments on the bonds of this company as agreed," Edison would accept bonds at par instead.[25]

Local agents had been drumming up investor interest in several Massachusetts cities as well, but the contracts for Shamokin and Sunbury marked the start of what Edison and Insull expected would be a construction "boom." In April, Insull had remarked that "[Edison] has practically left his Laboratory & now makes my Office his Headquarters & is attending to purely business matters. . . . [T]here are plenty of . . . places which are just crying for these Plants."[26] Upon reflection a few months later, Edison himself came to believe that he "could take hold and push the system better than any one else," remarking, "It is so complicated that I do not feel like trusting it to new and untried hands, because science and dollars are so mixed up in it."[27] On May 3, the day Shaw summoned him to Pennsylvania, Edison gave Insull full power of attorney to act in his stead "to sign contracts for the erection of Edison Electric Light Installations"

[21] Shaw to TAE, May 3, 1883, Document File (hereafter DF), NjWOE (*TAED* D8360B).

[22] TAE agreement with Edison Electric Light Co. of Shamokin, May 4, 1883, Samuel Insull Records, Loyola University (Chicago) Archives (*TAEB* 7: Doc. 2438).

[23] "History of the Edison Electric Illuminating Co. of Sunbury Pennsylvania," typescript on file at the Thomas Edison Papers.

[24] TAE to Joshua Bailey, May 6, 1883, Misc. Letterbook 1:310B, NjWOE (*TAED* LM001310B).

[25] TAE agreement with Shamokin, May 4, 1883, Samuel Insull Records (*TAEB* 7: Doc. 2438).

[26] Insull to Johnson, Apr. 3, 1883, Misc. Letterbook 3:120, NjWOE (*TAED* LM003120; *TAEB* 7: Doc. 2420).

[27] "Promoting the Electric Light," *Electrical World* 1 (Aug. 4, 1883): 489.

and to conduct all other business "appertaining to [his] Central Station Construction Department."[28] That agreement reflected a deepening professional relationship that would influence Edison's work in the region. Insull, a Londoner a dozen years Edison's junior, had taken charge of the inventor's financial books and swelling correspondence in February 1881, just as his boss was relocating from the rural Menlo Park laboratory to the New York metropolis. By force of personality, ceaseless work, zest for power, and devotion to his principal, Insull became, in short order, Edison's de facto business and personnel manager. The power of attorney agreement allowed him to mind the dollars while Edison took care of the science.

Thomas A. Edison Construction Department and the Three-Wire Village Plant System

The Thomas A. Edison Construction Department, as it was officially designated, provided an informal financial and administrative framework in which Edison and Insull could manage a variety of transactions over a wide geographic area. Edison gave no attribution for his notion of a construction department, but the idea was not entirely novel. The organization of specialized construction companies had precedents in capital-intensive projects such as submarine telegraphy and telephone exchanges, and there were by this time numerous examples of independent contractors and suppliers in electric lighting. The tradition of referring to the construction department as a company goes back at least to 1894, but it functioned as a contractual surrogate for Edison himself, who was personally liable for its obligations.[29] The department had no independent legal standing, nor was it a branch of another entity such as the Edison Electric Light Company. It was not necessarily in anyone's interest to specify too closely the relationships among Edison, the Electric Light Company, or the Edison Company for Isolated Lighting, but within the unwritten understandings among the principals, the light company used the construction department's services and exercised some oversight of its operations. Edison's sketchy plan for the new entity created enduring ambiguities over its specific functions and its relations with existing organizations.[30]

[28] TAE power of attorney to Insull, May 3, 1883, NjWOE (*TAED* HM830175).

[29] The formation and operation of the construction department is discussed more fully in the "Thomas A. Edison Construction Department," *TAEB* 7: Doc. 2437.

[30] By prior contract, the Company for Isolated Lighting controlled Edison's patents in areas without municipal gas service (see *TAEB* 6: Doc. 2299 n. 4). Adding to the confusion, the two Edison

Just what was the system that Edison committed to build in Shamokin and Sunbury, and how did it differ from the one working so well in New York? We digress here to explicate a fundamental problem in the design of the conductor network beneath Manhattan's streets, one that Edison began to recognize even before the Pearl Street plant was completed. Edison had arranged the conductors in what he called the "feeder and main system." A few heavy "feeder" lines radiating from the station supplied current at about 110 volts to a grid of smaller "mains" running down each street. The overall pattern looked on paper something like a rectilinear spider web made of expensive, refined copper. It has not proved possible to calculate the overall cost of the Pearl Street plant, but retrospective figures range from several hundred thousand to (more likely) a bit over a half million dollars, both figures being well above the original estimates. Nor is it certain how much went into the conducting rods, but it is clear that copper was a major expense of the Pearl Street district, even as the metal's price was falling. One accounting by the Edison Electric Illuminating Company, which built and owned the plant, put the price of its insulated conductors (not installed) at $114,000, more than 20 percent of the total for the entire project.[31] Faced with an uncertain investment climate, Edison's backers were not eager to put up money for a second New York plant that they had originally imagined would quickly follow in or around the theater district.

From the beginning of his electric light research in 1878, Edison recognized certain tradeoffs between construction costs and the operating efficiency of an electric light system. These compromises were grounded in physical laws that, as it turned out, he understood better than many contemporary practical electricians and even academic physicists. With the aid of Francis Upton, a young, college-educated physicist and mathematician who had trained with the great Hermann von Helmholtz in Berlin, Edison systematically tried to calculate the ideal design parameters of a system years before the first paving stone was lifted in New York. But his calculations were predicated on the distribution of large amounts of current through a relatively small area with a high concentration of paying customers. The physical limitations, and consequently the economic constraints, of less densely populated areas were more severe.

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companies had overlapping officers and investors. Sherburne Eaton served both as president and often failed to differentiate these roles in his prolific correspondence.

[31] Edison Electric Illuminating Co. of New York memorandum of expenses, Apr. 1, 1883, DF, NjWOE (*TAED* D8326E1).

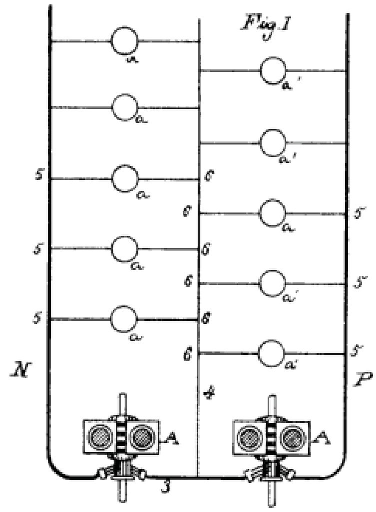
Two physical principles governed what Edison could do. One was the law articulated in the 1840s by English physicist James Prescott Joule and identified with his name ever since.[32] Joule's Law states that the amount of electrical energy in a circuit converted to heat (wasted, for Edison's purpose) is proportional to the circuit's resistance and also to the *square* of the current, or volume of electricity. That is, tripling the current increases by nine times the energy lost as heat. The other controlling factor was Ohm's Law (voltage = current × resistance), one implication of which is that voltage is inversely proportional to current for a given quantity of electrical energy.[33] This relationship suggested a way to mitigate the harsh implications of Joule's Law if Edison could raise the resistance of the lamps so as to increase the voltage relative to the loss-inducing current. The alternative was to lower the resistance in each circuit by increasing the amount of conductive copper, an unappealing option outside a densely populated city, where there would be fewer revenue-producing lamps per foot of conductor.

Edison naturally wanted to lower the cost of building a plant without compromising its efficiency. He was already designing a new system, one which he later adopted for Pennsylvania. He planned to use higher voltage, meaning that he could transmit the same energy with less current and, therefore, smaller conductors. But this was direct current, which cannot readily be stepped up or down by induction transformers like those now used for AC. He couldn't use much more than 110 volts in his lamps without burning them out. His first attempt was a 330-volt system, with lamps in each house grouped in blocks of three so each would operate at 110 volts. The trouble was that each group could have only one switch; the three lamps turned on or off together. Edison thought this "village plant system" would be economical in towns with fairly low population density. This was the system used in the small demonstration plant that he had persuaded the Edison Electric Light Company to build in Roselle, New Jersey, which worked well.

But Edison had vowed all along that his lamps could each be turned on and off independently, just like a gas lamp, a promise broken in his initial design for the village plant system. He came up with a solution that was ingenious and, it turns out, not unique. At almost exactly the same time, a young mathematician and engineer named John Hopkinson, working

[32] *Complete Dictionary of Scientific Biography* (Detroit, 2008), s.v. "Joule, James Prescott."

[33] *Complete Dictionary of Scientific Biography*, s.v. "Ohm, Georg Simon."



Schematic drawing from Edison's patent on the three-wire system. Lamps (circles) are connected between one leg of the main circuit from the dynamos and the small neutral (or balancing) wire.

for the Edison Electric Light Company, Ltd. in London, independently came up with the same solution, as did the German electrical manufacturer William Siemens.[34] Called the three-wire system by both Edison and Hopkinson, it used two dynamos connected in series, each generating at 110 volts. A third distribution wire ran from a neutral point between the two machines, so that one of the conducting wires was 110 volts above it and the other 110 volts below it. Lamps were placed in pairs, one connected from the positive voltage line to the neutral, the other from the neutral to the negative line. Every lamp therefore experienced 110 volts, and the current flowed through the paired lamps in series from the positive to the negative lines.[35] The result was that electricity was transmitted at 220 volts, permitting the conducting wires to be smaller than in the 110-

[34] Regarding the origins of Edison's three-wire system and its relationship to that of Hopkinson, see *TAEB* 6: Docs. 2308 n.1 and 2407 n. 4; Israel, *Life of Invention,* 219; Samuel Insull to Edward Johnson, Apr.1, 1883, Misc. Letterbook 3:115, NjWOE (*TAED* LM003115).

[35] Edison's US Patent 274,290 also included the idea that, at least in principle, additional compensating wires and proportionally higher voltage could be used, but Edison did not expect to achieve proportional reductions in copper. TAE marginalia on Harry Mather Doubleday to TAE, July 21, 1883, NjWOE (*TAED* D8305J).

volt two-line system. The neutral line could be smaller still, as it would (at least in principle) conduct only a small current to balance the system as lights were turned on or off individually. Edison calculated that there would be a savings of 62.5 percent over a comparable two-wire network.[36] To reduce the cost further, he accepted high electrical losses, resulting in a voltage drop of at least 10 percent along the feeder lines.[37] The three-wire plan was an innovation of great economic benefit, though copper would remain a major part of the construction bill for each station.[38]

Even with the copper-saving three-wire design, cost hemmed in Edison's plans. Of the $19,209 contracted by the Shamokin illuminating company, only $4,802 was to be paid to Edison before the station was ready to go into operation. In the meantime, while he was not responsible for erecting the Shamokin station building itself, he had to finance from his own pocket the purchase, shipment, and installation of everything from steam engines and dynamos to poles and wires. The inventor's pockets were deep, to be sure, lined by regular royalties and commissions on his earlier inventions, an ongoing retainer from the Western Union Telegraph Company, and income from investments in government bonds and from his own manufacturing shops. But the cash flow outlook for construction on the scale that he and Insull envisioned was still a daunting one, which led them to do the work as cheaply as possible.

Although the Shamokin company's quirky insistence on subcontracting the construction work saved Edison some money, it also substantially slowed the work, in effect handing the honor of the first operating Edison three-wire plant to the smaller, less affluent town of Sunbury. Perhaps because out-of-towners ran it, the Sunbury company was content to leave all construction to Edison. The good news was that, unlike in Shamokin, where construction quickly bogged down, Edison's men put up the Sunbury building quickly. The bad news, however, was that *Edison's* men put up the building *quickly*. Edison had no experience with this work.

[36] In an 1884 explanation and overview of the system, a top assistant in the construction department calculated the savings at 69 percent. TAE to William Andrews, Aug. 10, 1883, DF, NjWOE (*TAED* D8316ANI); Henry Guimaraes report, Aug. 29, 1884, Charles Batchelor Collection, NjWOE (*TAED* MB141).

[37] Insull to Johnson, Sept. 25, 1884, Letterbook 18:419, NjWOE (*TAED* LB018419).

[38] Edison was billed, in the aggregate, at least $20,000 for copper conductors up to November 1883 (Insull to Ansonia Brass & Copper Co., Nov. 27, 1883, Letterbook 13:25, NjWOE [*TAED* LB013025]; see also the "Village Plant Construction," *TAEB* 7: Doc. 2424 n. 9). In the illustration, taken from Edison's US Patent 274,290 (issued March 20, 1883), the third (or "compensating") wire runs between the negative (**N**) and positive (**P**) main lines of the direct-current system; dynamos **A** and **A** are at the bottom.

In the middle of May, he designated an assistant, William Rich, as the superintendent of construction. Rich (a former miner) had, as far as is known, no knowledge of construction, but the one-story structure got finished somehow. In June, Edison spent about three weeks, on and off, in Sunbury, boarding at the City Hotel. The local company asked him to move up the operational date of the plant so it would be ready for the "general celebration" planned for Independence Day, which would be "an excellent opportunity to exhibit our light" to the general public and prospective customers.[39] Edison's crews, dispatched from New York, pushed the work hard, but their haste, combined with inexperience, overconfidence, and a penny-wise, pound-foolish approach to expenditure, created lasting problems. For example, the roof soon began to leak, a defect that would appear in a number of Pennsylvania plants.

"Go to school on this job": Edison's Sunbury Experience

As often happens with innovative technological systems, successful completion of the Sunbury plant depended less on executing the newest big idea than on myriad prosaic details. Edison had subcontracted the job of putting up poles and wires to Bergmann & Company, the New York manufacturer of electrical apparatus in which he was a partner. With one month to go, he nagged Bergmann: "poles dont grow right on the exact spot where they will be needed. . . . I would also remind you that the Almighty has'nt yet grown any trees which attain the necessary height and diameter within a week." Only on June 19 did the town issue a permit to erect the poles; workmen then labored against both drenching rains and "the entire change of the plan of running the Pole line" to have them ready by the appointed day.[40]

Edison had been quoted several years earlier stating that "steam engineering forms 75 per cent. of the electric light," and it was that mature technology which came closest to upsetting the July 4 debut.[41] He had been overseeing installation and testing of the dynamo, a model of his own design that the Edison Machine Works built in New York. The machine

[39] Frank McCormick to TAE, June 1, 1883, DF, NjWOE (*TAED* D8361D).

[40] TAE to Bergmann & Co., June 5, 1883, Letterbook 17:68, NjWOE (*TAED* LB017068, *TAEB* 7: Doc. 2457); Frank McCormick to TAE, June 19, 1883; Charles Hanington to TAE, June 29, 1883; both DF, NjWOE (*TAED* D8361U, D8340ZAV).

[41] "The Coming Light," Feb. 12, 1880, unidentified clipping in Menlo Park Scrapbook, Cat. 1014:34a, NjWOE (*TAED* SM014034a).

worked as intended, but in the excitement of July 3, one of his lieutenants forgot to tend the engine lubricators. As a result, the babbitt bearings ran dry and had to be relined in an all-night repair session. Insull, mindful that cost overruns ultimately came from Edison's wallet, made a half-hearted threat to recover the expense from Frank Sprague, a young electrical engineer (who soon left Edison to launch his own brilliant career).[42] Insull also scolded Charles Hanington, who had supervised the wiring, for submitting a bill for eleven days of labor by twelve different men. In his defense, Hanington argued,"Sunbury was very much mixed from the start . . . and I dont think more than ½ of the people that had a hand in it understood it. . . . I was not the only one to go to school on this job."[43]

Edison, too, went to school in Sunbury, though not all of the lessons to be learned were readily apparent. He stayed in town for several days after the plant opened to monitor its performance and to continue training the staff. Before leaving, he wrote out and signed twelve pages of trouble-shooting instructions, including nine possible dynamo problems and their remedies. This primitive manual was the first of several efforts to codify knowledge essential for the reliable and economical operation of central stations far from the resident expertise in New York.[44] Edison left behind in Sunbury one of his principal electricians, William Andrews, but just a few days later, an intense thunderstorm showed how ill-equipped Andrews was to manage on his own. He reported to Edison that lightning had "been snapping most viciously around our light fixtures" in the City Hotel, producing a few cracks "as loud as the firing of a gun cap" and leaving "Some of the folks here . . . quite scared." Edison, with years of experience with uninsulated telegraph lines, instructed Andrews to ground the system through a high resistance during daylight hours and during storms (though doing so would shut down the system) and to "put the omnibus [main conductor] to dead ground when not running storm or no storm."[45] The report from Andrews was the first of many about unexpected contingencies. Some of those contingencies could easily have been avoided,

[42] Samuel Insull to TAE, July 10, 1883, DF, NjWOE (*TAED* D8367Y3; *TAEB* 7: Doc. 2485).

[43] Samuel Insull to Charles Hanington, July 10, 1883; Hanington to Insull, July 10, 1883; both DF, NjWOE (*TAED* D8316AFE, D8340ZBD).

[44] TAE memorandum, July 8, 1883, facsimile reprinted in Jehl, *Menlo Park Reminiscences*, 3:1102–13 (*TAED* X001J3A, X001G2BD; *TAEB* 7: Doc. 2484); see also TAE to William Andrews, Aug. 4, 1883, Construction Dept. Letterbook 14:260, NjWOE (*TAED* LBCD1260, *TAEB* 7: Doc. 2500).

[45] Andrews to TAE, July 11 and 16 (with TAE marginalia), 1883; TAE to Andrews, July 19, 1883; all DF, NjWOE (*TAED* D8361ZAV, D8361ZBE, D8316AIE); Harry L. Keefer and Samuel N. Keefer, "First 3-Wire System in World Installed Here," *Sunbury Daily Item,* Sept. 1, 1927.

particularly those arising from penny pinching during the construction phase. The mere existence on paper of a construction department did not guarantee that the abilities of the nation's most famous technician could be transferred to other crafts or to geographic regions beyond his direct oversight.

Wiring was a particular problem. Left in the supposedly expert hands of Bergmann & Company, the interior wiring worked well enough but was unsightly.[46] Before the plant was even a month old, Frank McCormick, the Sunbury company president, fumed that Bergmann's crew "have caused a great deal of complaint because of the manner in which the work is done and the conduct of the men doing the work." He complained that they had placed unconcealed wires "over the walls and ceilings with no regard whatever for the appearance of things" and had cut private telephone lines lying in their way. They also charged "exhorbitant [*sic*] prices for putting in lamps, in some cases as high as $3.75 per lamp." The stalwart Phillips Shaw, after inspecting the Sunbury system, reported to Edison, "the wiring makes me Sick. I certainly Shall be ashamed to Show this work to people of other towns." He filed similar complaints from Shamokin. The Sunbury directors voted to take the work out of Bergmann's hands and contract for it themselves, further annoying Edison by publicizing their decision.[47] Edison acknowledged the problems but implied that the underlying fault lay not in the workers' competence but in their efforts to economize on costly materials. He vowed that his laboratory assistants in New York were already at work on a cheaper wiring system.[48]

The wiring difficulties were indicative of two general problems that would plague the pioneering Pennsylvania plants to varying degrees. One challenge was to find—or train—a staff to set up and operate what was a fairly esoteric high-tech system. The other was to adapt the technical details of the system in response to feedback from those actually installing and using it. Drawing a bright line between his work as an inventor and his immediate future as a contractor, Edison reportedly boasted to a newspaper while setting up the Sunbury plant that he had "closed [his] laboratory" and gone into business because "there is nothing more

[46] The Sunbury installation was typical of early Edison plants in Pennsylvania and elsewhere in that most of its customers were commercial establishments such as the City Hotel and various shops.

[47] McCormick to TAE, July 25, 1883; Shaw to TAE, July 23 and 31, 1883; TAE to Shaw, Aug. 2, 1883; all NjWOE (*TAED* D8361ZBK, D8361ZBH1, D8340ZBX, D8316ALD).

[48] TAE to Frank McCormick, Aug. 2 and July 26, 1883, both DF, NjWOE (*TAED* D8316ALB D8316AJB; *TAEB* 7: Doc. 2496).

in electric lighting to be invented or required." Soon after, he promised to be "simply a business man for a year. I am now a regular contractor for electric light plants, and I am going to take a long vacation in the matter of inventions."[49] Edison took great personal pride in his ability to adapt an invention or system to unforeseen conditions of actual use through a rapid series of changes—what we now call "innovation." But his experience with innovation had, until this point, been entirely hands-on: he observed a device in operation, identified problems, and devised solutions. In this case, however, the system was in use outside his personal view, meaning he had to rely on reports from others. Some information came from users or investors completely untutored in electricity, whose accounts were of unknown reliability. More coherent and sophisticated information came from his lieutenants in the field, though these men, despite possessing technical vocabularies and skills, also were largely inexperienced with the village plant system. Andrews, Edison's chief electrician, who managed the installation of most of the Pennsylvania plants, fired off dozens of letters and telegrams with critiques and suggestions. Edison, preoccupied in New York with preparing estimates and preliminary layouts for scores of projected new village plant installations, weighed these reports and gruffly advised him by return mail and telegram.

Some of the problems reported from Sunbury, Shamokin, and elsewhere were amenable to technical solutions, and Edison spent part of his planned year as a "business man" working instead in his makeshift laboratory atop the Bergmann & Company factory in New York. The single most serious and persistent difficulty had to do with voltage regulation. The proper voltage was crucial to the system's success: too low and lights would dim, causing customer complaints; too high, even for a moment, and lamps would burn out. (Replacement came at the expense of the company, not the irate customer.) Edison had largely solved this problem in the two-wire Pearl Street district, but the three-wire village plan was a dynamic system in which small changes on one part of the circuit could produce outsized effects on the other. It also raised the possibility of a geographically asymmetrical load in which one leg of the circuit would require more current than the other. Edison devised what he called a "feeder regulator" or "equalizer," essentially a set of resistance coils, to

[49] "Edison," *Chicago Daily Tribune*, June 19, 1883, 8; "The Electric Light," *New York Evening Post*, Aug. 1, 1883, 1.

alleviate the imbalance, and he called for them to be installed at Sunbury and Shamokin. Simple in principle, feeder regulation depended on reliable instrumentation to indicate line conditions to an operator back at the station. Properly interpreting signals from instruments in multiple branches of the network, especially when those devices acted inconsistently, was a difficult art to master.[50]

Vexed by reports of "enormous" lamp breakage, Edison exchanged numerous letters with Andrews on the subject throughout that first summer. They managed to ameliorate the difficulties somewhat, but in early 1884, with seven months of experience behind him, Andrews concluded that the problems were "the almost inevitable consequence of starting up new Stations, and running the same by guesswork."[51]

The larger concern of regulation was simply managing the minute-to-minute changes in load, particularly at dusk, as customers turned on their lights, and again at the end of the evening. If steam power at the station were not adjusted accordingly, the dynamos would generate electricity at a voltage too low or too high for the lamps. In October 1883, after an unrecorded amount of work in his laboratory, Edison prepared to patent a voltage indicator that can be seen in retrospect as one of the first electronic devices. It was based on the phenomenon called the Edison Effect, first noticed at his Menlo Park laboratory in 1880. Edison found then that a wire inserted into the vacuum of a lamp bulb but not electrically connected to the filament acquired an electrical charge when the bulb reached incandescence; moreover, beyond that point, the charge in the extra wire increased out of all proportion to the voltage applied to the lamp.[52] The disproportionate electrical response of the modified bulb, Edison realized, was just the sort of feedback mechanism he needed for a sensitive indicator, and he had the new devices in service at several plants in Pennsylvania (as well as in Massachusetts) before the end of 1883.[53]

[50] For a more complete explanation of the three-wire system and its regulation, see "Distribution System Regulation" and "Voltage Indicators," *TAEB* 7: Doc. 2505 and Doc. 2537 n. 6.

[51] Andrews to TAE, Aug. 12, 1883; Andrews to Edison Construction Dept., Feb. 16, 1884; both DF, NjWOE (*TAED* D8361ZCJ, D8442ZBH).

[52] No one could explain this action without a theory of the electron—still more than a decade in the future—but it was the result of electron transfer from the heated filament wire. This principle is the basis of the vacuum tube. See "Edison Effect and Lamp Life," *TAEB* 5: Doc. 1898.

[53] To Edison's chagrin, he soon found not only that the new indicators were fragile and ill-suited to long railroad journeys from his lamp factory in Harrison (East Newark), New Jersey, but their electrical characteristics changed over time, rendering them quite useless for the job. See "Voltage Indicators," *TAEB* 7: Doc. 2538.

For customers and managers of the Sunbury plant plagued by lamp breakage, the new instruments could not come soon enough. Roughly one hundred lamps failed each month throughout the fall. Frank Marr, an attorney serving as the local company's treasurer and legal representative, reported that eight lamps arced (short-circuited across the filament) in one November evening, destroying the sockets as well as the lamps.[54] Edison blamed the company for deliberately exceeding the capacity of his ten-candlepower lamps. The company reduced the electrical pressure in the 110-volt system, first to 105 volts, then lower, to the point that disgruntled customers took to supplementing their dim electric lights with gas. Edison dispatched one of his most experienced lieutenants to investigate, and fingers were pointed in various directions. The inexperienced Sunbury company operators had little choice but to rely on Edison's recommendations on this and other matters, such as a planned expansion of the service area and the rates to charge customers.[55]

Although Edison was too quick to blame operators for all of the plant's ills, he was correct to suspect a deficit of skill or attention on the part of the operating engineers. Edison had relinquished full control of the plant to the Sunbury company in early August despite misgivings about its high coal consumption and the ability of its fireman. Concerns about the capability of local skilled and semiskilled labor to operate the machinery with only a few weeks of training would haunt his experience not only at Sunbury but in a number of other plants. It is not clear what type of workers the local Edison illuminating companies sought or could hire, but it is likely that they would have looked favorably on stationary steam engineers. In Sunbury, the Pennsylvania Railroad's large car and locomotive shops were probably the major employer of the type of labor the company required. Even so, the electrical instrumentation in the plant would have been outside the experience of almost anyone in the area, and correctly interpreting and responding to the instruments was not a simple matter, as Edison's own experts understood. Long overnight shifts surely aggravated these deficiencies.

[54] Frank Marr to TAE, Nov. 3, 1883, DF, NjWOE (*TAED* D8361ZDN); a capsule biographical summary of Marr and his subsequent involvement with electric lighting in Pennsylvania is in *TAEB* 7: Doc. 2533 n. 3.

[55] TAE to Frank Marr, Nov. 7, 1883, DF, NjWOE (*TAED* D8316BEU; *TAEB* 7: Doc. 2546); Frank McCormick to TAE, Oct. 23 and Nov. 5, 1883; TAE to McCormick, Oct. 26 and Nov. 9, 1883; Thomas Conant to TAE, Nov. 4, 1883; TAE to Marr, Nov. 13, 1883; Marr to TAE, Nov. 3 and 15, 1883; all DF, NjWOE (*TAED* 8361ZDK, 8361ZDO, 8316BCW, 8316BFH, D8360ZCC, D8316BFQ, D8361ZDN, D8361ZDQ).

Supervision of operating engineers was another problem, particularly in Sunbury. The plant's owners and managers were professional men (and out-of-towners, at that) with little or no industrial experience; they entrusted its operation entirely to an engineer and his assistant. In December, Edison received a roundabout report from William Andrews, then working in Lawrence, Massachusetts, that the Sunbury engineer "got drunk the other night and left Station in care of a boy." Frank Marr investigated and, after excoriating Edison again about his choice of subordinates and about interior wiring, reported that the engineer, one William Bateman, was routinely on duty from 3:00 p.m. until 8:00 a.m. and was permitted a few hours' sleep while a young assistant minded the machines. On the night in question, he claimed, the youth had simply failed to wake Bateman before leaving for the evening.[56]

This incident, however, turned out not to be an isolated one, and various complaints continued to reach Edison's office in New York. At the end of January 1884, Alfred Tate, an assistant to Samuel Insull, dispatched construction supervisor William Rich to fix the Sunbury plant's leaky roof and look into other physical problems. Rich's on-site observations provided a broad indictment of the plant's operations. Windows were broken or painted over, a sheet of metal covered a hole in the roof directly over the voltage regulator, there was extensive corrosion, and the interior generally was unkempt. Rich pointed out that the dynamos' original driving belts betrayed little wear, having been replaced because they produced noise that "disturbed the slumbers of the engineer (but still he slept on)." He also related another incident in which Bateman had absented himself, leaving a young assistant in charge. More damning news about Bateman soon came from Andrews, who corroborated Rich's account of the station's "filthy condition" and poor operation. Andrews noted that Bateman was in debt "all over Sunbury" and had "made the station a regular rendevouz for women—I found a couple of doz. empty beer bottles behind boiler." He concluded that Bateman's tenure "shows the evil of leaving a station entirely in charge of an engineer, with no one else in the town that knows anything about Station matters, or has authority to act."[57] Accounts of inebriated engineers also came in from Bellefonte and Hazleton. In February 1884, only a week into the operation of the Hazleton plant, a report reached

[56] William Andrews to Samuel Insull, Dec. 5, 1883, DF, NjWOE (*TAED* D8361ZDY; *TAEB* 7: Doc. 2563); Marr to TAE, Dec. 8, 1883, DF, NjWOE (*TAED* D8361ZEB).

[57] Rich to TAE, Feb. 2, 1884; Andrews to TAE, Feb. 9, 1884; both DF, NjWOE (*TAED* D8458F, D8442ZAV).

Edison that the engineer had "been intoxicated for several days." Edison concluded that in these towns, "in Every Case trouble may be traced to carelessness," and he belatedly drafted a standard contract delineating the responsibilities of the station engineer.[58]

Problems with the System

Problems in Sunbury foreshadowed troubles throughout the region. In addition to staffing and management troubles, the leaky roof in Sunbury was symptomatic of systemic scrimping on generic construction to make the plants more affordable. Edison went to Shamokin in late September to oversee the startup there, but that plant was soon plagued by boiler and engine problems. Elsewhere, he held down costs by ordering engines and boilers too small for the work they had to do. They burned through too much coal and too much of the companies' expected profits.

Edison addressed these manifest problems early in 1884, though not quickly enough to please local investors. In Sunbury, he fired the engineer and put in his own people.[59] He was only able to do so because the undercapitalized company had paid for its plant in stock shares instead of cash, effectively giving him a controlling interest, a pattern that would be repeated by cash-poor and dissatisfied Edison lighting companies throughout the region.[60] He paid particular attention to Hazleton because of the financial involvement there of George Bushar Markle Jr., whose father, now retired, had been a powerful coal operator and leader of efforts to suppress the Molly Maguires. The Markle family was linked through its railroad investments with Drexel, Morgan & Company, whose partners remained deeply involved with the Edison companies in New York. James Hood Wright, a Drexel partner particularly close to Edison, was also connected by the marriage of his stepdaughter into the Markle family. After the Hazleton plant's debut, seemingly rocky even in comparison with the region's other stations, Sherburne Eaton of the Edison Electric Light Company warned in early March 1884 that Edison should quickly

[58] Sherburne Eaton to Samuel Insull, Feb. 18 and 20, 1883; TAE to Insull, Mar. 8, 1884; TAE draft contract, ca. Feb. 5, 1884; all DF, NjWOE (*TAED* D8439U, D8455ZAL, D8439ZAI [*TAEB* 7: Doc. 2625], D8439ZAA1).

[59] TAE to Sherburne Eaton, ca. Feb. 3, 1883, DF, NjWOE (*TAED* D8458E; *TAEB* 7: Doc. 2603).

[60] Regarding payments in stock of the Sunbury company see, for example, TAE to Frank McCormick, Aug. 4, 1884, Letterbook 18:221, NjWOE (*TAED* LB018221; *TAEB* 7: Doc. 2709).

make amends because "Markle means J. Hood Wright," and their collective potential future investment in electric lighting was substantial.[61]

Edison's efforts to improve operations in Hazleton, though swift and effective, proved insufficient to meet the adverse circumstances he faced throughout the region in the first half of 1884. Most of those circumstances were his and Samuel Insull's direct responsibility, to be sure, the culmination of bad planning that led the president of the Sunbury plant to complain, just after its first anniversary, that the whole business "looks very much like a swindle."[62] Some could also be attributed to honest misapprehensions of the risks in a new and untried business. The construction "boom" Insull anticipated came both too fast and too slow: it demanded the rapid outlay of large sums of cash but, after the first wave of expenses, did not generate enough new business to make those debts bearable. It is extremely difficult to reconstruct Edison's financial records, but it can be said that in the first few months of his construction department business he advanced at least $43,000; by the spring of 1884, despite some repayments, he was out of pocket for tens of thousands of dollars and was having trouble collecting the sums due him.[63] Village plant systems were simply too expensive for the sole proprietor business model Edison had adopted for their construction. Despite having modified the network's design to trade some operating efficiency for lower initial costs, he recognized in March 1884 that "the 1st investment is the trouble in pushing our biz."[64] Six weeks later, on April 24, he announced his intention to leave the construction business and negotiate its takeover by the Edison Electric Light Company; a few weeks later, in mid-May, he began releasing members of his engineering staff.[65]

[61] Information on the Markle family from the 1880 federal census for Hazleton (Luzerne County), p. 660; *National Cyclopaedia of American Biography*, 24:138, 18:153, and C:525; and Michael Novak, *The Guns of Lattimer* (East Brunswick, NJ, 1978), 42. Reports of the Hazleton station and quotation from Eaton to Samuel Insull, Feb. 18 and 20, and Mar. 4, 1884; all DF, NjWOE (*TAED* D8439U, D8455ZAL, D8439ZAC [*TAEB* 7: Doc. 2617]).

[62] Frank McCormick to TAE, July 18, 1884, DF, NjWOE (*TAED* D8458ZAE).

[63] Construction Dept. "Trial Balance[s]" show in detail Edison's running expenses as of September 1 and October 1, 1883 (NjWOE [*TAED* HM830186E, HM830186F]). Summaries of expenses for individual central stations are in Edison Construction Dept. Ledger (1883–86), esp. pp. 2–41, NjWOE (*TAED* AB033).

[64] TAE marginalia on letter from William Andrews to Edison Construction Dept., Mar. 2, 1884, DF, NjWOE (*TAED* D8442ZBY; *TAEB* 7: Doc. 2615).

[65] TAE to Sherburne Eaton, Apr. 24 and May 15, 1884, both DF, NjWOE (*TAED* D8427ZAL, D8416BOY; *TAEB* 7: Docs. 2655, 2672).

Edison's action coincided with a circumstance entirely beyond his control: an acute liquidity crisis that brought the nation's banking system, after months of worsening conditions, to the brink of a full-fledged panic in May.[66] These events complicated Edison's efforts to extract himself from the construction business. The Edison Electric Light Company, which he had considered a tepid partner all along, was itself feeling financial strain, exacerbated by having to take stock in the local illuminating companies to which it sold operating licenses, rather than getting the cash it originally expected. The company was also affected by the recent defaults of two of its principals (and Edison backers), financiers Henry Villard and Egisto Fabbri. It had also been trying to gain a toehold in the increasingly lucrative manufacturing operations (especially lamps) that Edison and his partners had financed and controlled themselves. These conflicting interests led to a series of negotiations for the general reorganization of the Edison lighting business in the United States. No agreements were signed until September, but a consensus seems to have been reached by mid-June 1884 by which the Edison Company for Isolated Lighting (a stock company with a directorate interlocked with that of the main Edison firm) would take over the construction business. Among the questions to be settled was how to resolve the standing complaints of the local illuminating companies against Edison and his construction deptartment for defective workmanship.[67]

Denouement

A traumatic and unexpected event—the death of Edison's wife in August—symbolized his separation from the central station electric lighting business. Distracted by grief and the responsibility for three young children, Edison assented to the contracts turning over his construction affairs to the Edison Company for Isolated Lighting. Without any fanfare or public announcement, his stint as a man of business ended, and he soon turned his attention to finding new inventive projects.

Only the matter of money remained. In 1885, as Edison focused his creative energies on other projects, Insull directed his considerable persuasive powers to extracting the cash the local illuminating companies in Pennsylvania, Massachusetts, and Ohio still owed. The debtors

[66] "On the Verge of a Panic," *New York Times*, May 15, 1884, 1.
[67] See *TAEB* 7:481–82, esp. n. 4.

included all five of the Pennsylvania firms: Sunbury, Shamokin, Mount Carmel, Bellefonte, and Hazleton. Insull whittled down the amounts until September 1885, when Edison authorized Phillips Shaw to make settlements with four of the firms. The decision to delegate the power to settle these accounts may have emerged from a special directors' meeting of the Edison Electric Light Company on September 4, called, at least in part, to discuss "a proposition from P. B. Shaw."[68]

Edison provided Shaw with a confidential memorandum outlining the terms he hoped to reach with each organization. Insull had calculated that the various illuminating companies in the Northeast owed Edison $12,960. Of this, the Pennsylvania companies owed the bulk, amounting to some $8,725. Mount Carmel accounted for $2,813, followed by Sunbury ($2,416), Shamokin ($2,238), and Bellefonte ($1,256). The Hazleton firm also owed $762, but Edison left this out of the memorandum. He realized that collecting the payments in cash would be difficult or impossible, in some cases because the company was cash poor and in others because the amount was in dispute or because of dissatisfaction with the construction department's installation.[69]

Edison separately promised to pay Shaw a 5 percent commission on the amount he received in cash from Shamokin, Mount Carmel, and Bellefonte. He did not offer any commission for Sunbury, perhaps because he expected that company to pay in shares of stock. Edison said he would collect the money from Hazleton himself.[70]

Shaw's aid was enlisted only after Insull had run into heavy resistance in his own attempt to collect the debts. In June, Insull had despaired of getting anything out of Shamokin and Bellefonte without threatening to sue. He considered these "the most aggravated cases" of all the outstanding accounts. "We find it absolutely impossible to get any satisfaction from the Shamokin Co.," he complained to Edward Johnson, a friend of Edison and an irrepressible promoter of his inventions, now president of the Edison Electric Light Company. Insull thought there was "no excuse whatever for the Shamokin Co. keeping Mr. Edison out of his money," especially since its directors had agreed the year before to make good its obligation. The Bellefonte enterprise had also acknowledged its debt and sent a check for

[68] Frank Hastings to TAE, Sept. 2, 1885, DF, NjWOE (*TAED* D8526ZAB); TAE to Shaw with enclosure, Sept. 4, 1885, Letterbook 20:467C, NjWOE (*TAED* LB020467C).

[69] Insull to Edward Johnson, June 3, 1885, and TAE to Shaw, Sept. 4, 1885, Letterbook 20:315A, 467C, NjWOE (*TAED* LB020315A, LB020467C).

[70] TAE to Shaw, Sept. 4, 1885, Letterbook 20:467A, NjWOE (*TAED* LB020467A).

$500 in partial payment, but it now claimed to be too strapped to make a full settlement. A skeptical Insull pointed out, "although the Bellefonte Co. cannot find money to pay Mr. Edison a bill which has been standing about for 18 months, they are somehow able to raise money to increase their plant."[71]

Shamokin's refusal to pay stemmed from long-running dissatisfaction with its plant. Construction defects had manifested themselves as early as December 1883, but these difficulties were soon compounded by the poor performance of the dynamos and a high rate of lamp failure. In early 1884, Shamokin president William Douty complained serially that the three 8½ × 10 engines produced by the Providence-based Armington & Sims Engine Company were generating only thirty horsepower and that at least one of them had started "kicking" and would not properly regulate its speed.[72]

Efforts to solve these problems did not satisfy the Shamokin company, which prompted a meeting in New York in June 1884 among Edison, Insull, Francis Upton (manager of the Edison Lamp Company), Sherburne Eaton of the Edison Electric Light Company, and Douty, Andrew Robertson, and John Mullen from the Shamokin firm. Edison later claimed that as a result of the settlement reached that day, Shamokin had been compensated for its difficulties when the Edison Electric Light Company agreed to return its bonds. He noted further that the Shamokin firm, the Edison Electric Light Company, and he had signed a memorandum to this effect at the June meeting, after which the parties had paid him $805.48 and promised to settle the balance as soon as he had replaced a dynamo and two malfunctioning engines and upgraded other equipment.[73]

Immediately after the meeting, Edison personally wrote to Armington & Sims about replacing two of the original engines with one 14½ × 13 engine. He also decided to replace one of the three original sixty-five-horsepower "H" dynamos with two twenty-eight-horsepower "S" dynamos. But in part because Armington & Sims was reluctant to take out its engines, the new equipment was not shipped until the end of September. Even after they were in place in early October, William Brock, the local man-

[71] Insull to Johnson, June 3, 1885, Letterbook 20:315A, NjWOE (*TAED* LB020315A).

[72] Douty to TAE, Dec. 29, 1883, and Jan. 5, 1884; William Brock to Douty, June 20, 1885; Insull to Sherburne Eaton, Feb. 15, 1884; Insull to Douty, Feb. 18, 1884; all DF, NjWOE (*TAED* D8360ZDC, D8457C, D8523ZBE, D8416AOA, D8416AOQ).

[73] Memorandum of conference, June 11, 1884, NjWOE (*TAED* HM840222); TAE to Shaw with enclosure, Sept. 4, 1885, Letterbook 20:467C, NjWOE (*TAED* LB020467C).

ager, complained that the dynamos could not be run because the necessary ancillary equipment had yet to arrive. The new machinery did not prevent problems with lamp breakage, and difficulties persisted with the remaining original steam engine. In July 1885, Douty, replying to a letter from Edward Johnson, noted that because of "the troubles still existing—Caused by the materiel machinery &c furnished by Thos A Edison our Company do not feel disposed in any way to pay Mr Edison one penny more than we have paid him—In law and Justice we do not owe him anything."[74]

Despite such resistance, Shaw evidently achieved some success in collecting monies from the Pennsylvania companies. On September 18, he billed Edison $135.25 on commission for settling the Shamokin and Bellefonte accounts. He also seems to have negotiated an agreement with Sunbury. According to those terms, Edison accepted $1,650 in Sunbury stock, with the understanding that he would subsequently surrender his aggregate interest of 61.51 shares for half as many (at $100 par value) in a reorganized company there. Edison acceded to these terms after Shaw convinced him that the company had only $1,745.78 in total assets. As it turned out, the company had to borrow $400 from Shaw to fulfill its obligation. From Mount Carmel, Edison took 48 shares of stock, later valued at $2,400. From Bellefonte, he agreed to accept just $750, payable in three notes due in two, four, and six months. It is not clear what settlement Edison made with Shamokin. On September 19, Edison sent Shaw signed releases to be given to the Mount Carmel, Bellefonte, and Sunbury companies on the terms stated.[75]

The early experience with the Edison village plant system in Pennsylvania exhibited mixed results at best, which might be expected under the circumstances. After all, electric lighting was a new technology that was evolving rapidly even as it was being implemented. Nonetheless there were,

[74] TAE to Armington & Sims, June 12, 1884, Construction Dept. Letterbook 17:394A, NjWOE (*TAED* LBCD6394A); William Brock to Frank Hastings, Oct. 3, 1884; Brock to TAE, Oct. 10, 1884; Douty to Edward Johnson, July 2, 1887; all DF, NjWOE (*TAED* D8457ZBI, D8457ZBJ, D8523ZBG).

[75] Shaw to Samuel Insull, Sept. 9 1885; Shaw to TAE, Sept. 18, 21, and 25, 1885; William Schwenk to TAE, Oct. 23, 1885; all DF, NjWOE (*TAED* D8523ZBR, D8523ZBT, D8523ZBV, D8523ZBS, D8523ZBW, D8523ZBY); TAE agreement with Edison Electric Illuminating Co. of Sunbury, Sept. 22, 1885; TAE agreement with Edison Electric Illuminating Co. of Bellefonte, Sept. 1885; TAE agreement with Edison Electric Illuminating Co. of Mount Carmel, Oct. 23, 1885; all NjWOE (*TAED* HM850268, HM850269, HM850270); Vouchers (Laboratory) no. 476 (1885) for Sunbury; no. 101 (1886) for Mt. Carmel; both NjWOE; TAE to Shaw, Sept. 19, 1885, Letterbook 20:498A, NjWOE (*TAED* LB020498A).

even in the short run, some notable successes, such as the Edison plant in Harrisburg. The success of the Harrisburg system is perhaps attributable to the strong local executive management of John Irvin Beggs (1847–1925). Beggs, a native of Philadelphia, started his career as a bookkeeper for the Philadelphia & Reading Coal & Iron Company. By 1882, he had become an insurance executive in the state capital. His first experience in the electrical industry came in 1884, when he invested in the Harrisburg Electric Company, which proposed to construct an Edison plant in the city. The company seems to have gotten off to a rocky start. The *Western Electrician* subsequently reported that Beggs "soon realized that unless an aggressive policy was pursued, the enterprise would prove a failure, and he accordingly invested more money in the project and assumed personal supervision over its operations." Beggs served as secretary, treasurer, and general manager of the Harrisburg Electric Company, which started up its plant on May 1, 1885. The plant remained in continuous operation from its inception and was reputed, according to the *Western Electrician*, to be "the most profitable electric light plant in the United States."[76]

Beggs's efforts did not go unnoticed by the Edison interests. The Edison Illuminating Company of New York (which operated the Pearl Street plant) soon recruited him as its vice president and general manager. In this capacity, he oversaw the opening of two new central station plants in the city and significantly increased the number of isolated plants in New York. Under his management, the company's revenue increased from $157,000 in 1887 to $750,000 in 1890, and the customer base grew from 500 to 1,500. After the formation of the Edison General Electric Company in 1889, Beggs was made manager of the Central District of the United States and, from his headquarters in Chicago, supervised the company's electrification efforts in eleven states.[77]

The other Edison Pennsylvania illuminating companies may not have been quite as successful as the Harrisburg Electric Company, but they were by no means failures. Although Edison withdrew from direct personal involvement in constructing new stations and returned to his true calling as an inventor, he had managed to school others in the development and operation of the village plant system. All of the Pennsylvania companies continued to operate and became self-sustaining, demonstrating both the

[76] "John I. Beggs," Edison Pioneers biography, NjWOE; "John I. Beggs, President of the Association of Edison Illuminating Companies," *Western Electrician* 7 (Sept. 20, 1890): 1.

[77] "John I. Beggs," *Western Electrician*, 1.

virtues of central station electric lighting and the deficiencies of Edison's DC system. Later, as electrification matured and became more centralized, the smaller Edison illuminating companies in Pennsylvania and elsewhere were bought up by larger concerns and incorporated into emerging regional systems. The Sunbury, Shamokin, Mount Carmel, Hazleton, and Williamsport companies, for instance, were all eventually subsumed in the Pennsylvania Power and Light Company, while in 1927, Bellefonte became part of the West Penn Power Company.[78]

In spite of the success of the Edison lighting companies in Pennsylvania over the long term, high capital costs would remain a major hurdle in developing the central station model of electric light and power that Edison envisioned. The solutions to the problem required nearly a decade, the formation of industrial giants General Electric and Westinghouse Electric (and the latter's more advantageous system of alternating current), and creative new ideas about financing capital construction (and for rural electrification, government intervention on a large scale in the 1930s).[79] But while the financing and administration of electrification would require a much a higher level of organization and greater economies of scale than Edison anticipated in the early 1880s, it is also true that his efforts to establish village plant systems in Pennsylvania and elsewhere helped not only to solve many sticky technical issues, they also provided practical experience to "untried hands" and extended hands-on technical knowledge of electric lighting outside of New York. This, in turn, helped to create a new skilled workforce capable of handling the next phase of electrification in the United States.

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[78] Hughes, *Networks of Power*, 431–33; Sylvester Kirby Stevens, *Pennsylvania: Titan of Industry*, 3 vols. (New York, 1948), 3:848.

[79] Alfred D. Chandler, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, MA, 1990), 214; Christopher Kobrak, *Banking on Global Markets: Deutsche Bank and the United States, 1870 to the Present* (Cambridge, 2007), 52.

Boom and Bust in Pittsburgh Natural Gas History: Development, Policy, and Environmental Effects, 1878–1920

PITTSBURGH AND WESTERN PENNSYLVANIA have a rich energy history focused on the development and utilization of the resources of coal, oil, and natural gas. Within the last ten years the region has experienced a boom in natural gas production from the Marcellus Shale deposit that extends throughout the state. The drivers of this boom have been a rise in gas prices and the application of the technology of hydraulic fracking (nonconventional horizontal drilling). Thousands of wells have been drilled throughout Pennsylvania, and thousands more are projected. Extensive discussions are taking place in the state about controversial issues such as regulatory policy, extent of drilling, duration of supply, and environmental impacts.

This natural gas boom, however, is not the region's first. It mirrors in many ways a boom that began in the late nineteenth century and extended intermittently for several decades. This article will sketch out the history of this period of natural gas exploitation, emphasizing issues of policy, risk, and environmental impacts. Many similar issues have arisen from the current Marcellus natural gas boom, suggesting that closer attention to history might have helped avoid some of the environmental and governmental policy problems currently being encountered. For the purposes of clarity, the article is separated into two sections: the first presents the history of natural gas developments in the region, while the second discusses in a topical fashion issues relating to environmental impacts.

A Brief History of Gas in Pittsburgh

Before natural gas consumption began in Pittsburgh in the late 1870s and 1880s, five manufactured gas companies supplied gas made from coal

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(also known as town gas) to the city. The process that manufactured gas from organic fuels such as coal was first developed in Europe and was transferred to the United States at the beginning of the nineteenth century. In 1816, Baltimore became the first American city to develop a gas lighting system, and Pittsburgh followed in 1837. This manufactured gas was used primarily for streetlights and for domestic purposes such as lighting and cooking. Its high production costs limited both its domestic market and its use for industrial purposes. When natural gas entered the city in the late nineteenth century, the manufactured gas companies found it increasingly difficult to compete with it because of natural gas's lower cost and higher energy content.[1]

Drillers seeking oil and salt in the northwestern corner of Pennsylvania had discovered natural gas in the 1860s and occasionally used it to heat boilers and to power drilling equipment. Mostly, however, it was flared, or burned off, because of a lack of demand. In the mid and late 1870s, however, drillers found substantial gas supplies in Butler, Armstrong, and Clarion Counties, close to potential industrial consumers. Two iron manufacturers located north of Pittsburgh—Spang, Chafant, and Company in Etna and Graff, Bennett, and Company in Millvale—were pioneers who began bringing gas into their mills by pipeline.[2] The use of natural gas rather than coal to provide heat had obvious advantages in regard to fuel costs, ease of handling, and consistency of temperature, and other mills soon followed.[3]

[1] Joel A. Tarr, "Pittsburgh and the Manufactured Gas Industry," *Pittsburgh Engineer*, winter 2006, 12–14; *Progressive Age*, Feb. 15, 1898, 60. In 1898, the manufactured gas companies combined with the Philadelphia Company and other natural gas companies to form the Consolidated Gas Company of the City of Pittsburg. The manufactured gas company was increasingly unprofitable.

[2] John B. Pearse, "Natural Gas in Iron Working," appendix D of Pearse and Franklin Platt, *A Report on the Use of Natural Gas in the Iron Manufacture*, in Platt, *Second Geological Survey of Pennsylvania, 1875: Special Report on the Coke Manufacture of the Youghiogheny River Valley in Fayette and Westmoreland Counties* (Harrisburg, 1876), 183, notes that pipelines were forced to follow a winding route "due to the hostility of the farmers, who, fearing conflagrations, refused the right of way, and compelled the location of the line along the township roads."

[3] In September 1883, Andrew Carnegie, the largest iron and steel manufacturer in the region, contracted with the Acme Gas Company to provide natural gas from its Murrysville wells, about twenty miles east of the city, to his three Pittsburgh-area plants: the Edgar Thomson Bessemer Works, the Homestead Steel Works, and the Union Mills. The use of gas at the Edgar Thompson Works resulted in the reduction of four hundred tons of coal a day. *Annual Report of the Geological Survey of Pennsylvania for 1886*, part 2, *Report on the Oil and Gas Region*, John F. Carll (Harrisburg, 1887), 676 (hereafter *Geological Survey, 1886*); Pearse and Platt, *Report on the Use of Natural Gas*, 161–216; George B. Hill & Co., *Pittsburgh: Its Commerce and Industries, and the Natural Gas Interest* (Pittsburgh, 1887), 8–9. Natural gas also became the preferred fuel for the making of glass, giving rise to firms such as Pittsburgh Plate Glass and the Rochester Tumbler Company. See "Glass: Pittsburgh as a Center," in

Natural gas did not enter the city itself until the early 1880s. While gas had been discovered in the Murrysville region (the "Haymaker Well") in the late 1870s, entrepreneurs were initially reluctant to pipe it to untested markets because doing so required investment in expensive and untried infrastructure.[4] Risk of explosions and the dangers involved in piping gas under high pressure into residential markets also constrained natural gas adoption.[5] Additionally, the manufactured gas companies, fearing competition for the residential and street lighting markets, tried to block the entrance of natural gas into the city.

In 1882, two gas firms, the Fuel Gas Company and the Penn Fuel Company, were incorporated under the Pennsylvania Corporation Act of 1874. This act gave gas companies permission to provide heat and light to municipalities without specifying that either manufactured gas or natural gas be used; the Pittsburgh City Council proceeded to award the two firms charters to distribute the fuel.[6] The Fuel Gas Company had originally thought it would bring coal gas into the city from mine-mouth coal processing plants. The record-breaking natural gas output of the Haymaker Well in Murrysville, however, convinced them to drill their own well, and in 1882 the company began piping gas into Pittsburgh's South Side from its Murrysville well. In the same year, the Penn Fuel Company, which had acquired the Haymarket Well, began distributing natural gas by pipeline to customers in Pittsburgh's East Liberty and Lawrenceville neighborhoods.[7]

Controversy erupted in the courts between the two companies over who had the exclusive right to distribute natural gas in the city. On February 2, 1885, in the case of *Emerson and the Penn Fuel Company v. the Attorney General*, the court ruled that neither company had the right, because the Corporation Act of 1874 only authorized the distribution of manufactured

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Pittsburgh, Engineers' Society of Western Pennsylvania (Pittsburgh, 1930), 365–74; Albert Williams Jr., *Mineral Resources of the United States, Calendar Years 1883 and 1884* (Washington, DC, 1885), 242. Hereafter cited as *Mineral Resources, 1883–84.*

[4] Andrew Carnegie, "The Natural Oil and Gas Wells of Western Pennsylvania," in *The Empire of Business* (Toronto, 1902), 264–80; *Geological Survey, 1886*, 601, 664–81; George H. Thurston, *Allegheny County's Hundred Years* (Pittsburgh, 1888), 205.

[5] Thomas P. Roberts, "Natural Gas," *Proceedings of the Engineers' Society of Western Pennsylvania* 2 (1884): 341–45.

[6] The two firms combined in late 1884. See, "A Natural Gas Deal," *Milwaukee Sentinel*, Nov. 19, 1884, 2. A third firm, the Chartiers Valley Gas Company, was organized on July 31, 1883, also receiving its charter under the Pennsylvania Corporation Act of 1874. See *Geological Survey*, *1886*, 678–79.

[7] *Mineral Resources, 1883–84*, 239; *Geological Survey*, *1886*, 674–75; Roberts, "Natural Gas," 331–46; and David A. Waples, *The Natural Gas Industry in Appalachia: A History from the First Discovery to the Maturity of the Industry* (Jefferson, NC, 2005), 44–47.

gas. This ruling also invalidated all city ordinances conferring legal rights in regard to natural gas distribution and left the standing of the companies formed to provide natural gas to customers in a legal limbo.[8] The state legislature was the only body capable of solving the problem by enacting an act regulating the new fuel of natural gas.

In February 1885, the state house and senate held extensive discussions about issues involving risks of explosions, terms of incorporation, and eminent domain.[9] Because of the novelty of natural gas, few precedents existed. As approved, the resulting Natural Gas Act of 1885 permitted the chartering of corporations "for the purpose of producing, dealing in transporting, storing and supplying natural gas." It stipulated that gas companies could only enter a city with city council permission unless they had been supplying such gas prior to the Natural Gas Act's passage. The act gave gas corporations the right of eminent domain "for the laying of pipe lines for the transportation and distribution of natural gas" and contained specific requirements regarding the sealing and plugging of abandoned wells, with a $200 fine if the regulations were not followed. While no governmental agency was tasked with its enforcement, the act provided that if a well was left unplugged, an owner of adjacent lands or "in the neighborhood" of the well could plug it at the expense of the original owner. The motivation for this feature appears to have been both to avoid waste and to prevent flooding of adjacent wells. Governor Robert E. Pattison signed the act on May 29, 1885.[10] Thus, the development and marketing of natural gas in the 1880s had resulted in unprecedented regulatory legislation (Act 32, 1885), a phenomena that was repeated again in regard to nonconventional drilling in the Marcellus Shale in the first decade of the twenty-first century (Act 13, 2012).

The first interpretation of the Natural Gas Act occurred in 1886 because of events relating to the distribution of natural gas in Pittsburgh. In the spring of 1884, while drilling for gas on his Pittsburgh estate ("Solitude")

[8] Emerson and the Penn Fuel Company v. Attorney General, Pennsylvania Supreme Court, *Weekly Notes of Cases*, vol. 15, no. 27 (Feb. 12, 1885): 425–31.

[9] "Natural Gas," *Daily Legislative Record*, Feb. 3, 1885, 142–43, Feb. 4, 1885, 166, 170, and Feb. 23, 1885, 311. On the same day, the senate approved a bill to prohibit damage to "oil, gas or water wells, tanks, pipes and machinery connected therewith" and imposing a fine or imprisonment if the perpetrator was found guilty.

[10] Act to Provide for the Incorporation and Regulation of Natural Gas Companies, 1885 Pa. Laws 29. The act also required that pipelines be at least twenty-four inches below the surface if they passed over agricultural land.

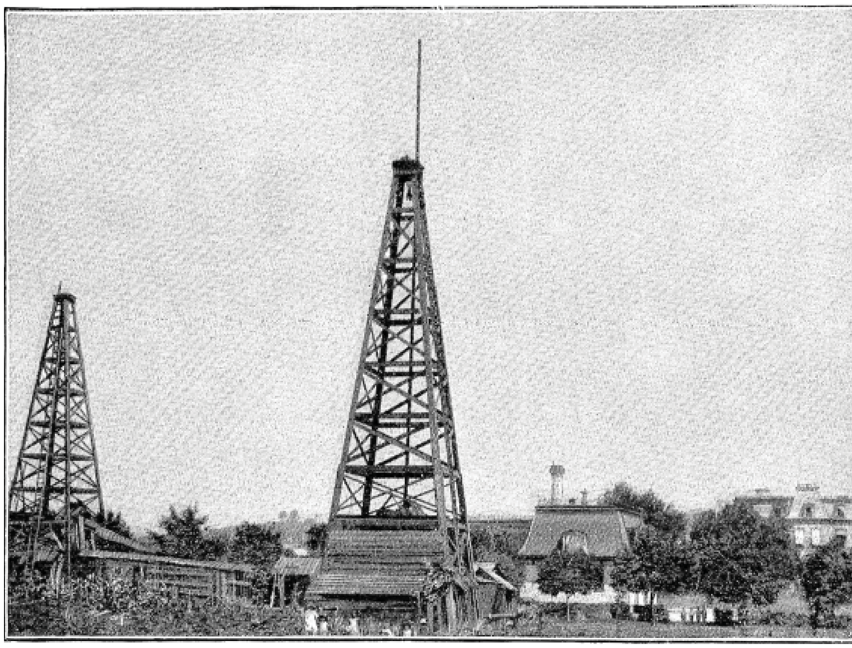


Fig. 1. The Westinghouse Well on His Estate, "Solitude," 1884. Source: *Pittsburgh and Allegheny Illustrated Review: Historical, Biographical, and Commercial: A Record of Progress in Commerce, Manufactures, the Professions, and in Social and Municipal Life* (Pittsburgh, 1889), 32.

to heat his hot house and conservatory, the inventor and entrepreneur George Westinghouse hit a "roarer," estimated to flow at about twenty million cubic feet per day (Fig. 1).[11] While the Westinghouse well was drowned out by water within several weeks, the realization that there was gas underground "started a perfect furore [*sic*] in gas drilling" throughout the city.[12]

Numerous derricks soon altered the Pittsburgh landscape, and gas standpipes flared through the night (Fig. 2). Westinghouse drilled seven more wells in Pittsburgh's Point Breeze and Homewood neighborhoods and

[11] The pressure of the gas was so great that a large wooden plug and drilling apparatus, weighing about 3,600 pounds, were blown many feet in the air. The gas ignited and burned for days, and a one hundred–foot-high torch lit the neighborhood until Westinghouse brought it under control with a stopcock. See, James H. Reed, "Pittsburgh and the Natural Gas Industry," in *Pittsburgh and the Pittsburgh Spirit*, Pittsburgh Chamber of Commerce (Pittsburgh, 1928), 127–29.

[12] Ibid.; *Mineral Resources, 1883–84*, 238–40; and Waples, *Natural Gas Industry in Appalachia*, 48–49. It was not unusual for western Pennsylvania wells to be drowned out by water.

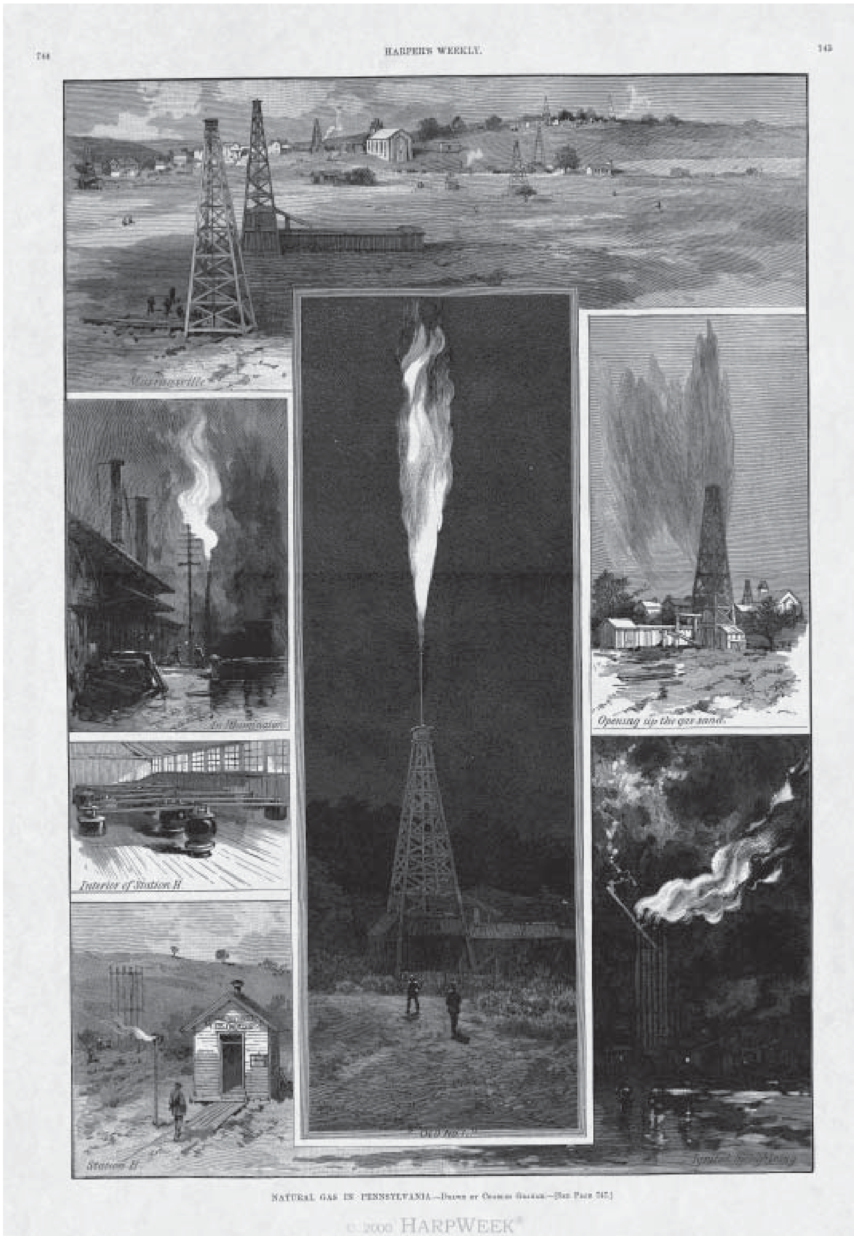


Fig. 2. Pittsburgh's First Natural Gas Boom. Source: "Natural Gas in Pennsylvania," *Harper's Weekly*, Jan. 14, 1885, 744–45.

acquired land in the Murrysville area, a proven gas reserve. He also organized the Philadelphia Company under an old state charter to supply gas to Pittsburgh residences and industries and its outlying area, aggressively acquiring industrial and domestic customers and competing firms.[13] Using his technical skills, Westinghouse began developing and patenting innovations in the transport of natural gas, gas regulators, and meters.[14] By the beginning of 1885, in addition to Westinghouse's Philadelphia Company, four other companies funded by various Pittsburgh banking interests were drilling wells in the city as well as in the ten-county region.[15]

In 1884 and 1885, while members of the state legislature in Harrisburg discussed the terms of the new state act, a number of natural gas explosions occurred throughout Pittsburgh and its region, increasing the urgency of securing new legislation. Natural gas pipelines and appliances were new technologies involving an explosive and volatile substance, and a number of technical questions existed about what was the best material for pipelines and what constituted safe gas pressure.[16] The distribution of the fuel to city consumers, most of whom were inexperienced in its use and would not necessarily notice if there was a problem (the gas was odorless), raised problems of risk. Westinghouse emphasized the safety of his distribution system and developed a technology to prevent leakage from gas supplies under high pressure. He also arranged for his city council allies to introduce a general ordinance ("the Westinghouse Ordinance") that specified the use of his innovation involving the use of double pipes in gas distribution lines.[17] Warning that "the extension of weak and imperfect pipes through the city" meant its inhabitants were "living on a powder magazine," the *Pittsburgh Post* demanded that the Westinghouse Ordinance be passed. On July 31, 1884, the council approved the ordinance and several

[13] *Annual Report of the Board of Directors of the Philadelphia Company,* 1885–86 (Pittsburgh, PA, 1886). For the early growth of the Philadelphia Company see George H. Thurston, *Pittsburgh's Progress, Industries, and Resources* (Pittsburgh, 1886), 13. Thurston claimed that by the late 1880s, three thousand families, thirty-four iron and steel mills, sixty glass factories, and three hundred small factories and hotels used natural gas. Stanley Paul Wagner, "Natural Gas Comes to Pittsburgh" (MA thesis, University of Pittsburgh, 1947), 50–56.

[14] For a full list of Westinghouse's natural gas patents, see Henry G. Prout, *A Life of George Westinghouse* (New York, 1921), 362–65.

[15] *Geological Survey, 1886*, 603–4; Roberts, "Natural Gas," 338.

[16] For a discussion of these issues, see Roberts, "Natural Gas," 341–45.

[17] "Gas Pipes," *Pittsburgh Post*, Aug. 8, 1884. This article quotes the Westinghouse patent language. There is a description of the Westinghouse two-pipe system in David T. Day, *Mineral Resources of the United States, Calendar Year 1886* (Washington, DC, 1887), 193–94. Hereafter cited as *Mineral Resources, 1886*.

months later approved a more detailed ordinance providing a franchise for the Philadelphia Company.[18]

Continued gas explosions that resulted in injuries, deaths, and property destruction, however, stimulated protest meetings throughout the city. On February 2, 1885, the *Pittsburgh Post* ran an editorial entitled "Death in the Streets," which warned, "Save in a state of war we don't believe any large city in the world was ever in a more perilous situation than Pittsburgh is today owing to the dangers of natural gas explosions."[19] The city council appointed a Natural Gas Commission, and in March 1885 it took extensive testimony from gas company personnel, technicians, and city officials to determine the cause of the explosions.[20] Seeking to take advantage of the public outcry, Westinghouse ran newspaper ads throughout 1885 and 1886, boasting that his Philadelphia Company had "facilities equaled by no other company for the safe and economical use of this fuel" and possessed reserves that would guarantee uninterrupted gas supply.[21]

In August 1885, after the Pennsylvania legislature had enacted the Natural Gas Act, the Pittsburgh City Council passed a general ordinance for natural gas that made the transportation and supply of natural gas for public consumption a public service open to regulation. Later, the council passed an act setting specific standards for the laying and testing of pipe under the direction of the city engineer. A number of the features in this ordinance involved George Westinghouse's patented improvements in gas transmission, giving him an advantage over his competitors. The passage of this ordinance, however, brought Pittsburgh into a legal collision with the state.[22]

In June 1885, People's Natural Gas Company sought to enter the city with a new pipeline carrying gas from its Murrysville wells.[23] The city, however, claimed that People's had not followed the requirements of the

[18] The Westinghouse Ordinances are in W. W. Thomson, *A Digest of the Acts of Assembly Relating to, and The General Ordinances of the City of Pittsburgh, from 1804 to Sept. 1, 1886, with References to Decisions Thereon* (Harrisburg, 1887), 506–7. They also stipulated that Westinghouse would provide free gas to the city properties.

[19] Quoted in Wagner, "Natural Gas Comes to Pittsburgh," 42.

[20] Ibid., 45–47.

[21] See, for instance, *Pittsburgh Daily Post*, Mar. 6, 1885, and the *National Labor Times,* May 15, 1886.

[22] Thomson, *Digest of the Acts of Assembly Relating to, and The General Ordinances of the City of Pittsburgh*, 369–75. Discussions of the ordinances can be found in City of Pittsburgh's Appeal, *Central Reporter . . . All Cases Determined in the Courts of Last Resort*, ed. Edmund H. Smith (Rochester, NY, 1887), 4:225–44.

[23] Entrepreneurs Joseph N. Pew and Edward O. Emerson, formerly of the Penn Fuel Company, founded People's Natural Gas. See Mary Brignano and Hax McCullough, *The Vision and Will to Succeed: A Centennial History of The People's Natural Gas Company* (Pittsburgh, 1985), 15.

council's natural gas ordinance and refused to grant a charter. People's sued, charging that the city ordinance was in violation of the state Natural Gas Act. In 1886, the state supreme court agreed with that assertion and found sections of the Pittsburgh ordinance invalid.[24] Preemption of the local ordinance permitted People's Natural Gas to enter and distribute gas throughout the city under the state act.[25] A similar conflict between the regulations of a municipality and state law regarding natural gas arose in 2014 when the Pennsylvania Supreme Court held that the municipalities could use their zoning power to forbid drilling in certain areas.[26]

By 1886 six companies had received municipal charters and were piping gas into the city as an industrial and residential fuel.[27] In addition, a number of iron and steel firms drilled wells on their own property.[28] Westinghouse's Philadelphia Company became the city's largest natural gas distributor, having consolidated with twenty other smaller natural gas firms, including the Acme Gas Company, the Allegheny Natural Gas Company, the Carpenter Natural Gas Company, the Penn Fuel Company, and the Fuel Gas Company. By 1888 it supplied seven hundred mills, factories, and commercial establishments and twenty-five thousand homes with fuel.[29]

Pittsburgh had been known as the "Smoky City" for most of the century because of massive coal use by industry and residences and was closely identified with the mineral as a source of both industrial progress and atmospheric pollution. The substitution of cleaner natural gas as a fuel, however, caused a sharp decrease in the number of smoky days. The coal

[24] City of Pittsburgh's Appeal, *Central Reporter*, 4:225–44.

[25] See Thomson, *Digest of the Acts of Assembly Relating to, and The General Ordinances of the City of Pittsburgh*, 639–725; Hiram Schock, comp. and ed., *Digest of the General Ordinances and Laws of the City of Pittsburgh to March 1, 1938* (Pittsburgh, 1938), 728–37; see 729n1 for parts of the 1885 ordinance voided by the courts.

[26] Marie Cusick, "Pennsylvania Supreme Court Strikes down Controversial Portions of Act 13," StateImpact Pennsylvania, Dec. 19, 2013, https://stateimpact.npr.org/pennsylvania/2013/12/19/state-supreme-court-strikes-down-act-13-local-zoning-restrictions/.

[27] David T. Day, *Mineral Resources of the United States, Calendar Year 1885* (Washington, DC, 1886), 239–41 (hereafter cited as *Mineral Resources, 1885*); *Geological Survey, 1886*, 692–94.

[28] Day, *Mineral Resources, 1885*, 241; David T. Day, *Mineral Resources of the United States, Calendar Year 1888* (Washington, DC, 1890), 486 (hereafter cited as *Mineral Resources, 1888*); *Geological Survey, 1886*, 692–94.

[29] *Annual Report of the Philadelphia Company*, 1885–86; Thurston, *Allegheny County's Hundred Years*, 207. One contemporary report noted that "there was a rage for organizing natural gas companies, as is shown by the fact that over five hundred of such corporations secured charters." These were largely small operations intended to supply towns and boroughs, most of which never went into operation or were bought out by larger firms such as the Philadelphia Company. See Hill, *Pittsburgh*, 9.

industry suffered from reduced demand, and estimates of the amount of coal displaced by natural gas ranged from six to twenty million tons per year as unemployment soared in the minefields.[30] National as well as local publications applauded the benefits of natural gas and the disappearance of the "black pall-like cloud" that had hung over the city. *Harper's Weekly* observed that a "peaceful revolution" had taken place in Pittsburgh due to natural gas; as a result, it had lost its "Smoky City" title (Fig. 3).[31] City boosters lauded the benefits of natural gas and boasted about its "almost incomprehensible quantities" and "inexhaustible" nature.[32]

Natural gas produced cleaner air, but it was not, contrary to popular belief, inexhaustible.[33] By 1890, fluctuating and declining supplies were negatively affecting industrial users, and some, including the Carnegie works, shifted back to coal.[34] In 1892 a speaker at a meeting of the Engineers' Society of Western Pennsylvania woefully observed:

> We are going back into the smoke. We had four or five years of wonderful cleanliness for Pittsburg, and we have all had a taste of knowing what it is to be clean. We all felt better, we all looked better, we all were better. But we are back into the smoke. It is growing worse day by day.[35]

The depletion of natural gas supplies was a constant concern of utilities, and they unsuccessfully experimented with methods to produce man-

[30] Day, *Mineral Resources, 1888*, 482–83; *Geological Survey, 1886*, 18–19; and "Natural Gas vs. Coal at Pittsburg," *National Labor Tribune*, July 24, 1886.

[31] "The City of Pittsburg," *Harper's Weekly*, Feb. 27, 1892, 202–3; Angela Gugliotta, "'Hell with the Lid Taken Off': A Cultural History of Air Pollution—Pittsburgh" (PhD diss., University of Notre Dame, 2004), 129–39.

[32] See, for instance, Thurston, *Pittsburgh's Progress*, 6–8, wherein he repeats and reiterates optimistic comments about gas supply he originally made in 1876 and in Thurston, *Allegheny County's Hundred Years*, 92–95, 202–9.

[33] The "rule of capture," a common law principle that maintained that any gas that came into your well, even if it originated from a neighbor's land, was yours, was upheld by the Pennsylvania Supreme Court in 1889 in the case of Westmoreland & Cambria Natural Gas Co. v. De Witt. The rule of capture produced an emphasis on digging multiple wells and pumping at a rapid rate lest your neighbor capture your gas.

[34] Wagner, "Natural Gas Comes to Pittsburgh," 73–74. By 1891, Carnegie's Edgar Thompson Works was using only coke for fuel, and in 1893 the Philadelphia Company terminated its contract with the firm. See Edgar P. Allen, "Natural Resources of Pittsburgh," *Proceedings of the Engineers' Society of Western Pennsylvania* 7 (1891): 11–13. In the 1891 edition of the gas industry publication *Brown's Directory of American Gas Companies*, which had begun including information about natural gas several years before, noted that it had omitted natural gas companies for that year because of sharp changes in the industry and because "the gas is rapidly disappearing." See E. C. Brown, comp., *Brown's Directory of American Gas Companies* (New York, 1891), 1.

[35] William Metcalf, "On Smoke," *Proceedings of the Engineers' Society of Western Pennsylvania* 8 (1892): 42–43.

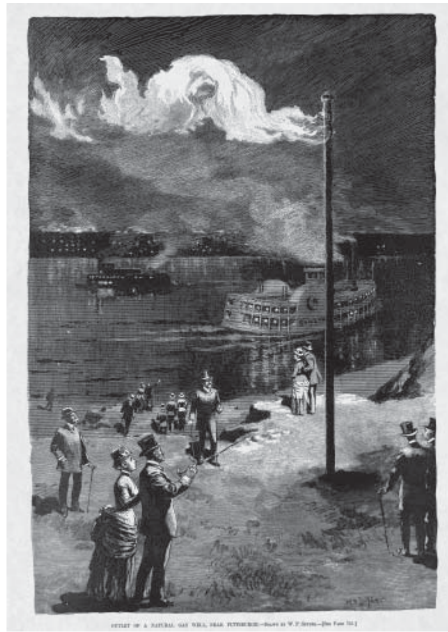


Fig. 3. A Pittsburgh Standpipe, 1885. Source: "Outlet of a Natural Gas Well Near Pittsburgh," *Harper's Weekly*, Nov. 7, 1885, 731.

ufactured gas from bituminous coal cheaply enough to compete with coal.[36]

The return of the smoke caused the city's first major smoke control effort. The Ladies' Health Protective Association of Allegheny County, an organization composed mostly of upper-class women, drove the campaign. Recruiting allies from among the engineering and business communities, the antismoke forces pushed for effective regulatory legislation. During the following years the city council passed various smoke control ordinances. These ordinances were, however, generally ineffective or found by the courts to be unconstitutional.[37]

By 1900, while the productivity of local wells had sharply diminished, natural gas supplies available in the region had increased due to the dis-

[36] By 1892 George Westinghouse was suggesting to his board of directors that the Philadelphia Company acquire property for manufacturing coal gas. See *Annual Report of the Philadelphia Company*, 1892, 6.

[37] Angela Gugliotta, "How, When, and for Whom Was Smoke a Problem in Pittsburgh," in *Devastation and Renewal: An Environmental History of Pittsburgh and Its Region*, ed. Joel A. Tarr (Pittsburgh, 2003), 110–25.

covery of new well fields, pipeline delivery of gas from West Virginia, and the development of compressing stations and metering. However, supplies were still inadequate to meet growing industrial and residential demand.[38] Between 1897 and 1913, the number of domestic gas consumers in Pennsylvania increased from a little over two hundred thousand to more than four hundred thousand, or about 30 percent of total gas consumption, while the number of industrial consumers rose from a little over one thousand to over four thousand.[39] Increasingly, gas supplies had to be imported from out of state (largely West Virginia) by pipeline; in 1913, for instance, the value of gas consumed in Pennsylvania was about 33 percent in excess of the value of gas produced in state. In addition, rises in the cost of producing gas from operations, well drilling, and transportation had increased the average price per thousand cubic foot from 13.4 cents in 1906 to 18.15 cents in 1913.[40] In 1918, Samuel S. Wyer, conservation chief of the US Fuel Administration, warned of a continuation of the supply problem, noting that 43 percent of Pennsylvania's gas consumption was imported from other states, that fewer new wells were being drilled, that the gas land reserves were declining, and that costs for all gas services were rising.[41]

Reduced production, price rises, and higher demand, however, were not the only causes of the crisis. The natural gas industry was well known for its wasteful practices. In 1913, for instance, the Bureau of Mines noted that the history of the natural gas industry was "an appalling record of incredible waste."[42] In its initial decades, gas for domestic use was often sold at flat rates by fixture, and low rates encouraged unnecessary use. Wells were drilled and gas erupted, but weeks of delay would occur before the wells were connected to pipelines or plugged. Pipelines often leaked badly, and both manufacturers and household appliances used gas ineffi-

[38] David T. Day, *Mineral Resources of the United States, Calendar Year 1900* (Washington, DC, 1901), 630–31.

[39] John H. Herbert, *Clean, Cheap Heat: The Development of Residential Markets for Natural Gas in the United States* (New York, 1992), 8–9; Samuel S. Wyer, *Natural Gas: Its Production, Service, and Conservation* (Washington, DC, 1918), 37. Industry paid on average 60 percent of what domestic users did; gas companies maintained that this resulted from the higher cost of servicing them. Because of the higher price paid by domestic consumers, gas companies were inclined to reduce industrial supplies before domestic in times of supply shortages. They also argued that domestic needs should have a higher priority than industrial.

[40] Richard R. Rice, *Oil and Gas Map of Southwestern Pennsylvania* (Harrisburg, 1916), 16–19.

[41] Samuel S. Wyer, *Present and Prospective Supply of Natural Gas Available in Pennsylvania* (Washington, DC, 1918), 3–4.

[42] Wyer, *Natural Gas*, 52–57.

ciently. Standpipes illuminated towns and cities with light throughout the night, and open flame or flambeaux torches were common.[43]

In 1916–20, as the United States confronted a fuel crisis based on increased defense and wartime demands, reduced natural gas availability became an area of major concern.[44] Fears about loss of supply and higher prices caused thousands of domestic and industrial users to shift to coal. Some demanded that industrial use of natural gas be ended to ensure domestic supplies. The gas companies, in conjunction with the state and federal governments, carried on an educational campaign focusing on the need for gas conservation and urged domestic consumers to reduce usage. In the 1917–22 period, the Equitable Gas Company, the largest Pittsburgh supplier, moved to preserve its natural gas supplies by constructing a plant near Pittsburgh to produce gas from coal and mix it with natural gas.[45]

In 1920, Pennsylvania state geologist George H. Ashley warned of an uncertain future for natural gas production in Pennsylvania and a need to prevent waste, explore new sources, and balance industrial and domestic uses to meet future needs. His implication was that unless these steps were taken, Pennsylvania's natural gas industry would follow the path of decline experienced by its petroleum industry a half century before (Fig. 4).[46] It is clear that the predictions concerning unlimited supplies of natural gas made when the gas boom began in the 1880s were misguided, as Ashley's warning confirms.

The Environmental Effects of Natural Gas

The rapid expansion of drilling in the Marcellus Shale for natural gas has raised a number of environmental issues related to air, water, and land contamination. In the period of the first natural gas boom, approximately 1880–1920, many similar environmental issues arose. The Natural Gas Act of 1885 set the framework for natural gas development in the state

[43] Reed, "Pittsburgh and the Natural Gas Industry," 130.

[44] John G. Clark, *Energy and the Federal Government: Fossil Fuel Policies, 1900–1946* (Urbana, IL, 1987), 48–127.

[45] On options for conserving natural gas supplies, see George H. Ashley, *Future of Natural Gas in Pennsylvania* (Harrisburg, 1920), 4. Also, see F. F. Schauer, "A Resume of the History, Organization, Operation, and Present Day Problems of the Equitable Gas Company, Pittsburgh & West Virginia Gas Company, & Philadelphia Oil Company" (unpublished document in author's possession, Feb. 15, 1932), 6–7. The Elrama plant was shut down in 1927. The Equitable Gas Company was founded in 1888 as a separate company and was acquired by the Philadelphia Company in 1900.

[46] Ashley, "Future of Natural Gas in Pennsylvania."

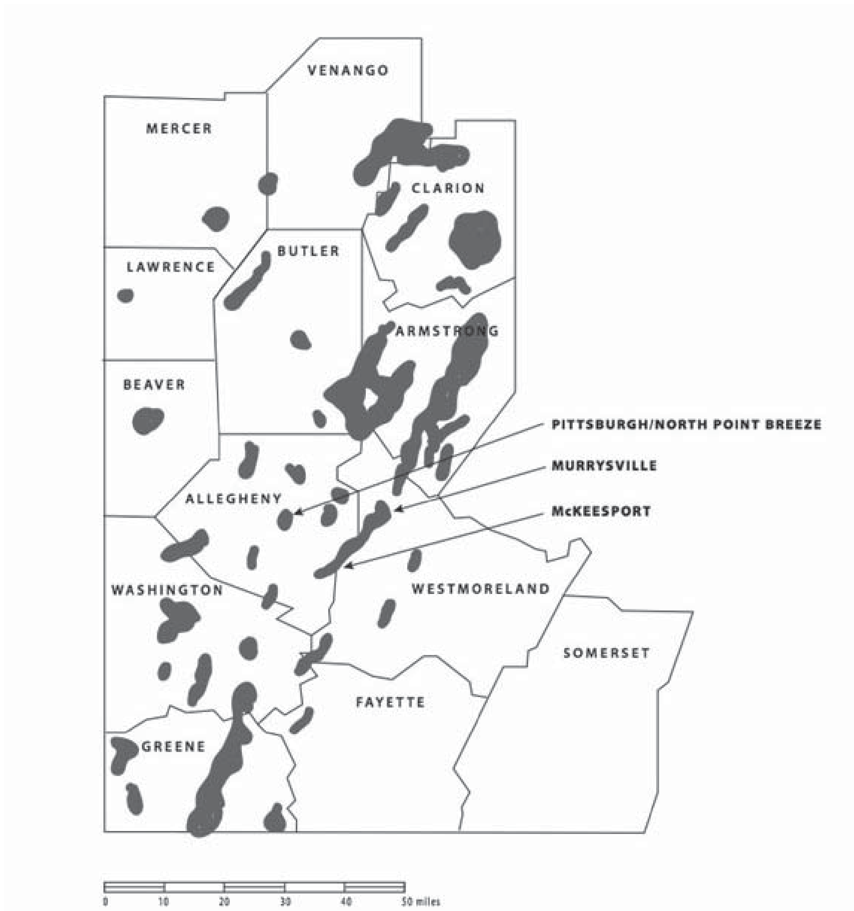


Fig. 4. Location of Natural Gas Fields in Western Pennsylvania, 1920. Source: George H. Ashley and J. French Robinson, *Oil and Gas Fields of Pennsylvania*, vol. 1, *Pennsylvania Geological Survey*, 4th ser. (Harrisburg, 1922).

during this period, and the only new laws enacted by the legislature into the 1920s involved gas conservation measures and environmental issues. This section of the essay will focus on the similarities of the environmental effects that occurred in the earlier period of natural gas development and the recent era of exploitation of the Marcellus Shale.

Air Pollution

As previously discussed, natural gas development in Pittsburgh was a major factor in reducing smoke and improving air quality during the 1880s and into the 1890s. Its increasing unavailability, however, and the return to coal by many users, especially industrial users, restored the smoke burden. In Pennsylvania today, many environmentalists view the substitution of natural gas for coal, especially by coal-burning utilities, as a major step toward cleaner air and reduced health costs from coal consumption. The major emissions concern involving natural gas today, however, relates to leakage of methane—a potent greenhouse gas—from well sites, pipelines, and other gas appliances.[47] Past concern over emissions related primarily to the fact that, as the 1927 *Natural Gas Handbook* noted, "gas leaking into the atmosphere means a continual loss in money," although gas explosions and fires were also an issue.[48] A description of an 1883 Butler County well, for instance, observed that the "flame of this natural torch is about 40 feet long and fifteen feet wide, and keeps at these dimensions night and day with striking regularity."[49] Regular leakage from site operations occurred because of excessive blowing of water from wells, lowering of rock pressure from rapid production, and the flaring of gas to secure oil from a well. According to one expert writing in 1919, this latter factor was "the principal cause of the depletion of many gas fields, and is responsible for a greater volume of gas waste than probably all other causes put together."[50] In addition to the waste from wells, considerable leakage occurred along pipelines. The Bureau of Mines conducted numerous studies of pipeline leakage; summaries of their findings can be found in their reports in natural gas publications.[51]

Leakage had also proven to be a serious problem in natural gas fields located near or in residential areas. From 1919 to 1921, a natural gas boom occurred in what was known as the McKeesport Gas Field, drawing

[47] A recent National Academy of Sciences report concludes that in Pennsylvania 4 to7 percent of anthropogenic methane emissions come from orphan wells. Mary Kang et al., "Direct Measurements of Methane Emissions from Abandoned Oil and Gas Wells in Pennsylvania," *Proceedings of the National Academy of Sciences* 111 (2014): 18173–77.

[48] John C. Diehl, *Natural Gas Handbook* (Erie, PA, 1927), 330.

[49] Pearse and Platt, *Report on the Use of Natural Gas*, 183–84.

[50] Wyer also noted that the amount of natural gas wasted from the state's over sixteen thousand oil wells was an amount "equivalent to about one-third of all the natural gas used for domestic consumption in the United States." Wyer, *Natural Gas*, 53–54.

[51] See section on "Leakage," in Diehl, *Natural Gas Handbook*, 330–41.

from the Speechley Sandstone at a depth of about three thousand feet. Supposedly over a thousand wells were drilled, often on small residential lots. Wildly exaggerated predictions had been made about the extent of the field, but, as state geologists predicted, production rapidly declined. Many well bores that were never properly plugged were covered over by structures or filled by landowners. Some surface methane leakage occurred in the 1930s, but the most serious problems occurred after World War II as a result of scavengers removing many well casings during the war to sell as scrap metal. Methane, according to a 2007 National Energy Technology Laboratory study, leaked into buildings from "abandoned and improperly plugged wellbores, creating air pollution and explosion hazards."[52]

Wells were especially dangerous in coal mining areas because methane could leak into mines and cause explosions. In 1913 the Bureau of Mines held a conference in Pittsburgh to discuss this issue. The report of the conference warned that leakage from abandoned gas wells had caused many coal mine explosions and suggested a number of regulations in regard to well drilling, abandonment, and plugging to reduce the risk. It also concluded that "it would be useless to enact laws without a special officer to carry them into effect" and recommended that states create well inspection departments. Surveyors who drew surface maps for coal companies were careful to indicate the presence of gas and oil wells on them.[53]

Landscape Effects

The extensive drilling that took place in western Pennsylvania damaged and fragmented the landscape through deforestation and the construction of well pads, roads, pipelines, surface reservoirs, and other structures.

[52] National Energy Technology Laboratory, "Methane Emissions Project Borough of Versailles, Pennsylvania, Executive Summary" (report, Pittsburgh, Oct. 31, 2007), 1–2. The McKeesport boom actually covered a much larger area than Versailles but methane leakage appears to have been not as problematic in other locations because wells were more distant from each other. For the state geologist's perspective on the boom see George H. Ashley, *The McKeesport Gas Pool* (Harrisburg, 1920).

[53] George S. Rice et al., *Oil and Gas Wells through Workable Coal Beds: Papers and Discussions* (Washington, DC, 1913). The Consol Energy Collection at the University of Pittsburgh Archives Center contains many maps drawn by surveyors of surface conditions, including gas and oil wells above coal mines. In 2013 the Bureau of Oil and Gas Planning and Program Management of the Pennsylvania Department of Environmental Protection began using such maps to locate historic oil and gas well locations. See Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management, *Historic Oil and Gas Well Locations from Bureau of Oil and Gas Planning and Program Management PADEP—WPA Mines, K Sheet, H Sheet* ([Harrisburg], 2013), http://www.pasda.psu.edu/uci/MetadataDisplay.aspx?entry=PASDA&file=PADEP_HistoricOilGasWells.xml&dataset=1137.

Between 1880 and 1920, the number of productive wells rose rapidly, reaching almost fifteen thousand in 1917. The total number drilled was higher, because some wells were nonproducing.

The extent of these landscape disturbances in the past was not recorded, but recent US Geological Survey (USGS) studies have devised a set of landscape metrics using geographic information systems (GIS) and other instruments to estimate the effects of today's drilling for both conventional and nonconventional natural gas wells. In Allegheny County between 2004 and 2010, conventional (non-Marcellus) wells took up 0.4 hectares per site, and the disturbed hectares were 0.7 per site. Further, each well was associated with 0.3 kilometers of road. In Washington County, which is also in western Pennsylvania and was an early producer, conventional wells took up 0.8 hectares, disturbed 2.0 hectares, and were associated with 0.3 kilmeters of road.

These metrics can be used to provide an order of magnitude estimate of the effects of past drilling. Existing records note that over seventeen thousand wells were drilled in western Pennsylvania over the period from about 1878 to 1920. If the values in the recent USGS study for landscape disturbance for Allegheny County are extrapolated to the region for the earlier period, seventeen thousand acres were used for drilling, thirty thousand acres were disturbed, and 3,100 miles of road were constructed. If the values for Washington County are extrapolated to the region for the earlier period, thirty-four thousand acres were used for drilling and eighty-five thousand acres were disturbed. Even these numbers may be conservative. By 1917 gas companies controlled 2.5 million acres in Pennsylvania through lease and outright ownership, and their impact may have extended well beyond the acres suggested by modern studies.

Surface and Water Well Pollution

The reports of the Department of Health (DOH) and of the Sanitary Water Board note various complaints about gas and oil pollution of water supplies from drilling site runoff. In 1906, for instance, the Clarion Water Company in Clarion County complained that the development of natural gas and oil wells in the watershed had polluted the sources of water from which they supplied the town and asked for permission to extend their water-gathering area to a clean source. The DOH investigated, finding the company's supplies indeed to be polluted and "prejudicial to the public health." The department reported that the "waste material produced in the operation of drilling the wells, in shooting them, and in cleaning them out, is deposited on the surface of the ground round about and eventually gets into the main stream of the water supply." The DOH ordered the water company to either filter the water or find a new source. It also ordered the company not to allow any gas or oil drilling on its lands and to regularly inspect the wells in the vicinity of the borough in order to prevent salt water from the wells from contaminating water supplies.[54]

In addition to ruling on the statutes relating to natural gas and oil, the courts considered nuisance cases generated by gas and oil pollution of private drinking water wells. In an 1890 case, the state supreme court affirmed damages against a natural gas company for permitting salt water to contaminate a private drinking water well because of inadequate casing, noting that "when the salt water is allowed to mingle with the fresh, it will spoil the whole neighborhood."[55] The gas companies appear to have settled other pollution cases of private wells out of court. The Pew Papers at the Hagley Museum and Library, for instance, contain several letters to Joseph N. Pew, president of People's Natural Gas Company, from attorneys representing clients complaining of injuries to their water supplies and livestock from gas well and pipeline leaks. These complaints appear to have been settled.[56] People's Natural Gas Company was aware that problems ensuing from poor casing could cause water pollution. It required that contractors ensure that casing be inspected and that if water was found "the well . . . be thoroughly drained and sand pumped until all drillings and sediments are removed."[57] It is unknown, however, if other gas companies—especially smaller and fly-by-night drillers—followed the regulations.

Many wells that were drilled came in dry, were quickly exhausted, or were flooded by water within a short time. Gas experts and engineers were aware that unless wells were plugged, they could become conduits for brine and water that would overwhelm neighboring wells and pollute

[54] See, *Second Annual Report of the Commissioner of Health of the Commonwealth of Pennsylvania* (Harrisburg, 1908), 486–88 (Google Books, accessed Nov. 10, 2011, http://books.google.com/books/about/Report.html?id=0xdNAAAAMAAJ).

[55] Nannie R. Collins v. Chartiers Valley Gas Co., 139 Pa. 111 (1890–91).

[56] J. M. T. Carpenter to J. N. Pew, Nov. 17, 1892; E. T. Bouser to People's Natural Gas Company, July 19, 1900; E. Robbins to People's Natural Gas Company, Nov. 22, 1894; and Moorhead and Head to People's Natural Gas Company, May 19, 1899, J. Howard Pew Papers, Hagley Museum and Library, Wilmington, DE. The Pew Papers also contain a "Proposal and Specifications for Drilling Wells," dated July 22, 1901.

[57] People's Natural Gas Company, "Proposal and Specifications for Drilling Wells," July 22, 1901, Pew Papers.

nearby surface waters and groundwater.[58] The 1885 Natural Gas Act had a requirement that wells be plugged after the gas was exhausted, but it appears to have been poorly enforced. In 1891, the state legislature again passed an act requiring the plugging of wells that were abandoned or not operating. The requirement had an environmental focus; plugging was required "in such manner as to prevent water from any such well injuring or polluting any spring, water well or stream" used for domestic, steam making, or manufacturing purposes. Violation of the act was made a misdemeanor.[59] A 1921 law provided more specific information about the manner in which wells were to be plugged and existing wells protected from water entering the gas strata from new well drilling, but plugging methodology remained relatively ineffective until after 1940 or so.[60]

Conclusions

This article has focused on the evolution of the Pittsburgh region's first natural gas boom and its environmental effects. As noted earlier, similar policy and environmental issues have arisen during the current Marcellus Shale natural gas boom. These include predictions concerning longevity of supply, policy initiatives to accommodate a new energy source, reductions in demand for coal with resulting unemployment, and regulatory clashes between state and local authority. In regard to environmental effects, issues relating to air quality and methane leakage, ground and surface water pollution, and landscape alterations have been present in both periods of natural gas development.

From the ongoing public and legislative discussions today regarding the Marcellus Shale boom, its effects, and the proper means of regulating

[58] For a discussion of groundwater pollution from early oil and gas wells see, Damian M. Zampogna et al., "Historic Oil and Gas Development, Mineral Extraction, and Contemporaneous Water Quality Data in Northeastern Pennsylvania," *Oil-Industry History* 14 (2013): 33–42.

[59] Act to Prevent the Pollution of Springs, Water Wells and Streams by Water Escaping from Abandoned Oil Wells and Gas Wells, 1891 Pa. Laws 122.

[60] See, Act for Plugging Oil Wells, 1878 Pa. Laws 57; Act for Plugging Abandoned Oil Wells, 1881 Pa. Laws 110; Act for Oil Pipeline Regulation, 1883 Pa. Laws 61; Act for the Incorporation and Regulation of Natural Gas Companies, 1885 Pa. Laws 29; Act to Protect Oil, Gas and Water Wells, 1885 Pa. Laws 145; Act on the Right of Companies to Eminent Domain, 1887 Pa. Laws 310; Act to Prevent the Pollution of Springs, Water Wells and Streams, 1891 Pa. Laws 122; and Act to Regulate the Drilling, Operating, and Abandoning of Oil and Gas Wells, 1921 Pa. Laws 912. S. Taku Ide et al., "CO_2 Leakage through Existing Wells: Current Technology and Regulations" (paper presented at the Eighth International Conference on Greenhouse Gas Control Technologies, Trondheim, Norway, June 2006), available at http://sequestration.mit.edu/pdf/GHGT8_Ide.pdf. See, also, Blakely M. Murphy, ed., *Conservation of Oil & Gas: A Legal History, 1948* (Chicago, 1949), 429–35, for a discussion of numerous attempts to enact legislation regarding the conservation of natural gas in Pennsylvania.

them, it is clear that little attention has been paid to policy or environmental lessons that could be learned from the historical record regarding natural gas. Exploration of this history could help provide policy makers, regulators, and the public with perspectives on potential problem areas and help Pennsylvania avoid another legacy of environmental damage from energy development.

Appendix

Fig. 1A: The Number of Wells Drilled and the Number of Productive Wells in the State. The number of productive wells rose rapidly, reaching almost fifteen thousand in 1917. Roughly 20 to 25 percent were dry or otherwise unproductive. Source: *Mineral Resources of the United States*.

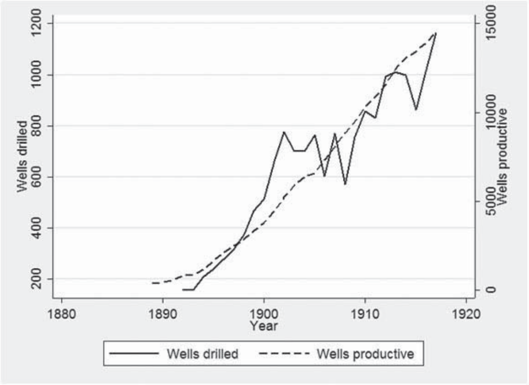
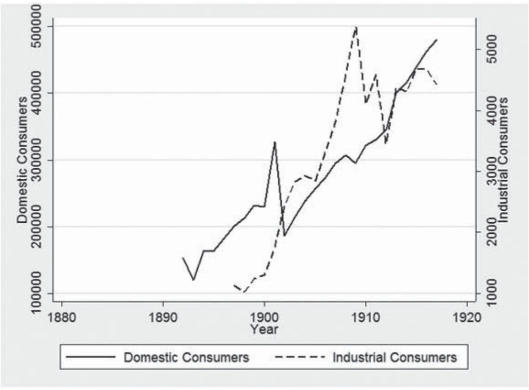


Fig. 2A: Domestic and Industrial Natural Gas Customers, 1890–1917. Source: *Mineral Resources of the United States*.



Carnegie Mellon University JOEL A. TARR AND KAREN CLAY

BOOK REVIEWS

The Ubiquity of Coal in the Mid-Atlantic

Home Fires: How Americans Kept Warm in the Nineteenth Century. By SEAN PATRICK ADAMS. How Things Worked series. (Baltimore: Johns Hopkins University Press, 2014. 200 pp. Illustrations, maps, notes, index. Cloth, $44.95; paper, $22.95.)

Fueling the Gilded Age: Railroads, Miners, and Disorder in Pennsylvania Coal Country. By ANDREW B. ARNOLD. Culture, Labor, History series. (New York: New York University Press, 2014. 286 pp. Illustrations, notes, index. $49.)

Routes of Power: Energy and Modern America. By CHRISTOPHER F. JONES. (Cambridge, MA: Harvard University Press, 2014. 320 pp. Illustrations, maps, notes, index. $39.)

I RECENTLY FOUND MYSELF in front of an exhibit of cast iron stoves at the Cumberland County Historical Society, thinking about the social systems embedded in their bulky forms. The display included an early nineteenth-century "ten-plate" model made by Peter Ege at nearby Pine Grove Furnace. This stove, which took advantage of manufacturing innovations to include a small oven, emerged out of a pivotal moment in the nation's first energy transition. German immigrants were accustomed to using stoves for home heating, though not for cooking, but immigrants from England's milder climate brought with them a cultural attitude that valued the less effective open fireplace and did not heat with stoves even during the cold winters of their new home. Urban residents increasingly shifted to more efficient stoves as easy access to wood supplies slowly declined—a decline that in turn laid the foundation for even more profound transitions to coal, natural gas, oil, and, eventually, electricity. At each stage, a number of recent works have argued, the mid-Atlantic region, marked by its entrepreneurial spirit as well as its enormous mineral resources, shaped this process as it slowly gave rise to the energy intensity of our contemporary world.

Taking stoves such as Pine Grove Furnace's ten-plate as his inspiration, Sean Patrick Adams links the domestic hearth of the average family living in one of the nation's growing cities with the broader process of industrialization. In *Home Fires: How Americans Kept Warm in the Nineteenth Century*, he puts to rest the notion that the move from wood to coal for home heating was either a product of simple market forces or the result of a singular breakthrough technology, such as Ben Franklin's famous "Pennsylvanian fireplace" (which, it turns out, blew smoke into the room and required constant tending). Explaining the rise of the "industrial hearth," as the author describes it, instead requires attention to the enormous capital and labor expended in transporting anthracite over hundreds of miles, the dirty and dangerous work done in iron works and coal mines, and "the bare-knuckle negotiations between colliers, railroads, wholesalers, and customers" (9). After overcoming the bias toward open fires, energy entrepreneurs faced technological hurdles in manufacturing effective appliances. These problems were not resolved until new transportation systems helped move the iron production process closer to retail customers. The substitution of finicky anthracite for wood took several more decades to achieve and "required a sustained transformation of everyday household practices on par with the most radical changes that the Industrial Revolution brought to the workplace" (41).

As the first volume in Johns Hopkins University Press's new How Things Worked series, the book is accessible, appropriately succinct, and modestly illustrated. Despite the expansive title, Adams makes clear that his story is really about the subset of Americans living in the urbanized Northeast and Great Lakes regions, where cold winters and dense populations drove the transition away from wood heat. Indeed, even as urban attitudes began to shift, coal's ascendency over wood required first that the anthracite coalfields of northeastern Pennsylvania be connected to the Atlantic seaboard by canals and then that the cost of coal be driven down by both cutthroat competition and the labor repression epitomized by the infamous Molly Maguire trials. In *Fueling the Gilded Age: Railroads, Miners, and Disorder in Pennsylvania Coal Country*, Andrew Arnold picks up the story of coal's rise in the closing decades of the nineteenth century, but shifts attention to central Pennsylvania, especially Clearfield County, a hundred miles northeast of Pittsburgh. Arnold chronicles the workers, mine owners, and railroad men who jostled for control of the region's high-quality bituminous coal even as industrial consumers gradually shifted to the enormous reserves of southwestern Pennsylvania and West Virginia for their coal. His goal is to unravel the complex, mutually dependent relationship between coal and railroads at the heart of the American industrial revolution as well as to explore the often overlooked agency of miners and operators in shaping the age of steam. Of course, their actions often manifested as resistance to the tidy plans of railroad managers seeking predictability and profitability, but Arnold emphasizes a "constructive role" in developing the ideas and systems at the root of industrial capitalism (6).

Fueling the Gilded Age's three sections focus on the ways in which these important constituencies tried and failed to impose their own visions of coalfield order by cooperating at some points and competing at others. Part 1, "Hubris," begins with a landmark strike in 1872 that undermined the tenuous balance of power in Clearfield County, traces the collapse of formal miners' unions under the weight of pernicious legal decisions, and concludes with the rise of the secretive Knights of Labor among a group of entrenched activists that were "well-regarded as leaders by the coal miners, and well-respected as permanent members of the community" (86). This partial victory for workers in the face of what appeared to be organized labor's total defeat was made possible, in part, by the rebellion of regional coal operators against the attempt of the railroads to impose price concessions—a story explored in part 2, "Humility." Amid the infamous labor violence of 1886's Great Upheaval, Arnold unearths an important compromise that allowed elected representatives to monitor company weighmen at each coal tipple. This agreement moved central Pennsylvania's operators and miners toward a pragmatic relationship "that was more functional than revolutionary" (115). The book's final part, "Stalemate," traces uneasy settlements achieved by the new United Mine Workers of America, the Seaboard Coal Association, and consolidated networks of the Pennsylvania and New York Central railroads that "froze a disorderly system in place" near the turn of the century (219).

Whereas Arnold begins with coal production and Adams frames his tale around domestic consumption, Christopher F. Jones in *Routes of Power: Energy and Modern America*, looks at the spaces in between, arguing that the "*roots* of America's energy transitions can be found in the building of *routes* along which coal, oil, and electricity were shipped" (2). In this story, as a result of decisions by entrepreneurs, industrialists, and political leaders to ship energy long distances rather than build factories near sources of power, the mid-Atlantic played a pivotal role in shaping new energy systems in the United States. Sustaining energy transitions required a positive feedback loop between economic investments in transportation infrastructure, the actions of humans who benefited from these new arrangements, and new consumption practices that locked them into place—social, cultural, and environmental-technological frameworks Jones describes as "landscapes of intensification" (8). He begins with the anthracite fields of northeastern Pennsylvania, where transportation boosters sought to make their fortunes by developing canals along the Lehigh and Schuylkill Rivers that would link mines to the growing markets of the Eastern Seaboard. In a pattern repeated in subsequent energy transitions, the supply of cheap fuel drove demand as Americans began to "create new relationships between energy and society that were facilitating the sustained growth of an urban and industrial economy" (60).

For Jones, the rise of oil was another step toward this new mineral energy regime as the desire for better and cheaper artificial lighting and effective lubricants for bigger and faster factory equipment drove oil-field innovation. This, in turn, was made possible by the steam pumps, cheap iron for well casings, and railroad networks that had been founded upon the availability of cheap coal. The liquid properties of oil allowed greater abstraction and commodification of natural resources, as increasingly sophisticated pumps and the construction of pipelines required less and less direct human intervention in the production and transportation processes.

The final third of the book focuses on the damming of the lower Susquehanna River for electrical production in the first decades of the twentieth century. While the use of water power could be considered an update of the earlier organic regime, in Jones's telling it becomes, instead, a hybrid energy system with users located far from the energy source, dam construction that required the use of mineral energy resources, and a distribution system that reinforced consumption patterns established by the use of coal and oil.

Taken together, these books suggest three key aspects framing the history of coal in Pennsylvania. First and foremost is its ubiquity. The enormous wealth of anthracite and bituminous coal offered both opportunities and challenges as the relatively low threshold for entering the industry drove fierce competition over price and made it virtually impossible for even a group of powerful producers to fully control the market. While each of the authors grapples with this issue in one way or another, a key gap in the three volumes is the lack of systematic attention to the vast bituminous fields of northern Appalachia. I found it odd, for example, that an introductory map in *Routes of Power* labeled "Mid-Atlantic energy sources" ignores bituminous coal entirely (7), but the issue is most significant in *Fueling the Gilded Age*. Arnold never fully explains how his focus on a relatively small area of central Pennsylvania relates to the broader mining area of which it was a part. Arnold is at his best when unraveling the complicated legal decisions that took place on a variety of levels—for example, in explaining the legal basis for the county-by-county development of the system of checkweighmen. However, the haphazard explication of local and regional contexts, exemplified by the complete absence of maps in the volume, partly undercuts his analytical framework and results in a narrative that is too choppy to be fully effective.

Second, these three works make it clear that coal production cannot be understood unless equal attention is paid to the transportation systems that moved energy to consumers. The rise of coal was connected intimately with the canals and especially the railroads that carried it to distant markets. The economic logic of mineral energy meant that increased use did not require the types of social trade-offs necessitated by earlier organic regimes, where the amount of accessible land set aside for the growth of forests limited urban concentrations and industrial growth. Further, by first increasing the distance between energy production and consumption and later by obscuring even its transportation by burying pipelines and transforming dirty fossil fuels into clean electricity, it became that much easier for users to ignore environmental and social costs suffered by rural "sacrifice zones," as Jones dubs them (12). One area left to explore (that is only suggested by Jones) is the increase of coal-by-wire power production that, especially after World War II, connected rural mid-Atlantic communities to ever more distant consumers.

Finally, understanding the ebbs and flows of coal production requires exploring a whole range of technological, social, political, and cultural networks. The energy regimes established in the transition to mineral energy have proven remarkably resilient—even forcing non-fossil-fuel resources, such as hydroelectric, solar, and nuclear power, to conform to consumption patterns and delivery systems predicated on unlimited, always accessible, and invisible power. Both Jones and Adams explicitly connect their stories of energy transitions in the nineteenth and early twentieth centuries to the current debate over the future of coal amid environmental concerns ranging from mercury emissions to global warming. *Home Fires*, especially, would have benefitted from a greater use of the lens of environmental history, with its emphasis on the back and forth between humans and the rest of nature. That said, Adams makes a strong case for the need to understand technological change as consisting of both material improvements in the process of doing things and the social, political, and cultural structures necessary for those changes to happen. Indeed, his book concludes with a story that illustrates the complicated factors necessary for new technologies to catch on by focusing on district steam heat—an energy transition that failed to take off.

In the end we remain, as Adams declares of the 1860s, enmeshed in an energy regime in which individuals may choose alternative ways of consuming power, but in which scaling those alternatives up to the regional or even community level would cause widespread social disruption. On the other hand, the history of coal in the region reminds us that while the process may be slow, energy transitions are possible given the right combination of political will, social awareness, and technological innovation. In any event, the ubiquity of coal in the mid-Atlantic, as well as the region's prime position bridging the resource fields of the Appalachian Plateau (which now also includes the wind farms of the Allegheny Ridge and the fracking rigs of the shale gas boom) and the population centers of the Atlantic Coast, means that this landscape will continue to play a pivotal role in the history of energy.

Shippensburg University ALLEN DIETERICH-WARD

HIDDEN GEMS

Houses No Warmer than Barns: Peter Kalm on Fireplaces and Firewood in Colonial Pennsylvania

The travel narrative of the Swedish-Finnish naturalist Peter Kalm (Pehr Kalm, 1716–79) is a familiar primary source for studies of colonial North America.[1] This essay highlights Kalm's comments on energy use in mid-eighteenth-century Pennsylvania and points to additional resources for Kalm's observations of the Delaware Valley region.[2]

[1] Kalm's work is probably best known through Adolph G. Benson's 1937 edition, *Peter Kalm's Travels in North America: The English Version of 1770* (1937; reprint, New York, 1966 [2 vols.] and 1987 [2 vols. in 1]). Benson revised and annotated John Reinhold Forster's translation, *Travels into North America*, 3 vols. (Warrington and London, 1770–71; 2nd ed. [abridged], London, 1772 [2 vols.]). Forster's translation, in turn, had been based on the German translation, *Reise nach dem Nordlichen America*, 3 vols. (Leipzig, 1754–64), of Kalm's original Swedish, *En Resa Til Norra America*, 3 vols. (Stockholm, 1753–61). Unless otherwise noted, my citations to Kalm's *Travels* refer to the Benson, 1987 reprint. All dates are New Style. All URLs cited were active as of Feb. 9, 2014.

[2] Joseph Lucas, trans., *Kalm's Account of His Visit to England on His Way to America in 1748* (London, 1892), Internet Archive, https://archive.org/details/cu31924028059693; W. R. Mead, *Pehr Kalm: A Finnish Visitor to the Chilterns in 1748* (Aston Clinton, Bucks., UK, 2003); W. R. Mead, *Pehr Kalm—His London Diary, 1748* (Aston Clinton, Bucks., UK, 2013; dist. by Buckinghamshire Archaeological Society); Pehr Kalm, *Resejournal över resan till norra Amerika*, ed. Martti Kerkkonen, 4 vols. (Svenska Litteratursällskapet i Finland, no. 419, 436, 525, 550) (Helsingfors/Helsinki, 1966–88); Bengt Hildebrand, ed., *Pehr Kalms Amerikanska Reseräkning* (Svenska litteratursällskapet i Finland, no. 356) (Helsingfors/Helsinki, 1956). Many of Esther Louise Larsen's translations of Kalm's scientific letters, papers, and dissertations by his students (effectively written by Kalm) have been digitized by Cornell's Core Historical Literature of Agriculture, available at http://chla.library.cornell.edu/c/chla/about.html. Tell Dahllöf, "Pehr Kalm's Concern about Forests in America, Sweden, and Finland Two Centuries Ago," *Swedish-American Historical Quarterly* 17 (1966): 123–45, available at http://collections.carli.illinois.edu/u?/npu_sahq,3149 (accessed Feb. 3, 2014); Th. M. Fries, J. M. Hulth, and A. Hj. Uggla, eds., *Bref och skrifvelser af och till Carl von Linné*, vol. 1 (Stockholm, 1922), part 8, 59–60, no. 1602; Pehr Kalm to Carl Linnaeus, Dec. 16, 1750, n.s., dated Dec. 5, 1750, *The Linnaean Correspondence*, http://linnaeus.c18.net, letter L1208 (accessed Feb. 9, 2014); Sven Lundqvist and Roland Moberg, "The Pehr Kalm Herbarium in UPS [Botanical Museum, Uppsala University]: A Collection of North American Plants," *Thunbergia*, vol. 19 (Uppsala, 1993), 1–62; Martti Kerkkonen, *Peter Kalm's North American Journey: Its Ideological Background and Results* (Helsinki/Helsingfors, 1959); Carl Skottsberg, *Pehr Kalm: levnadsteckning* (Stockholm, 1951). Recent studies of Kalm in English include: Fredrik Albritton Jonsson, "Rival Ecologies of Global Commerce: Adam Smith and the Natural Historians,"

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When Peter Kalm came to Philadelphia in the fall of 1748, he was surprised to learn that "the winters here [in America] are just as cold as in Sweden."[3] Equally surprisingly, American families burned far more firewood than their Swedish counterparts, yet their houses were "no warmer than barns."[4] Kalm's foremost goal in America was to collect native plants for the great Swedish scientist Carl Linnaeus. However, observing and accounting for this dramatic difference in energy use was an equally essential part of Kalm's broader, utilitarian mission: What could he learn about America's natural resources that might help Sweden's weak economy?[5]

Because Pennsylvania's winters were as bad as Sweden's, Kalm argued, "it clearly follows that trees and plants that withstand the winters here should do the same in Sweden."[6] Sugar maple and hickory were "the best wood for fuel in everybody's opinion," because they produced the most heat.[7] Black oak was best for charcoal.[8]

Kalm blamed the colonists' extravagant use of firewood on their large, open fireplaces, which followed the English design. In particular, they lacked the dampers (*spjäll*) that kept Swedish homes snug.[9] A century earlier, the original settlers of the New Sweden colony had not brought dampers with them; instead, as a makeshift, "the board ceilings in the first

American Historical Review 115 (2010): 1342–63; Paula Ivaska Robbins, *The Travels of Peter Kalm: Finnish-Swedish Naturalist, through Colonial North America, 1748–1751* (Fleischmanns, NY, 2007); Paul Andrew Sivitz, "Communication and Community: Moving Scientific Knowledge in Britain and America, 1732–1782" (PhD diss., Montana State University, Bozeman, 2012), available at http://etd.lib.montana.edu/etd/2012/sivitz/SivitzP0812.pdf; Constantine J. Skamarakas, "Peter Kalm's America: A Critical Analysis of His Journal" (PhD diss., Catholic University of America, 2009), available at http://books.google.com/books?id=iAsPL5Au73oC&source=gbs_navlinks_s; Karen Reeds, *Come into a New World: Linnaeus and America: An Exhibition to Commemorate the 300th Birthday of the Great Swedish Scientist, Carl Linnaeus* (Philadelphia, 2007); and *The Linnaeus Apostles: Global Science and Adventure*, 8 vols., ed. Lars Hansen, transcribed by Viveka Hansen (Whitby, UK, 2007–08), vols. 1 and 3.

[3] Pehr Kalm, "Pehr Kalm's Observations on the Natural History and Climate of Pennsylvania: Excerpts from His Letter of October 14, 1748," trans. Esther Louise Larsen, *Agricultural History* 17 (1943): 172–74. Pehr Kalm, "Peter Kalm's Short Account of the Natural Position, Use, and Care of Some Plants, of Which the Seeds Were Recently Brought Home from North America for the Service of Those Who Take Pleasure in Experimenting with the Cultivation of the Same in Our Climate," trans. Esther Louise Larsen, *Agricultural History* 13 (1939): 33–64.

[4] Benson, *Travels*, 235–36 [Jan. 16 and 21, 1749].

[5] Lisbet Koerner, *Linnaeus: Nature and Nation* (Cambridge, MA, 1999), 108–28.

[6] Kalm and Larsen, "Pehr Kalm's Observations on . . . Pennsylvania," 172–74.

[7] Kalm and Larsen, "Peter Kalm's Short Account," 36 [no. 4], 47 [no. 64]; Benson, *Travels*, 50–51 [Sept. 22, 1748], 655–56 [Dec. 11, 1749].

[8] Kalm and Larsen, "Peter Kalm's Short Account," 34, 59 [no. 106].

[9] Benson, *Travels*, 235–36 [Jan. 21, 1749]; Albert Barden and Heikki Hyytiäinen, *Finnish Fireplaces: Heart of the Home*, 2nd ed. (Helsinki, 1993), 12–13.

colonial houses [were] covered with earth to prevent the heat from escaping through the top."[10] A seventy-five-year-old settler, Mårtin Gäret (Martin Garret) recalled that "he himself had made a cover which he placed over the chimney on cold nights, thereby retaining much more heat than usual. But it was a lot of trouble to climb up on the roof of the house every night and morning."[11]

Kalm eagerly discussed heating experiments with Benjamin Franklin and was glad of the loan of one of Franklin's new stoves for the winters of 1749 and 1750: "It kept the house quite warm. . . . It proved often unnecessary to have a fire in the kitchen, and one could prepare chocolate and other food in the little stove."[12] In late November 1749, Kalm prudently laid in a supply of hickory and oak for the stove. Two weeks later, the Delaware River froze over, preventing farmers from bringing in new supplies of wood to Philadelphia. As Kalm records:

> The price of wood went up rapidly, because before that one had been able to buy a cord of hickory for 22 shillings, but now it had gone up to from 25 to 27 shillings per cord, and even then one had to hurry and take it lest it be snapped up by someone else. Oak wood rose from 16 to 19 and 20 shillings per cord, and one was glad to get it at that price.[13]

Looking at the Americans' spendthrift ways with firewood, at their increasing industrial demand for charcoal, and at their rapidly growing settlements, Kalm—echoing Franklin—predicted that "in future times Philadelphia will be obliged to pay a high price for wood."[14] Kalm's European experience, however, gave him a greater sense of urgency. In Finland, he had seen the "indescribable damage to forest and field" from thoughtless clearing of woodlands.[15] In England he had witnessed poor families paying for anything that would burn, from hedge clippings to dry

[10] Benson, *Travels*, 727 [Nov. 22, 1748]; Kalm, *Resejournal*, 4:264.

[11] Benson, *Travels*, 727 [Nov. 22, 1748]; Mead, *Pehr Kalm . . . Chilterns*, 68–69; Lucas, *Kalm's Account*, 7, 78, 126, 235–36, 265, 319, 337, 358.

[12] Benson, *Travels*, 652–55 [Dec. 8, 1749]. Kalm referred his readers to Benjamin Franklin's pamphlet, *An Account of the New Invented Pennsylvanian Fire-Places* (Philadelphia, 1744), available at Founders Online, National Archives, http://founders.archives.gov/documents/Franklin/01-02-02-0114, ver. 2013-12-27 (accessed Jan. 26, 2014).

[13] Benson, *Travels*, 50–51 [Sept. 22, 1748], 655–56 [Dec. 11, 1749]; Hildebrand, *Pehr Kalms Amerikanska*, 56 [Nov. 27, 1749].

[14] Benson, *Travels*, 50–51 [Sept. 22, 1748]; Franklin, *Pennsylvanian Fire-Places*.

[15] Kalm and Larsen, "Peter Kalm's Short Account," 55 [no. 88].

This pastiche of images of America and its natural resources emphasizes the wealth of wood. Vignettes of Philadelphia and William Penn appear in the frame. Engraved frontispiece by C[aspar] Philips Jacobsz (1732–89), to the Dutch translation, *Reis door Noord Amerika* (Utrecht, 1772) of Peter Kalm, *Travels into North America*. Courtesy of the John Carter Brown Library at Brown University.

leaves.[16] Unless the New World settlers cared for their fuel, forests, and fields more wisely, Kalm feared that the land he had grown to love would suffer the same fate.[17]

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[16] Mead, *Pehr Kalm . . . Chilterns*, 46–47, 64–65, 68–69, 109; Mead, *Pehr Kalm . . . London Diary*, 47, 96, 101–2, 110.

[17] Benson, *Travels*, 307–9 [May 18, 1749]; Lithander, in Dahllöf, "Peter Kalm's Concern," 142–45. Kalm left America from New Castle, Delaware, on February 5, 1751. Kalm to Linnaeus, Dec. 16, 1750.

Hopewell Furnace National Historic Site

Nestled within the largest contiguous forest in southeastern Pennsylvania, the restored buildings and structures of the Hopewell Furnace National Historic Site commemorate America's early energy history. The 848-acre park encompasses over 600 acres of woodland and 145 acres of farmland, meadows, and pastures.[1] Today, recreational uses such as hunting, camping, hiking, and fishing have complicated the interpretation of the rural site, but here discerning visitors learn about how industries extracted energy from the natural resources present in the very mountains and forests they have escaped the city to enjoy. Within this idyllic, pastoral landscape, an iron-making operation ran intermittently for over a century (1771–1883).

As in Europe, Americans enlisted charcoal as fuel to heat iron ore and extract pure iron and Pennsylvania was the center of such production due to its abundant natural resources. In 1771, ironmaster Mark Bird chose a site in the Schuylkill Valley of Berks County that boasted not only plentiful iron ore but also readily available waterpower, ample trees from which to make charcoal, and limestone to stimulate the smelting process. A twenty-five- to thirty-five-foot stone pyramidal furnace with a flattened top, set against a hill to anchor a charging bridge, heated the limestone and charcoal, separating out the impurities to create wrought iron fit for use by a blacksmith. A bustling, racially diverse, but isolated community of skilled and unskilled workers, including women and children, eventually grew around the glow, noises, and blast cycles of an iron furnace.[2]

The over four thousand–acre operation produced between 720 and 1,000 tons of iron for distant urban markets by consuming, manipulating, and despoiling its natural environment.[3] Because charcoal is created from the slow combustion of wood, woodcutters encompassed the largest segment of workers. The furnace required at least five thousand cords of wood to maintain an eleven-month blast cycle (depending on coal sup-

[1] KFS Cultural Resources Group, with Menke and Menke, *Cultural Landscape Report: Hopewell Furnace National Historic Site* (Philadelphia, 1997), 1. Hereafter cited as CLR.

[2] Joseph E. Walker, *Hopewell Village: The Dynamics of a Nineteenth Century Iron-Making Community* (Philadelphia, 1966), 19–20. A cast house, a manor-type home for himself, a blacksmith shop, a store, a barn, and tenant housing for workers supported the village.

[3] Walter Hugins, "The Physical History of the Furnace Group, 1770–1783" (Feb. 7, 1954), 4-5, Hopewell Furnace National Historic Site Files, Elverson, PA; CLR, 41; Robinson and Associates, "Historic Resource Study: Hopewell Furnace National Historic Site: Final" (Report prepared for the National Park Service, 2004), 34.

plies). However, the industry generally allowed for several years regrowth before cutting anew, and therefore the furnace owners rarely cut more than four thousand cords a year. In the meantime, the ironmaster purchased an additional two thousand to three thousand cords from woodlots outside the Hopewell property. A skilled collier smoldered the wood twenty-five to fifty cords at a time, creating enough smoke to cloud the air. Moreover, the smelting process created industrial waste, or "slag" piles, which workers occasionally recycled.[4] Lastly, headraces (open ditches) redirected water from Baptism Creek and springs near French Creek down the sloping meadow to the furnace's waterwheel. The stream powered the waterwheel, which pumped blowers for regular blasts of air. The oxygen maintained and intensified the heat, increasing the furnace's efficiency.[5] A nineteenth-century water rights dispute over the springs forced new owners to dam French Creek to replace the West Headrace.[6]

The Civil War and the building of the railroad further increased the demand for iron. By the 1880s, however, American industry was moving toward more efficient business models with the rise of cities and demand for steel construction. Under titans like Andrew Carnegie, the steel industry moved to urban manufacturing centers such as Pittsburgh and Bethlehem, consolidating all aspects of the manufacturing process with new technologies.[7] Small, independent, rural enterprises such as Hopewell could no longer compete with its product or process.

Hopewell Furnace, ironically, owes its second life as a historical park to a public economic relief and conservation program designed to offer unemployed men work and urban people refuge from their industrial home environments during the height of the Great Depression. French Creek became one of forty-six Recreational Demonstration Areas, where the ill effects of industrialization had hit hard. These woodlands offered locations for campgrounds, picnic sites, bridle paths, and hiking trails, all developed by the Civilian Conservation Corps. The dammed reservoir that had supplied water to the furnace would provide an attractive "center-

[4] One acre produced between thirty and forty cords of wood; a cord is eight by eight by four feet. Walter Hugins "The Story of a 19th-Century Ironmaking Community," in *Hopewell Furnace: A Guide to Hopewell Village National Historic Site, Pennsylvania*, Official National Park Handbook series, 124 (1983; Washington, DC, 1988), 30, 53; Robert B. Gordon, *American Iron, 1607–1900* (Baltimore, 2001), 15, 123, 148.

[5] CLR, 24–36; Hugins, "The Story of a 19th-Century Ironmaking Community," 29.

[6] CLR, 23–30. See chapter 8 for more detailed discussion of water rights issue.

[7] CLR, 42.

piece" for activities such as boating, fishing, and even swimming. The ruins of the defunct furnace could be an attraction too.[8]

Interviews with Harker Long, who oversaw the furnace's last blast, provide descriptions of the "dear old furnace and village."[9] In the winter of 1936, former Hopewell caretaker and collier Lafayette Houck agreed to perform a charcoal-making demonstration lasting several days.[10] In 1938, the iron plantation became the first National Park Service (NPS) site to earn national recognition for industrial history in the United States.

Unfortunately, indecision over what era in which to "freeze" preservation and interpretation of the site challenged the interpretation of Hopewell as a landscape of continuous energy production. As one observer noted in 1959, "The visitor today can hardly realize that the furnace—with its lazily-turning waterwheel . . . was once the hub of great activity."[11] But in the 1960s, the park revised its interpretative program and, after thirty years, reintroduced on-site charcoal-making with regular demonstrations by collier Elmer Kohl. Each August, the event shows interested members of the public how wood was converted into energy in a presentation that engages all of the senses.[12] In the 1980s, NPS changed the site's name from Hopewell Village to Hopewell Furnace to reflect a new interpretive focus on iron-making technology.[13] This shift has helped teach visitors about the long, intimate, and complicated relationship between American technology, labor, industrial production, and natural resources.

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[8] Leah S. Glaser, *Hopewell Furnace National Historic Site: An Administrative History* (Philadelphia, 2005), 8, 23–55.

[9] See John P. Cowan, "Notes on Interview with Harker Long, of Birdsboro," Apr. 5, 1938, Hopewell Village File to Sept. 1940, Northeast Regional Office, National Park Service, Philadelphia; Christopher Fisher Motz, Monthly Report, Apr. 5, 1941, "NMP-CCC Hopewell Village April 1, 1941 to December 1941," box 56, RG 79, NARA-Mid Atlantic Region (Philadelphia).

[10] NPS researched and produced a detailed report and booklet, both of which are still available today: Jackson Kemper, *American Charcoal Making in the Era of the Cold Blast Furnace*, National Park Service Popular Studies series, 14 (1941); Arthur Sylvester and Jackson Kemper, *The Making of Charcoal as Followed by the Colliers of the Schuylkill Valley* (Pottstown, PA, 1937); Kemper to Arthur Sylvester, Dec. 16, 1936, Papers of Charles Hosmer, Special Collections, National Trust Library, University of Maryland, College Park.

[11] G. Clymer Brooke, *Birdsboro: Company with a Past, Built to Last* (New York, 1959), 11.

[12] Harry Hart, taped interview by Leah S. Glaser, July 26, 2003, copies at Hopewell Furnace National Historic Site, Elverson, PA.

[13] "National Park Service Area Name Changed to 'Hopewell Furnace National Historic Site,'" press release, Nov. 1, 1985, Historical Central Files, Hopewell Furnace National Historic Site.

Locating Philadelphia's Water-Powered Past

In the eighteenth and nineteenth centuries, watercourses were critical to processing and power for manufacturing, and Philadelphia County once had numerous creeks that mill proprietors exploited. A series of scaled surveys undertaken by Philadelphia County officials when new roads or alterations to existing roads were proposed provides visual documentation of the importance of rivers and creeks to early industry. These records, part of the holdings of the Philadelphia City Archives, begin in the early years of the county. Much of the collection predates detailed, large-scale maps and thus is a unique record of the region's development as well as a vital adjunct to textual material such as deeds and newspapers. Captured on a number of surveys are the dams, millponds, and raceways that became the power systems of early endeavors in textile and paper production, among other industries. The plans, drawn by district surveyors, also boast a certain degree of artistry; color washes and outlines or generic sketches of houses, stables, barns, inns, bridges, and the occasional church are common features. Striking on some of the plans as well are the topographical details that signal a county once filled with hills and valleys, its varied terrain making even small rills powerful when water descended. Surveyors mapped the land to facilitate the construction of county infrastructure, simultaneously documenting the landscape that such construction helped to obliterate.[1]

These surveys enable us to tell a richer story about early industry and the ways Philadelphians commodified the landscape near watercourses. Consider the plan done in 1808, when residents petitioned for a road to connect the Falls Bridge over the Schuylkill River to the "old Lancaster road" in Blockley Township on the west bank (Fig. 1). The survey for Falls Road shows the outlines of John Thoburn's mill and tenant houses, as well as the creek adjacent to the mill, the woodlands and meadow areas, and the tracts of neighbors whose

My sincere thanks to Adam Levine for the exchanges and collaboration we have had over more than a decade, and for the work he has done to preserve Philadelphia's past. Thank you as well to James M. Duffin, Jefferson Moak, and David Baugh for their assistance with the road surveys and other archival finds, and Brian Black and Tammy Gaskell for comments on this essay.

[1] Road Petitions, Clerk of the Quarter Sessions Court, 1685–1919, RG21:26, Philadelphia City Archives and Records (cited hereafter as Road Petitions). Most files contain the petitions of residents to Quarter Sessions Court to open the road and a report of the jury appointed to view the route and assess damages for taking private property. Where disagreement arose about the need for or the route of the road, or regarding the amount of damages, depositions are also contained in files and reveal additional information about surrounding built structures, topography, and watercourses. The petitions and outcomes are supplemented by the Road Dockets of the court.

Fig. 1. 37-0702, Blockley, 1808, Road Petitions, Clerk of the Quarter Sessions Court, 1685–1919, RG 21:26. Courtesy of the Philadelphia City Archives and Records.

land would also be crossed (or parcels taken) by the road. A subsequent plan of the route identifies the mill as a "calico factory," the millpond Thoburn had formed by damming the creek now apparent.[2]

Newspapers and nineteenth-century chroniclers help to identify the mill property, its manufacturer, and the goods produced. The structures had been built by entrepreneur John Nicholson in 1794 for a glassworks but had been neglected since Nicholson's bankruptcy in 1797. A stone mill and fourteen small dwelling houses (visible on the 1808 survey) remained. Thoburn, who had been printing calico since about 1803 on a small creekside property in Darby in Delaware County, leased the Blockley site for a term of ten years beginning in March 1806. The open ground upon which to spread cloth to dry and whiten in the sun, the brook, with sufficient volume to rinse the cloth at each stage of production, and the channel into the Schuylkill River to dispose of refuse bleaches and dyes recommended the property for calico printing. A few months later, when one of the owners died, the premises came up for sale, and Thoburn bought them.[3]

[2] The draft even captures a plan of the orchard and gardens of neighbor George Aston's country house. Petitions 37-0702, Blockley, 1808 and 37-0711, Road Petitions.

[3] Arlene M. Palmer, "A Philadelphia Glass House," *Journal of Glass Studies* 21 (1979): 102–14, http://www.jstor.org/stable/24190039. For the public sale of Nicholson's property, see *Philadelphia Gazette*, Dec. 6, 1797. The property ended up in the hands of merchants Philip Nicklin and Robert Griffith, assignees of Nicholson. They seem to have had no tenant until Thoburn. Nicklin died suddenly and intestate in 1806, and the property was put up for sale. *United States' Gazette*, Feb. 25, 1806; "Act to Authorize the Sale and Conveyance of the Real Estate of Philip Nicklin, by his surviving partner and legal representatives," Ch. 2819, *The Statutes at Large of Pennsylvania from 1806 to 1809*, vol. 18 (Harrisburg, 1915), 483–86; *Democratic Press*, Dec. 5, 1807; West Park, Title Papers, 1867–ca. 1954, Fairmount Park Properties, box 971, N-5, RG149.6, Philadelphia City Archives and Records (hereafter cited as West Park, Title Papers); Charles Robson, *The Manufactories and Manufacturers of Pennsylvania of the Nineteenth Century* (Philadelphia, 1875), 323.

Although he was printing calico with blocks, Thoburn's Philadelphia rivals used some machinery powered by water, and he likely did the same. The property's fifty acres and the situation of the creek enabled Thoburn to dam the watercourse without flooding adjacent tracts and antagonizing neighbors. Despite the small size of the rivulet (it merited no name on nineteenth- or twentieth-century maps), its descent toward the Schuylkill River gave it a fall sufficient to turn waterwheels. A later survey of the area showed a proposed road in profile, revealing the topography of the stretch.[4]

Access to the Schuylkill River also facilitated transporting his goods to Philadelphia markets and ports, and Thoburn advertised fabrics for sale in the Atlantic Coast's press. He specialized in indigo-blue dyes and other "American" printed calicoes. He also sold bedspreads and shawls "manufactured by John Thoburn & Co." and India cottons that he imported. His ads as well as the city directories noted his mercantile location on North Third Street in commercial Philadelphia but did not mention the mill location.[5] Surveys, therefore, are key in documenting the footprint of Thoburn's manufactory.

In 1813, Thoburn sold the Blockley property to woolen and cotton manufacturer Samuel Winpenny. Thoburn moved to a mill site further up the Schuylkill in Norristown. There he ran his machinery with the power of another creek, this one with "about sixteen or seventeen feet fall," and produced cotton cloth. Unfortunately, the Schuylkill Navigation Company (SNC) dam at Flat Rock flooded the site and reduced the creek water's fall to a mere twenty inches. Thoburn sued the SNC.[6] Chronicler Charles Hagner remarked wryly in 1869, "How Mr. Thoburn came out of this long litigation I do not know, but this I do know, that . . . his attorney, afterwards owned the mill and farm attached to it." In an ironic twist, the corporately controlled waterpower of the SNC made the waterpower of mill sites on tributary creeks "utterly useless."[7]

[4] On block calico printers' use of water-powered machinery, see "Calico Printing Factory," *Aurora General Advertiser*, May 16, 1799; Petition 73–1368, Blockley, 1848, Road Petitions.

[5] Robson, *Manufactories and Manufacturers*, 323; *Washington (DC) Expositor*, Nov. 19, 1808; *Poulson's American Daily Advertiser*, Apr. 12, 1809; Robert Sutcliff, *Travels in Some Parts of North America, in the years 1804, 1805 & 1806* (Philadelphia, 1812), 260; James Robinson, *The Philadelphia Directory, for 1808* ([Philadelphia,1808]); John Paxton, *The Philadelphia Directory and Register, for 1813* ([Philadelphia, 1813]).

[6] President, Managers and Company of the Schuylkill Navigation Company v. Thoburn, 7 Serg. & Rawle 411 (1821).

[7] West Park, Title Papers; Charles V. Hagner, *Early History of the Falls of Schuylkill, Manayunk, Schuylkill and Lehigh Navigation Companies, Fairmount Waterworks, etc*. (Philadelphia, 1869), 59–60. On Samuel Winpenny, see also Philip Scranton, *Proprietary Capitalism: The Textile Manufacture at Philadelphia, 1800–1875* (New York, 1983), 273–74.

On the Blockley site, meanwhile, subsequent owners enlarged the milldam and installed or added to the "water wheels, gearing and pipes."[8] In 1834, William Simpson purchased the establishment and printed silks and, in 1842, added calicoes. Two years later, Simpson expanded the works, and by 1869, when his sons took over, the property "comprise[d] some thirty distinct buildings, and . . . three large reservoirs, fed by a stream of the purest water."[9] The Simpson factory ran on steam power (though the water wheels were still in place at late as 1876), but water was essential for the boilers to produce that steam. Simpson used creek water as well for processing the cloth and for dousing any fires that might arise.[10]

In 1876 the Fairmount Park Commission purchased the Simpson print works and annexed the property to the West Park. The Simpsons agreed to leave for the park's use "pipes connecting the dams and leading therefrom into the Schuylkill River"; thus, the mill's reservoirs persisted.[11] A bucolic urge led 1938 mapmakers to identify them as the Upper and Lower Chamounix Lakes (taking the name from a nearby mansion). But the "lakes" and the creek that fed them soon met their demise with development of the Schuylkill Expressway.[12] If any pipes still remain, they are the only vestiges of the waterpower system that once fueled the site's manufacturing.

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[8] West Park, Title Papers.

[9] Robson, *Manufactories and Manufacturers*, 323–24.

[10] West Park, Title Papers; Robson, *Manufactories and Manufacturers*, 323–24. Simpson's substantial factory is depicted in a watercolor by David Kennedy at the Historical Society of Pennsylvania and by a Hexamer survey done probably in the 1860s. *Simpson's Mill, Falls of Schuylkill* (1834), David J. Kennedy Watercolors Collection (Collection V61), Historical Society of Pennsylvania, available at http://digitallibrary.hsp.org/index.php/Detail/Object/Show/idno/3106. Kennedy identifies the sketch as the "south side near the Falls county bridge, previous to locating the Reading Rail Road, Sketched in the spring of 1834 by J. Strong surveyor, and after him by D. J. Kennedy." The valley to the left of the mill suggests the outlet for the creek. *Wm. Simpson's Print Works, Falls of Schuylkill 21st Ward Phila.*, in *Hexamer General Surveys*, vol. 2 (Philadelphia, 1866), plate 148, Map Collection, Free Library of Philadelphia, available at http://www.philageohistory.org/rdic-images/view-image.cfm/HGSv2%2E0148; and *William Simpson and Sons, Washington Print Works*, in *Hexamer General Surveys*, vol. 10 (Philadelphia, 1875), plates 858–59, Map Collection, Free Library of Philadelphia, available at http://www.philageohistory.org/rdic-images/view-image.cfm/HGSv10%2E0858%2D859. This survey captures the terrain of the "Hills" around the mill.

[11] West Park, Title Papers.

[12] Works Project Administration, "Topographical Plan of Fairmount Park" (1938), Fairmount Park Historic Resource Archives, Philadelphia, PA, available at http://www.philageohistory.org/rdic-images/view-image.cfm/WPA1938.

Anthracite Country Reaches for the World, 1851

Joseph Conrad opens his 1898 novella, *Youth: A Narrative*, with the claim that the events he will relate "could have occurred nowhere but in England." This story recounts the ill-fated voyage of the fictional *Judea*, a rickety vessel carrying six hundred tons of coal from Newcastle to Bangkok in the mid-1870s whose cargo spontaneously combusts, engulfing the ship in flames. The circumstances of the voyage are indeed fittingly English, or, at least, British. The trade route followed by the *Judea* was a product of the British Empire. Britain was a maritime nation with the world's dominant navy and a globe-spanning merchant marine. And Britain was the world's preeminent exporter of coal and guarantor of the steam infrastructure that helped keep the globe linked together. It is a measure of Conrad's literary genius that he, a Pole born under a Russian czar, could author a story that so captured Britain at the height of its world power.[1]

Except, had a group of Pennsylvanian coal dealers a half century before had their way, the same story might have been a distinctly American one, as a series of letters and questionnaires preserved in navy records in the US National Archives reveals. This cache of documents records the correspondence between Benjamin Springer and Philadelphia-based engineers, steam-engine manufacturers, and mechanics in early 1851.[2] Springer, himself a coal dealer and former president of the Coal Mining Association of Schuylkill County's Board of Trade, had just been appointed to a new position in the US Navy. As the department's first "Anthracite Agent," he would supervise the navy's purchase of anthracite fuel. The existence of the agent position itself was a result of Springer's six years of lobbying Washington on behalf of Pennsylvania's anthracite industry to adopt this coal as the favored fuel for the navy's increasing number of ocean-going steam vessels.[3]

Since the mid-1840s, the US Navy had preferred Cumberland coal from western Maryland, a semibituminous fuel. This choice had resulted from a massive research study on coal combustion by the Philadelphia chemist and geologist Walter R. Johnson, who found anthracite burned

[1] Joseph Conrad, *Youth: A Narrative, and Two Other Stories* (Edinburgh, 1903), 1–8.

[2] The letters are found in box 707, XF 1841–1851, Record Group 45, US National Archives and Records Administration I, Washington, DC (hereafter RG 45, NARA I).

[3] "Report to the Coal Mining Association," *Hazard's Register of Pennsylvania*, May 17, 1834, 310–12; "Naval Contracts and Expenditures," H. Rep. No. 184, 35th Cong., 2nd sess., Feb. 24, 1859, 133.

efficiently in naval steam engines but not quite as efficiently as coal from Cumberland. Mustering their political resources around 1845, the anthracite dealers dispatched Benjamin Springer to Washington to persuade Congress and the navy to force the adoption of what they believed to be their superior (and more expensive) fuel.[4]

The broader context for Pennsylvania and Maryland's fight over naval coal contracts involved potentially vast export markets. Government contracts were nice—they paid well and aided domestic marketing purposes—but in tonnage they could only represent a relatively small share of the total coal trade. Not so for export markets. Both Maryland and Pennsylvania coal dealers knew that the coal American naval vessels carried around the world, and dispatched to foreign ports for refueling American steam vessels, effectively advertised their fuel across the industrializing world. Coal dealers in both states knew of the veritable explosion in coal exports from Britain—in fact, between 1830 and 1845 British coal exports had come to dominate international markets. In just fifteen years, British exports to Prussia increased by 1,214 percent; to the East Indies and Ceylon, 2,025 percent; to Denmark, 1,800 percent; and even to the coal-rich United States, 287 percent. By the mid-1840s, Britain exported nearly 650,000 tons of coal annually to France alone. Each of these statistics signaled potential markets that naval contracts could help them break into, or, ominously, potential markets that a failure to act would mean losing forever.[5]

Hence Springer's solicitation of Philadelphia engineers and manufacturers to help persuade the government to quietly subsidize their industry. Springer's letters queried about the coal preferences of merchant steamers northeast of Maryland, the difficulty of converting bituminous-burning steam engines to anthracite ones, the comparative ability of bituminous and anthracite coals to produce steam, and their relative risks of spontaneous combustion. Unsurprisingly, the responses that flowed back to Washington uniformly endorsed anthracite.[6]

[4] "Naval Contracts and Expenditures," 133; Walter R. Johnson, "A Report to the Navy Department of the United States on American Coals Applicable to Steam Navigation, and to Other Purposes," Senate Doc. 386, 28th Cong., 1st sess., Nov. 28, 1843.

[5] R. C. Taylor and S. S. Haldeman, *Statistics of Coal: Including Mineral Bituminous Substances Employed in Arts and Manufactures*, 2nd ed. (Philadelphia, 1855), 37–38.

[6] See, e.g., B. H. Springer to James Cooper, Feb. 18, 1851; B. H. Springer to Messrs. Merrick & Son, Jan. 21, 1851; Reaney, Neafie & Co. to Springer, Jan. 28, 1851; George W. Snyder to Springer, Feb. 14, 1851; Norris Brothers to Springer, Feb. 5, 1851; Richard C. Taylor to Springer, Feb. 14, 1851, box 707, XF 1841–1851, RG 45, NARA I.

By the end of the 1850s, Springer's efforts to boost Pennsylvania anthracite for the navy were successful, but the anthracite operators' bid for world markets was not. Springer helped inaugurate a new series of technical examinations that confirmed the value of anthracite fuel in marine steam engines. His work also helped prepare the commercial relationships that allowed the Union navy to fuel itself almost exclusively with anthracite during the American Civil War. Foreign markets, however, proved less susceptible—Britain's imperial and trade networks, along with its highly developed coal industry, kept British coal as the dominant global export fuel until World War I. Still, these letters, and the history they help illuminate, suggest the importance of understanding Pennsylvania's early history of fossil energy not merely from state or national perspectives, but global ones as well. Had Benjamin Springer succeeded as his supporters in anthracite country had hoped, the tale of a doomed coal ship might have been a distinctly American story and not an English one, and Pennsylvanian coal, not Pennsylvanian petroleum, might have made the United States a world power in energy for the first time.[7]

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[7] Charles Stuart, "A Report of the Engineer in Chief of the Navy, on the Comparative Value of Anthracite and Bituminous Coals," *Journal of the Franklin Institute* 24, 3rd ser., no. 4 (1852): 217–22; James Mason Hoppin, *Life of Andrew Hull Foote, Rear-Admiral United States Navy* (New York, 1874), 366; A. N. Smith to Gideon Welles, Oct. 1, 1863, and "E. & R. No. 8," in *Annual Report of Secretary of Navy*, House Exdoc. 1/15, 38th Cong., 1st sess., Dec. 7, 1863, 761, 769. On coal exports, see Gavin Wright, "Selected mineral fuels—imports and exports: 1867–2001," Table Db190–197 in *Historical Statistics of the United States, Earliest Times to the Present: Millennial Edition*, ed. Susan B. Carter et al. (New York, 2006), http://dx.doi.org/10.1017/ISBN-9780511132971.Db155-272; and "Fuel and Energy 7. Coal Exports," in *British Historical Statistics*, ed. B. R. Mitchell (New York, 1988), 256–67.

Roadside America and the Engine(s) of Progress

Along the rolling, bucolic stretch of I-78 between Allentown and Harrisburg, billboards entice travelers to exit at Shartlesville for "Roadside America: The World's Greatest Indoor Miniature Village." A local institution since 1953, this attraction features remarkably detailed, handcrafted, miniature scenes of American history, industry, and progress, arranged in a sweeping, eight-thousand-square-foot tabletop tableau.[1] The life's work of creator Laurence T. Gieringer, Roadside America, with its emphasis on models of regional landmarks and locales, serves as a multifaceted material-culture "text" through which to explore key relationships between energy sources and Pennsylvania's lived history.

Gieringer, a native of Reading, was born in 1893, the first son of Anna and Charles H. Gieringer. Charles, a harness maker by trade, had the distinction of owning the first automobile in the area, a three-wheeled vehicle he drove from Connecticut to Reading in an overland trip that took just over twenty-two days.[2] Years later, Laurence would relate the indelible impression left on him by his father's journey and the dawn of automobile travel in a how-to article on building model gas stations.[3] This intersection of model making and energy, especially as it relates to transportation, was established early in Gieringer's life and fully realized in the vivid and kinetic model landscape he created.

Inspired by a boyhood ambition to re-create local landmarks in miniature form, the attraction is designed so that the visitor encounters discrete periods of Pennsylvanian and national history on a single plane, creating a patchwork quilt of Americana past and present. Guests walk around the model, their tours guided by the complimentary brochure that draws attention to scenes of note from the dawn of the republic to the "modern" (circa 1960) era. Signs ringing the model invite visitors to push buttons activating vignettes within the scenes: two frontiersmen saw a log, circus performers parade in their camp, a hot-air balloon soars high over a

[1] Peter George, "Roadside America: An Institution along Route 78," *Village Chronicle*, n.d., 56, clipping courtesy of Dolores Heinsohn personal archive. Though the current location of Roadside America in Shartlesville dates to 1953, the model has long been a regional sensation, being publicly exhibited in one form or another since 1935.

[2] Don Ambrose Agius, *The Story of Laurence T. Gieringer and His Roadside America* (Kutztown, PA, 1961), 18–19.

[3] Laurence Gieringer, "A Gas Station," *Model Builder*, Sept. 1946, 17–19.

baseball diamond as crowds cheer in the bleachers. This vibrant tapestry is interwoven with tableaux illustrating numerous uses and sources of energy in the development of American industry, travel, and communications technologies. While scenes of early frontier settlements show the use of water-, horse-, and manpower, it is in the richly detailed depictions of the coal, petroleum, and electricity industries that Roadside America shines—literally.

Particularly striking is the scale model, "sponsored" by the Reading Iron Works, of the Philadelphia and Reading Anthracite Colliery.[4] This marvelous miniature features a cross section of the mine's tunnels as well as a replica of the Locust Point coal breaker, which was, at the time of the model's construction, the largest of its kind in the world. The rail yard abutting the coal works emphasizes the interconnectedness of the coal industry in Pennsylvania with the country at large, as tiny cars wait to be filled with the extracted anthracite and race across tracks spanning the length and breadth of the model. Likewise, the oil refinery model harks back to the dawn of the American petroleum industry at the Drake Well in Titusville. The miniature Esso filling station with automobiles lining up at its pumps, located in the downtown section of the village of "Fairfield," illustrates the connection between the fuel and its uses.

In Roadside America, electricity is presented as a marker of modernity and progress. The miniature power plant, touted in the tour brochure as having "every brick . . . handcarved in complete detail," is situated at the center of the display, from which it appears to provide the energy to power the brightly lit movie theatre marquee in Fairfield as well as the interior lights of the village's residential and commercial districts.[5] This illumination is brilliantly displayed during the "Night Pageant" that occurs every twenty minutes, in which the lights in the room housing the model are dimmed in a simulated sunset. As Kate Smith's "God Bless America" plays over the public address system and pictures of Jesus, angels, and patriotic scenes project onto a back wall near a fluttering American flag, the sections of the model representing modern America blaze brightly while colonial and pioneer scenes fall into darkness.

The dynamic models of Laurence T. Gieringer's Roadside America vividly depict energy development and its numerous manifestations

[4] Agius, *Story of Laurence T. Gieringer*, 77.

[5] Roadside America, Inc., *Pennsylvania's Roadside America Incorporated: The World's Greatest Indoor Miniature Village*, n.d.

throughout central Pennsylvania's history. The interconnectedness of energy and history is perhaps nowhere better illustrated than in the model trains that crisscross the model. Steam, electric, and diesel engines share the same tracks, racing through towns whose streets teem alternately with horse-drawn wagons and automobiles, telegraph wires and telephone poles. These anachronistic juxtapositions underscore the technological development enabled by harnessing these energy sources while connecting such innovations to the land and people from which they derived.

This optimistic depiction of energy development and applications is due in part to the particular moment in history captured by the landscape of the attraction. After Gieringer's death in 1963, no additional models were added to the display, making the attraction a virtual time capsule of midcentury America. Thus, an unambiguous narrative of progress is not complicated by more recent developments, such as the disasters at Centralia and Three Mile Island or controversy surrounding the fracking of the Marcellus Shale. Likewise, the unintended consequences of transportation fuel innovations are, literally, outside the borders of the display; the America of Roadside America is absent suburban sprawl, deforestation, or mountaintop removal mining. Gieringer's America is one of innovation and potential—a tableau of a promise that had yet to be broken.

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