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Abstract
Five miles from the shore of Mashpee, Cape Cod, rays of sun reflect off the rolling ocean back into the Massachusetts atmosphere. A powerful and quiet 25-knot wind ripples the small waves over Horseshoe Shoal, home to Nantucket Sound's most valuable wind resource site. For over 10 years, a battle has been waged by Cape Wind, a private company under New England energy developers Energy Management Inc., over the construction of America's first offshore wind farm on these waters. Strict environmental permitting, objections from individuals concerned about sound and visual pollution, and difficult financial conditions have each played a major role in preventing construction from getting under way.

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Introduction

Five miles from the shore of Mashpee, Cape Cod, rays of sun reflect off the rolling ocean back into the Massachusetts atmosphere. A powerful and quiet 25-knot wind ripples the small waves over Horseshoe Shoal, home to Nantucket Sound's most valuable wind resource site. For over 10 years, a battle has been waged by Cape Wind, a private company under New England energy developers Energy Management Inc., over the construction of America's first offshore wind farm on these waters. Strict environmental permitting, objections from individuals concerned about sound and visual pollution, and difficult financial conditions have each played a major role in preventing construction from getting under way.

As the shallow waters of Horseshoe Shoal remain untouched by wind developers, the energy crisis in the United States has worsened. The U.S. Energy Information Administration estimates from 2003 predicted that, at current consumption rates, coal reserves would last another 250 years, oil another 10 years, and natural gas just 9 more years.[1] While these numbers accounted for U.S proven reserves and did not account for imports (America imports over half of its oil) and new discoveries, the sense of urgency endures: Currently, 44.9% of electricity in the U.S. comes from coal and 23.4% from natural gas. Even with anticipated gains in efficiency and reduction, the nation's need for renewable energy development is growing.

Given the U.S.'s current reliance on imported and domestic fossil fuels, expansion of renewable energy projects has been a priority across industries. In particular, solar energy has benefitted from

[1] Roger A. Hinrichs and Merlin Kleinbach, *Energy: Its Use and the Environment*, fourth edition. Toronto: Thomson Books, 2006, 15.

substantial government rebate programs, private financing and investment, and its “off-the-grid” capabilities. Transportation technologies, ranging from plug-in hybrids to fuel cell systems, have gained momentum from stricter emissions and fuel efficiency standards as well as cultural inertia from automakers’ marketing campaigns and the growing sustainability movement. Solar and transportation technologies are currently benefitting from technological momentum that closely parallels the forces that led to the construction of sociotechnical systems around coal and natural gas-fired electricity generation systems. Many of the innovative institutions, social conditions, and technologies that arose around coal-fired generation are applicable to these technologies, yet do not drive the integration of wind power into the American energy landscape.

Histories of these other sources have provided valuable insight into America’s dependence on fossil fuels for energy production. These studies provide a baseline structure for creating a history of wind power. As authors like Thomas P. Hughes, David Nye, and Louis Hunter have shown, key economic and sociocultural factors exacerbated the spread of electricity across the United States, elements of technological innovation that wind power has yet to harness. Situating wind power in a broader energy history fundamentally challenges traditional theories of technological change.

I. Building the Sociotechnical System

The timing of America’s electrification is as important to the contemporary energy discussion as any issue presented by environmentalists, industry CEOs, or U.S. politicians. During the 1800s, America was undergoing a monumental change in the ways work was done, the home was managed, people interacted, and business was conducted. Industrialization created expectations—expectations that Americans were now mobile, connected, and, at least in the workplace, efficient. While many of these notions took a century of inventions and infrastructure to truly take hold—for example, the progression from telegrams to telegraphs to telephones and its impact on interpersonal and business communications—a system of electricity production *did* seem to spring up “overnight.” While many theories posit that the convergence of technological knowledge, political conditions for expansion, and America’s abundance of coal were preexisting factors ensuring successful electrification, historians like Thomas P. Hughes point to “technological momentum” in explaining the rise of coal-powered electricity generation. Hughes views electrification as a convergence of factors: “Men and institutions developed characteristics that suited them to the characteristics of the technology. And the systematic interaction of men, ideas, and institutions, both technical and nontechnical, led to the development of a supersystem—

a sociotechnical one—with mass movement and direction. An apt metaphor for this movement is 'momentum.'"[2]

The electrical network that formed in the U.S. during the late 19th and early 20th century required supporting infrastructure, both in physical construction of power lines and generation plants as well as institutions to facilitate the operations. The expansion of education in energy engineering—developing schools and programs producing innovative findings in the science of electricity generation and transmission—was tied directly to the rise of fossil fuel electricity production in the U.S. Engineers and scientists became cogs in a new system that commodified power in an unprecedented way, carrying coal-fired power generation to full fruition. As Hughes notes, the system's construction relied heavily on a merger of interests: "The professors teaching the courses may be regular consultants of utilities and electrical manufacturing firms; the alumni of the engineering schools may have become engineers and managers in the firms; and managers and engineers from the firm may sit on the governing boards of engineering schools."[3] Invested stakeholders, then, were at the helm of a system that would change U.S. manufacturing and home life, and impel society towards a "consumer culture" that fueled the development of coal-fired electricity generation.

Perhaps the best example of how education, science, and politics converge to create technological momentum was the creation and implementation of the Rural Electrification Act. Engineer Morris Cooke had been drafting ideas and plans for rural electrification of the U.S. during his time in the offices of Pennsylvania mayors and governors in the 1920s, applying technical knowledge gained at Lehigh University in 1895. However, it was not until Cooke applied the methods of scientific management that his plan took off.[4] Scientific management is the application of scientific methods—observation, data collection, and technical interventions, for example—to the administration of a project or occupation. This form of management was growing in industrial America, largely due to the work of Frederick Taylor, also an engineer, who became a consultant to many large industries and promoted industrial efficiency.[5] The spread of Taylor's ideas into industry helped Cooke navigate the complex economic and logistical task of providing power to rural communities and expand a consumer culture that was previously confined to cities. Cooke was appointed the administrator of the Rural Electrification Administration under Franklin Delano Roosevelt in 1935. He effectively leveraged the

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[2] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930*. Baltimore: Johns Hopkins University Press, 1983, p.140.

[3] Thomas P. Hughes, "The Evolution of Large Technological Systems," in *The Political Economy of Science, Technology, and Innovation*, ed. Ben Martin and Paul Nightingale. Northampton, MA: Edward Elgar, 2000, p. 288.

[4] Hindy Lauer-Schachter, *Frederick Taylor and the Public Administration Community: A Reevaluation.* Albany: State University of New York Press, 1989, 75-78.

[5] Lauer-Schachter, *Frederick Taylor,* 80-90.

industrial movement of scientific management to create a technical plan for government implementation, brining coal-fired electricity to millions of farms and homes by the middle of the 20th century.[6]

The growth of the sociotechnical system around coal-fired electricity generation gave key actors control over how electricity was produced and distributed. In particular, the connection of actors and interests in education, politics, and the private sector gave way to "large, centralized" generation sources—companies that were largely vertically integrated, owning mines, generating equipment, transmission lines, and other infrastructural technologies associated with large-scale electricity distribution.[7]

II. Coal and Wind: Commodification

With the growth of a sociotechnical system around urban and rural electricity transmission, coal became an input to a vital and profitable process, which led to the rise of scale economies and economic instruments for its sale and trade. Today, the global economy is heavily influenced by fossil fuel prices and their direction, attesting to coal-fired electricity generation's seamless integration into the American economic and social structure.[8] Coal's weight can be calculated, ownership of mines is definable by land and property rights, it can be transported by boat, rail, or truck, and the costs of mining and transporting are related to the efficiency of related technologies.

The same cannot be said for commodifying wind. Because wind is a natural (and invisible) force, predicted only by changing patterns and forecasts, building a sociotechnical system around it has proved difficult. Companies innovate based on technologies to harness the wind, such as turbines and windmills, yet cannot sell and trade the source itself because ownership is limited to the use of the land. The industry has less of a propensity for vertical integration, which was a vital outcome of coal commodification and key to its success as a source of electricity generation.

The geographical "problems" of wind turbines' visibility and land consumption are consistent reasons for objections to wind farms and widespread implementation of wind power. Turbines are said to "interfere with the value of open space," an argument that pits both environmentalists and pro-coal

[6] Hughes, *Networks of Power,* 145.
[7] Louis C. Hunter and Lynwood Bryant, *A History of Industrial Power in the U.S., 1780–1930: Vol. 3: The Transmission of Power*. Boston: The MIT Press, 1991, 148-152.
[8] Martin V. Melosi, *Coping with Abundance: Energy and Environment in Industrial America 1820–1980*. Philadelphia: Temple University Press, 1985, 130-210.

individuals against wind development.[9] The "visual pollution" argument against wind energy and turbine construction is also deeply entrenched in the broader energy history of the U.S. The establishment of high-voltage transmission lines—the first of which was built by American Gas & Electric in 1917—allowed cities to be powered by large plants located on the edge of town, often near rivers, rail stations, or, in many early cases, at the site of the coal mine.[10] This placed the energy source out of the sight of the end user; a switch is flipped, a button is pushed, a television is plugged in, and no connection is made between the individual and the source itself. After two centuries of using electricity blindly—paying an electric bill once a month and having light and energy "on demand"—Americans have created an obstacle to meeting energy demand through highly visible technological advancements.

III. Restoring the "Mystique" of Energy

Fossil fuels benefitted from the "mystique" surrounding the conversion of solids and liquids to heat, light, and, finally, useable energy, especially prior to increased environmental analysis of energy production. This phenomenon spread with rural electrification—electricity was a relatively new concept even in the early 20th century, as consumer electronics flooded the market only after industrial and commercial operations had enhanced technologies and transmission capability. The "computing revolution" and other energy-intensive changes were largely confined to commerce, industry, and transport. As Regina Lee Blaszczyk explains, during this time, electricity was reflected in American culture as "white magic," one that would lead to a futuristic "electrical utopia."[11] In addition to this interpretation of electricity generation, coal and its capacities produced new thoughts about time and space—railroads moved Americans vast distances in short periods of time, powered factories that mechanized labor and maximized production, and illuminated houses and streets at the flip of a switch. From the opening of Thomas Edison's first commercial electric plant in 1882 to the spread of transmission lines during the 1936 Rural Electrification Act and onwards, Americans had become fascinated with the possibilities that lie within the chemical compounds of fossil fuels.[12]

The sociotechnical system built around renewable energy sources is both newer and much different than that built around fossil fuels. Renewable energy sources have always occupied a unique and complex position in the American energy system. The very term "renewable" has been the subject

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[9] Martin J. Pasqualetti, "Morality, Space, and the Power of Wind-Energy Landscapes," *Geographical Review* 90, no. 3 (July 2000).
[10] Hunter and Bryant, *The Transmission of Power*, 148-215.
[11] Regina Lee Blaszczyk, *American Consumer Society, 1865–2005: From Hearth to HDT*. Wheeling, WV: Harlan Davidson, 2009, 139.
[12] Hughes, *Networks of Power*, 201.

of numerous debates in political, technical, and social arenas; for the purposes of this historical analysis, two sources will be considered "renewables"—hydroelectric power and wind power. Hydropower presents interesting parallels to wind energy production, especially in terms of societal perception and how humans have developed a relationship to energy sources.

While environmental historians and historians of technology have elucidated the role of coal's "mystique" in strengthening the current electricity supply's sociotechnical system, many have also theorized about a similar connection to renewable sources. Perhaps the most compelling example of this is Richard White's description of the Columbia River in *The Organic Machine.* White's historical narrative profiles the changing community built around the river and its hydroelectric dam. While White devotes a considerable portion of the text to detailing the impacts of dams and fisheries on the river itself, his most meaningful points reach beyond the intricacies and particularities of harnessing the Columbia for energy and livelihood. He theorizes that humans have come to know nature through "work," in both the practical and scientific senses of the word—a relationship that continually changes with the conditions of the environment and society. The result is the view of the river as an "organic machine," one that harnesses natural moving forces for the increased productivity and sustainability of human life. White defines the role of humans in a system of energy, work, and technology, he reveals how harnessing natural sources alters the state of both human society and the surrounding environment.[13] The social, cultural, and practical effects of this particular dam are minuscule in comparison with the changes introduced by the coal-powered system of industrialization and electrification; however, White's ideas help to frame wind power as a similar "organic machine" that has its own set of impacts and possibilities.

Conclusion

Renewing the natural connection to energy sources may prove vital in overcoming the historically difficult process of building a sociotechnical system. As wind technology progresses and becomes more adaptable to the American way of life, maintaining the view of wind as an "organic machine"—one that both shapes and is shaped by society—leads to new understanding of the U.S. energy landscape. By using land, economic and educational institutions, and political power to develop the necessary technological "artifacts" needed to harness the wind, Americans have the opportunity to reorient themselves in their relationship to nature. Rather than obscuring sources of energy, converting

[13] Richard White, *The Organic Machine: The Remaking of the Columbia River*. New York: Hill and Wang, 1996.

fossil fuels into damaging greenhouse gases, and expanding the "consumer culture" that coal-fired electricity has influenced, turbines reestablish the connection to the source. Broader energy history reminds us that technological momentum can threaten our ability to control outcomes in a technologically advanced society, but that it can also be harnessed to promote new systems with favorable developmental results.

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