CHAPTER 6

ENERGY, UTOPIA, AND THE AMERICAN MIND

> Between the dynamo in the gallery of machines and the engine-house outside, the break in continuity amounted to abysmal fracture of a historian's objects. No more relation could he discover between the steam and the electric current than between the Cross and the cathedral.
>
> **Henry Adams**

In his classic 1964 work, *The Machine in the Garden*, historian Leo Marx observes that mechanization gradually became part of the pastoral image of America as the public imagination was captivated by technologies that represented progress. Marx's hypothesis came from his analysis of literature and art, and he pointed out that even Emerson wrote that "Machinery and Transcendentalism agree well."[1] Four years later, in *Wilderness and the American Mind*, Roderick Nash took a similar approach regarding the social construction of wilderness with his well-known line claiming that the wilderness was made by "the literary gentlemen wielding a pen, not the pioneer with his axe."[2] Similar to Marx's characterizations of mechanization and Nash's ideas about wilderness, modern attitudes toward energy in general, and electricity in particular, were formed in the last two decades of the nineteenth century through the influence of public events, in the press, and in literature. Just as ideas about race, gender, and disabilities are social constructions, so are perceptions of energy.

Attitudes about electricity began to form with Americans' first exposure to electrical technologies. As a nebulous, invisible energy source that society found hard to define, the abstraction of electricity began with the invention of the telegraph in 1848, accelerated after the world's fair of 1876, and shifted again between 1882 and 1900. In the last two decades of the century, the perception of electricity changed from a mysterious entity to a utopian energy source. The public began to see the systems and technologies on display at the fair in 1876 as solutions to problems associated with energy derived from old-world fire and smoke. The attitudinal shift that occurred was due both to advances in electrification technology itself and to cultural influences derived from events, press coverage, and literature. Technologically, the adoption of alternating current, the electrical technologies on display at the Chicago World's Fair in 1893, and the much-anticipated opening of the Niagara Falls generating station in 1895 deeply affected public attitudes. Culturally, press coverage of these events, along with positive portrayals in the popular genre of utopian literature, depicted electricity as a panacea—an unlimited, progressive power source with no deleterious consequences. The first stage of energy abstraction occurred with electricity's midcentury American debut; the next stage emerged after 1882, as technological advancement drove more practical applications and allowed for greater space between generation and consumption.

As successful as Thomas Edison's Pearl Street Station was at delivering on his promise to illuminate parts of midtown in 1882, the inherent flaw in his direct current system remained. To provide power to all of Manhattan, or any other large city, a plant would have to be placed every few miles to transmit power to the businesses and residences that wished to consume it. Edison's original plan included thirty-six independent coal-burning power stations to supply power to central New York City alone.[3] Recognizing this weakness in Edison's direct current system, George Westinghouse aggressively pursued alternating current after his engineers implemented the technology in 1886. Westinghouse's strategy was not without risk: the original alternating current power was single phase, which had some technical limitations, and there was no electric motor yet perfected that would run on alternating current power.

Two years prior to Westinghouse's successful pilot project in Great Barrington, the Serbian inventor Nikola Tesla had moved to New York to take a job with Edison. Tesla had worked for an Edison affiliate in France and was recommended to Edison by a colleague, Charles Batchelor. As a young engineer in Budapest, Tesla had experimented with and developed concepts for a polyphase alternating current system, including an electric motor and an efficient generating system, but Edison, who had invested money and pride in his direct current systems, would not consider any of Tesla's ideas regarding the superiority of alternating current. Assigned to work on improving Edison's "Jumbo" direct current generators, Tesla lasted six months in his contentious employment under Edison. After working for a year as a ditch digger in New York, Tesla met Charles F. Peck and Alfred S. Brown, two investors who were interested in electricity as a business, who assisted him in setting up the Tesla Electric Company in 1887.[4] Peck and Brown were interested not just in electricity but in energy in a broader sense, including geothermal energy from the ocean.[5] While working on several alternative energy projects for Peck and Brown, Tesla perfected his "Electro Magnetic Motor," which he patented in May 1888 along with three other inventions for the transmission of alternating current electrical power.[6] In July, Tesla, Peck, and Brown sold their patent portfolio to Westinghouse, who was ready to move forward with larger distribution systems and the deployment of alternating current power.

The Westinghouse/Tesla partnership was key in the development of the modern electrical grid, but not without an initial struggle with Edison, who tried to discredit alternating current technology. The "battle of the currents" between Edison and Tesla has been written about at length in both histories of technology and studies of public relations. An overview of the controversy begins with Edison's market share in the deployment of direct-current-generating installations across the country being threatened by the Westinghouse alternating current system, and Edison fighting back with a negative public relations campaign that attempted to paint alternating current technology as dangerous. Edison's smear campaign went as far as lobbying the state of New York to accept electrocution as a method of capital punishment, using the Westinghouse system. A colleague of Edison's, Harold P. Brown, convinced state authorities in New York in 1889 that it would be a humane method of death. Both Brown and Edison testified in Cayuga County Court that the current was so lethal that death would be instant.[7] Edison had already publicly electrocuted horses, dogs, and an elephant to demonstrate the negatives of alternating current, yet the Westinghouse interests argued correctly that direct current power at the same voltage and amperage would be lethal as well. In public, the battle between Edison and Westinghouse played out in the press, with Edison arguing in the *North American Review* that his system was absolutely safe and that the alternating current system of Westinghouse was deadly.[8] Edison did have his own credibility on his side, and his direct current system as deployed *was* fundamentally safer than the Westinghouse alternating current system. The Edison system in Manhattan was referred to at the time as a "low tension" system, which meant it was low voltage, transmitted at less than two hundred volts—shocking, for sure, but not instantly lethal. Alternating current systems, however, including those of Brush, Westinghouse, and all other arc light businesses, were normally transmitted at over a thousand volts, which, while not necessarily lethal, would cause visible effects such as burning, arcing, and other injurious manifestations. While Edison and Brown spun the issue to be over the merits of alternating current versus direct current, it was more a debate over high-voltage versus low-voltage as well as variances in amperage. In addition to Edison's credibility as an influential factor in the debate, there had been a number of accidental electrocutions of line workers in the 1880s, and since all alternating current systems used overhead wires, these were often public spectacles where electricity suddenly became nonabstract and quite salient.[9] Between Edison's credibility and a well-orchestrated public relations campaign by Westinghouse's competitors, the New York prison system decided that alternating current power, deemed the "executioner's current" by Brown, would be an instant and humane method of capital punishment.[10] On August 6, 1890, the first execution in an electric chair, of convicted murderer William Kemmler, was anything but instant or humane. The *New York Times* headline, "Far Worse than Hanging," needed no explanation.[11]

While this episode has been framed by historians as an illustration of Edison's mercurial personality as well as a story of the struggle between emerging standards, it is perhaps more relevant in the study of how the public came to view electricity. Americans' acceptance of electricity was not without setbacks. The "wire panic" in New York City occurred when several horrendous accidental electrocutions of workers led to a brief period of technological pessimism in 1889.[12] Regardless of these incidents, however, the public came to accept electricity as a beneficial and abstract technology—horrendous death was possible with any technology, from railroads to industrial accidents—but the sensational accounts of accidental or irresponsible death did not faze the public's perception. Less than three months after Kemmler's execution, the *Electrical Engineer* reported that the Westinghouse Electric and Manufacturing Company would have the best year it had ever had, with new installations of alternating current systems in more than ten cities.[13] In 1893, twenty-seven million Americans traveled to Chicago to marvel at the lights of the Columbian Exposition world's fair—powered by alternating current technology.[14] The Kemmler episode and the well-publicized accidental electrocutions in New York demonstrated that the public's confidence in electricity was not easily swayed. Despite Edison's best efforts to discredit Westinghouse, the inherent disadvantages of Edison's system, primarily in its inability to transmit power efficiently at distances more than about a mile, worked in Westinghouse's favor.

Between 1887 and 1890, the Westinghouse Company continued to compete with Edison's direct current systems, and despite financial difficulties due to rapid expansion, alternating current systems slowly began to take market share. In 1887, Westinghouse systems supplied power for 134,000 incandescent lamps; by 1890 the number had grown to half a million, with 300 central stations producing power.[15] By the end of 1890 alternating current systems were gaining preference and the Edison Company was losing money. In his December 1890 essay published by the *North American Review*, Westinghouse succinctly explained the benefits of the alternating current system and the deficiencies of direct current, pointing out that alternating current was preferred by a five-to-one margin.[16] Edison General Electric stock plummeted. Edison's investors, including J. P. Morgan and Anthony Drexel, had already merged several of Edison's companies into the Edison General Electric company in 1889, and although the company was still pushing direct current, management was demanding that Edison work on a competing alternating current system. By 1892 Morgan merged Edison General Electric with another, more profitable competitor, Thomson-Houston, changed the name of the new company to General Electric, and forced Edison out as a principal. Edison owned stock in General Electric, but was no longer active in the company. Commenting to the *New York Times*, Edison said, "I cannot waste my time over electric lighting matters, for they are old. I ceased to worry about these things ten years ago."[17] While Edison's departure from General Electric was a significant step in the demise of direct current power, two other events that transpired afterward marked the final blow, one being Westinghouse's winning bid to provide lighting for the Columbian Exposition in Chicago in 1893 and the other being the decision by the developers of the Niagara Falls generating station to use Westinghouse/Tesla technology.

If the Corliss engine was the heart of the world's fair in Philadelphia in 1876, then the electric light was at the center of the fair in Chicago in 1893. If Philadelphia represented the beginning of a process of technological abstraction, where power generation and consumption were first separated by emerging technical systems, then Chicago represented a new level of technological fantasy, in which a white city and white lights eclipsed the realities of burning coal. Historian Robert Rydell's assessment, that the "effort by America's leaders to define social reality reached a new level of sophistication with the Chicago World's Columbian Exposition of 1893" is telling, because electrical power was featured and was squarely at the center of the definition of what an ideal society should be.[18] Organized to celebrate the four hundredth anniversary of Christopher Columbus's landfall in the New World, the Chicago planners were determined to outdo anything that had come before. Covering an area of 633 acres, the fairground site was at Jackson Park, where architects Daniel H. Burnham and John W. Root designed the fair's neoclassical buildings. Painted in white, the compound became commonly known as the White City. The fair's opening on May 1, 1893, was initiated by President Grover Cleveland, who, after a speech, pressed a button that started an Allis steam engine, much like the opening of the fair of 1876 when President Grant had started the giant Corliss steam engine. Setting the Columbian Exposition apart from Philadelphia, the *Chicago Tribune* said of the fair's opening:

> This dramatic ceremony will bear little resemblance to the touching of the button by President Grant at the opening of the Centennial Exhibition at Philadelphia. In the first place, though it was popularly believed at the time that by this act he started up the Corliss engine, it is now reported that he only rang a signal bell, and that the engineer opened the throttle by hand. In the second place, the Corliss engine furnished all the power and operated all of the equipment in the Centennial Exhibition, while the Allis engine, though much larger than the Corliss, does not furnish more than one-twentieth of the power required in the World's Columbian Exposition.[19]

Here, the reporter made an effort to outdo the past, and in the context of technology. The article borders on ridiculing the nonautomated world of the past. Not only was Grant's engine starting flawed, but once the Corliss did start, it paled in comparison to the new two-thousand-horsepower Allis-Corliss engine in Chicago—and even though it was bigger, the Allis still was not big enough to supply the power for the fair, its function being only to run a pump for the water fountains as well as two dynamos that could power twenty thousand lightbulbs near the fountains.[20] Philadelphia here is framed as old steam, and Chicago as new and electric. Rydell describes the fairs in terms of "symbolic universes," and as such, the symbolism at Chicago was one of progress, power, and electricity intertwined.[21]

While the *Tribune* reporter highlighted the Allis-Corliss engine at the center of the building known as the Palace of Mechanical Arts (commonly referred to as the machinery building), the article leaves out the real heft driving the fair. The main power plant, removed from the primary exhibit hall, covered a space one hundred feet wide and one thousand feet long and housed seventy-seven engines, nine of which were devoted to turning generators that produced electricity to run up to 120,000 Westinghouse-provided lights.[22] The biggest engine was an E. P. Allis quadruple expansion condensing steam engine capable of generating three thousand horsepower. Another twenty-three engines drove smaller generators to power outdoor arc lighting. In 1893, journalist John Patrick Barrett wrote of "dynamos of all conceivable kinds . . . which were divided into two classes, those producing direct or continuous current and those generating alternating currents. Late advances made in electrical science permit the use of either kind for the same purposes, but for the utilization of electrical energy at any conceivable distance from the source of power, the alternating current system possesses advantages of flexibility that make its use imperative."[23] Barrett's comments, reinforced by others, not only highlight the promise of transporting energy over great distances but also speak to the flexibility and advantages of electricity—and deservedly so. Just seventeen years after Philadelphia, the Chicago fair featured tens of thousands of lights, numerous electric motors, a complete fair telephone exchange, fire and police alarm technologies, grand visual displays, the Edison "Tower of Light," and thirty-eight thousand colored arc lights shining over rising and falling jets of water in the center pavilion.[24] The Westinghouse display, along with a number of novelty lights, featured a likeness of Christopher Columbus outlined with small incandescent bulbs.[25] The White City had arrived, and it was progressive, modern, and above all else, electric.

The official attendance at the fair in 1893 was approximately 40 percent of the US population at the time.[26] The White City was a harbinger of modernity for rural and urban visitors alike, with electricity at its center. Journalist Teresa Dean wrote in her diary that she heard a man say, "I tell everyone in my town that they must come to the Fair. And if they can't get the money to come any other way, they better knock a man down gently and take his money, and then after they return from the Exposition, go to work and pay back in installments the man they've robbed."[27] Writer Hamlin Garland famously wrote to his parents, "Sell the cook stove if necessary and come, you must see this fair."[28] The *Chicago Record* reported that a woman from Texas named Mrs. Lucille Rodney walked from Galveston on railroad ties, a distance of thirteen hundred miles, to get to Chicago.[29] The *Chicago Daily Tribune* reported on the opening of the Electricity Building at the fair as "overpowering in its magnificence, rivaling nature in the variety of her wealth and color."[30] Poet Daniel Oscar Loy, struck by the building's luminescence, wrote:

> In the Electric Building
> I tarried for an hour,
> Learning all there is to learn
> About electric power.
> I heard Thomas Edison
> Speaking of his latest light,
> Which is as bright as the sun
> Making day out of night.[31]

The *Rock Island Daily Argus* reported that the fair was "the climax in electricity's upward march through the nineteenth century,"[32] while the *Bismarck Weekly Tribune* declared the 1,250,000 candlepower of lighting as "so complete and extensive" that it was "well worth the journey to see."[33] Ralph Pope, secretary of the American Institute of Electrical Engineers at the time, mentioned that faith in electricity was all-consuming, that "people have got an idea that electricity can do anything."[34] Dean noted that "in the Electricity Building, which was brilliantly lighted . . . we went there and stood looking at the electric picture of Columbus."[35] A correspondent with the *Omaha Daily Bee* reported on housewives who saw electric ovens "without the semblance of a spark or fire," and "little wires that run to irons for laundry purposes."[36] Just three years after

Edison's attempt to discredit alternating current technology with the Kemmler execution and various scares over wires and electrocution, in Chicago and around the country, the public had come to embrace electric power.

While the public face of technology had changed between 1876 and 1893, behind the scenes the fundamentals were familiar. Far removed from the dynamos and the power plant was an iron structure that housed over forty immense boilers that supplied steam for all of the engines, including those that ran the dynamos in the power plant. The steam, born of immense boilers and transported underground, was ultimately created by oil-burning fire, produced in the fire-room nine feet below the boilers.[37] The oil that produced the heat, which made the steam that drove the engines and dynamos, ultimately resulting in displays of clean electricity, was pumped to the fire room from storage tanks a half mile away.[38] The fuel oil itself was likely Ohio oil, refined in Whiting, Indiana, where John Rockefeller's Standard Oil Company had recently completed a refinery to serve the Chicago market.[39] One contemporary report boasted that "there is no smoke, dust, or dirt as there would be if coal were burned."[40] Reinforcing the imperative that the White City—a symbolic universe—must be free of smoke, a sophisticated system was installed that included an "inspector of smoke," who was stationed in a cabin near the main oil valves yet in view of the fire-room chimneys. In the case of a chimney emitting smoke, the inspector could push a button—one for each set of boilers—that would vibrate a gong near the specific boiler, which then would alert the fireman to attend to his fires, regulating the oil flow to reduce the smoke. Considering that those observing the exhibits saw only clean white lights and quiet electric motors, the operation behind the scenes was abstraction realized, a technological sleight of hand that obscured energy generation from consumption, thus reinforcing inconsequentiality. Even at its point of creation, electricity is shrouded as a secondary source of energy. Electricity's journey begins once it has been removed from the forces that ultimately create it, as dynamos must always be turned by other energy forms. It is here that the direct line back to the primary energy source quickly starts to blur. For the public, the electrical technologies represented modernity and progress. Electricity came from dynamos—not from the oil fields of western Ohio, and not from the fires beneath the boiler room.

Cutting through the celebratory rhetoric and the complexity of the hidden infrastructure, there were a few dissenting voices. Henry Adams, historian and great-grandson to John Adams, had been fascinated with electricity and wrote regarding the Chicago fair in 1893 and the Paris exposition of 1900 that electricity was "but an ingenious channel for conveying somewhere the heat latent in a few tons of coal hidden in a dirty engine house kept carefully out of sight."[41] Whether or not Adams's ambivalence toward technology was the antimodernist rant of a "displaced patrician" has been debated, and although he stood mostly alone in his skepticism over electricity, he did keenly observe the problem.[42] Adams's "dirty engine house kept carefully out of sight" came to define electrification in the United States in the forthcoming century. The ideal city, as embodied in the White City of Chicago, moved the engine house away from the lights, buried the fires in the ground, and posted smoke spotters to make sure any mischief exiting the chimneys was quickly reined in. Beneath it all was the paradigm of steam, but soon this too changed.

Winning the contract to supply the lighting and power for the world's fair in Chicago vindicated Tesla's technical foresight and Westinghouse's vision for the future of electrical transmission. But while the alternating current systems in place at Chicago might have captured the imagination of the American public, signaling that the age of electricity had arrived, the promise of unlimited electric power from Niagara Falls left a larger legacy.[43] The promise of Niagara Falls as a source of electrical power generation had been talked about since the early 1880s. Although no practical plans for large-scale generating stations were in the works until 1886, some were already speculating that Niagara could supply enough electricity for all of North America. In an article published by the *Chicago Daily Tribune* in June 1881, Sir William Thomson, now Lord Kelvin, conjectured that "Niagara [was] the natural and proper chief motor for the whole of the North American Continent; and it now seems quite within the bounds of possibility that people who are now living may witness the application of this chief motor to the indicated uses."[44] Lord Kelvin visualized the use of batteries, which were not perfected at the time of his writing, that could store power from Niagara and possibly be shipped to other cities via trains to supply power. He was a staunch direct current advocate, and although he did envision transporting electricity over long distances, his idea was to physically move the power to where it was needed. In addition to the power that Niagara could supply, Lord Kelvin mused of atmospheres: "Smokeless and clean, uncontaminated with the products of combustion; with flowers and fruit flourishing in town gardens; with our rooms, and especially our public rooms and places of assembly, freed from the heat which gas occasions; and with nature and art manifest in their true colors by night as well as by day."[45]

In effect, Lord Kelvin was describing an electrical utopia powered completely by the natural force of Niagara Falls. The significance that he attached to the grand cataract continued to grow as journalists and others reluctantly recognized that the world's coal fields might be exhaustible, and therefore alternatives such as power from Niagara should be approached with a "practical interest."[46] In short, Niagara became idealized and hydropower became the foundation on which a newly imagined electric future could be built. Within the broader context of late nineteenth-century Progressive America, the promise of Niagara represented another step in human mastery over nature, just as Jacob Bigelow had envisioned in 1829. Ever since Francis Bacon expressed the idea that "the empire of man over things is founded on the arts and sciences alone," Western civilization had found advancement wrapped in the systematic exploitation of natural forces, and in the late 1800s the timing was right for Niagara. Optimistic about an imminent era defined by technological progress, Americans saw firsthand—in Philadelphia and then in Chicago—the possibilities of an electric future. Although the giant Corliss in 1876 and banks of dynamos in 1893 represented mechanical perfection, it was only because the fire and steam that drove them were tucked away in a "dirty engine house," part of an inconvenient truth that was easily ignored.

In 1886, it was Thomas Evershed, an engineer who had worked on the Erie Canal, who first outlined a large-scale plan for harnessing the power of the falls. His plan was to bore deep vertical shafts at a point in the upper Niagara River west of the city of Niagara Falls that would channel water downward into a deep tunnel. The tunnel would run for over two miles, beneath the city, and through various wheels with shafts extending upward through the ground the power of the falls could be captured for mechanical power to be supplied to hundreds of mills. Local promoters, enthusiastic over Evershed's plan, acquired the requisite property but ran short on capital and were forced to sell their holdings.[47] Three years later, a group of investors led by New York banker Edward Dean Adams and backed by J. P. Morgan formed the Niagara Falls Power Company. Whereas Evershed's original plan was to exploit the power of the falls to run hundreds of mills with mechanical energy, Adams's group concluded that the power of the falls was best captured at a central station to generate electricity. The original plan called for transmission of the power to Buffalo, which was largely a speculative technology at the time because long-distance transmission of electrical power had not yet been perfected. In 1890, workers began digging tunnels, and in 1891, Niagara Falls Power sought plans for the best system of hydroelectric power generation at the falls. Although the planning phase of electrical generation at the falls occurred in the midst of the Edison-Westinghouse debates over direct and alternating current, the company selected Tesla's alternating current. As construction of the power station commenced during the Columbian Exposition in Chicago, excitement as to the potential for Niagara power grew. Tesla himself had predicted that the electricity generated at Niagara could provide power around the world, with the potential for running streetcars in London and streetlights in Paris. In his enthusiasm, Tesla claimed that "humanity will be like an ant heap stirred up with a stick. See the excitement coming!"[48] At the official opening ceremony of the Niagara hydroelectric plant, Tesla, as had so many others before him, spoke of electricity in religious terms, adding that man's subjugation of nature would save humanity:

> We have many a monument of past ages; we have the palaces and pyramids, the temples of the Greek and the cathedrals of Christendom. In them is exemplified the power of men, the greatness of nations, the love of art and religious devotion. But the monument at Niagara has something of its own, more in accord with our present thoughts and tendencies. It is a monument worthy of our scientific age, a true monument of enlightenment and of peace. It signifies the subjugation of natural forces to the service of man, the discontinuance of barbarous methods, the relieving of millions from want and suffering.[49]

Tesla was not alone in his excitement over the potential of Niagara. In the media, Niagara took on a larger-than-life role in the future of the country, with stories of electrical force so great that it was "impossible to conceive what would be possible by its application . . . turning out invisible force to give life the factories and railroads."[50] Other stories, picking up on earlier visions of coal-free power, explained that "the line of the roof of the [Niagara] power station is unbroken by chimneys. This is because the building is heated throughout by electricity."[51] Speculation that Niagara could displace coal, that "its daily force was equal to the latent power of all the coal-mines in the world each day," was not unheard of.[52] Although the electricity generated at Niagara was at first sent via wire only to Buffalo, twenty-six miles away, there was growing speculation that harnessing the falls to supply more distant locations was a real possibility. Even a press report of "an atom" of Niagara power that had been transmitted around the world via telegraph line was cause for national coverage and great excitement.[53] Tesla and others believed that Niagara's power would make Buffalo the "greatest city in the world," a phrase that Westinghouse eventually adopted in its advertising.[54]

In its own way, the establishment of power generation at Niagara had a substantial impact on the American public's attitudes toward electricity. At the world's fair in Philadelphia in 1876 the public discourse portrayed electricity in terms of amazement and mystery. By the early 1880s Edison's commercialization of the lightbulb and lighting systems led to a portrayal of the inventor in terms of practicality and progress. Chicago's White City of 1893 impressed upon visitors that the ideal city ran on clean electricity, with endless possibilities. Now, with Niagara online, a cultural custom was being established in the press that endless coal-free electrical energy could be transmitted anywhere. At Niagara it seemed that humankind had mastered nature and tamed the mysterious force of electricity for the good of society, a panacea realized. In an age of smoke, Niagara represented the possibilities for alternative energy, an extinguished flame, a realization of Edison's earlier promise that power for light, heat, and cooking would all be delivered into one's home by wire. Between the White City of Chicago and the promise of Niagara, the cultural construction of electricity as a utopian and progressive force for the future now accelerated. American English began to incorporate expressions that could not have existed prior to the introduction of electricity; words such as "human dynamo," "electrifying," and "shocked" began to appear in a number of publications and advertisements.[55] In literature, works that incorporated themes of energy and electricity were nothing new, but began to shift as the promise of invisible energy appeared on society's horizon.

Electricity as a mysterious force had made its literary debut in London in 1818 with the publication of *Frankenstein, or, The Modern Prometheus* by Mary Shelley. At the time of Shelley's writing, galvanism, or animal electricity, was a popular topic in London, inspired by the work of Luigi Galvani and his experiments with frogs' legs and electric shock. In *Frankenstein*, Shelley uses an electric shock as the vital force of life, an idea that captured the imagination of both English and American readers in the early nineteenth century.[56] By 1851, Herman Melville incorporated the enigmatic force of energy into American literature in *Moby Dick*. For Melville's antagonist Captain Ahab, it is the electrically charged spark of lightning that represents omnipotent force. Ahab is so captivated by the white light of lightning that his first mate Starbuck must pull him out of his trance and back to the harpoon and the hunt—yet it is electricity that will guide him and "light the way to the white whale."[57] In Mark Twain's satire *A Connecticut Yankee in King Arthur's Court* (1889), the American Hank Morgan travels backward in time after a blow to the head and attempts to modernize sixth-century England by using his knowledge of the future. During his exploits, Morgan performs feats of magic through the use of technology. One of Morgan's first acts is to build an electric plant in Merlin the magician's cave, with which he electrifies fences for protection, runs wires for dynamite charges, and lights up castles to the amazement of King Arthur's subjects.[58] Twain, a person who was fascinated with electricity—to the extent that he allowed the passage of a current through his body when visiting Tesla's laboratory—also includes an offhand explanation of proper wiring and grounding in his novel.[59]

While the works of Shelley, Melville, and Twain took advantage of the mysterious nature of electricity the force, American utopian and dystopian novels in the late 1800s illustrate the confidence assigned to electricity as a progressive energy source. Literature scholar Jean Pfaelzer has argued that the "nineteenth-century utopian novel . . . can hardly be understood as a serious prediction of historical process."[60] While this may be true in the realm of economic development and politics, several works do foretell of advances based on emerging technological developments. In a time of great social change, the utopian novel was a literary expression of the author's anxieties, and smoke, steam, and energy played important roles in the most popular works of the late nineteenth century. Kenneth Roemer observes that "coal, soot, and other odor-producing fuels" were commonly replaced by electricity in utopian works between 1888 and 1900, and along with aluminum and high-speed rail, electricity was the most mentioned technology.[61]

An analysis of this popular genre not only validates Roemer's observations but reveals utopian settings that mirror cultural perceptions derived from the White City and Niagara, both of which were characterized as clean electrified spaces. An example of this portrayal is found in the most popular work of the period, Edward Bellamy's 1887 publication *Looking Backward: 2000–1887.*[62] As Bellamy's protagonist Julian West finds when he visits the year 2000, smoke and fire are gone. His host from the future, Mrs. Leete, explains, "Electricity of course, takes the place of all fires," and thus she not only removes flames and smoke in the forthcoming world, she positions electricity as a sole power source.[63] Through Mrs. Leete, Bellamy reflects an early manifestation of energy abstraction. Writing at a time when all electricity was derived from fire and steam, Bellamy reinforced the disconnection between coal and current by promoting a position that dismissed the link between power generation and consumable energy. In the utopian world of Mrs. Leete, electrification represented the new, the clean, and the future—and it was antithetical to fire. As part of Bellamy's utopian ideal, technological advancements were assumed to be safe and part of a more humane, orderly, and civilized future. Bellamy's lesser-known sequel, *Equality*, published in 1897, continues with similar themes, although electricity plays an even bigger role. In *Equality*, West witnesses electric plows and motors connected by a system of flexible cables, electric cars for travel, and a possible precursor to the internet in electrically connected "electroscope" networks.[64] As in *Looking Backward*, Bellamy's sequel reinforces the role of electricity as a replacement for whale oil and as a successor to steam; although *Equality* was written during the time of Niagara's development, there is no mention of the source of the electricity.[65]

In 1890, Populist political leader Ignatius Donnelly published *Caesar's Column: A Story of the Twentieth Century*, which describes electricity as a force that has been conquered, as well as a force on which "the happiness of millions depends."[66] Extending Shelley's depiction of electricity as life-giving, Donnelly wrote of a future in which the "slow process of agriculture would be largely discarded, and the food of man would be created out of the chemical elements of which it was composed, [then] transfused by electricity and magnetism."[67] In Donnelly's future world, the technology of electricity is far more advanced, dynamos are replaced by the "magnetism of the planet itself," there are electric magazines, and electric air transports that consist of "huge, cigar-shaped balloons, unattached to the earth."[68] By removing dynamos from the future, Donnelly not only increased the distance between generation and consumption, he removed generation completely, making the derivation of electrical energy completely inconsequential. Clearly, in this scenario electricity becomes the transformative technology, yet since Donnelly's novel is a dystopian rant against capitalism, only the ruling elite truly enjoy the spoils of technology. As with Bellamy's work, Donnelly's novel is a cautionary tale against the excesses of capitalism, and along with equating electricity with technological advances, both works portray electricity as an egalitarian social force, in contrast to Gilded Age coal-based capitalism.

Donnelly and Bellamy were not alone in associating electricity with a cleaner, better future. William Dean Howells, one of the most influential and widely circulated authors of the period, also saw electricity as part of an improved future.[69] In Howells's utopian *A Traveler from Altruria*, published in 1894, "the capitals are clean," partly due to "electrical expresses that transport the artist, the scientist, and the literary man."[70] While Howells was cleaning up cities with electrical expresses, in *The Human Drift*, author King Camp Gillette envisioned a modern world powered by electricity derived solely from hydropower. Clearly motivated by the excitement over the coming of Niagara, Gillette's utopian city of Metropolis is completely powered by hydropower-driven dynamos. Located "about ten miles east of Niagara and Buffalo," Metropolis includes not only manufacturing centers but also luxury apartments that are "heated and cooled by automatic mechanisms, lighted by electricity, and electrically connected with the whole outside world."[71] Gillette's work serves as another example of coal, smoke, and steam as the antipode of the utopian space.

In feminist utopian works of the time, electricity plays a commanding technological role as well. Mary Bradley Lane's publication *Mizora: A World of Women* (1881), includes carriages propelled by compressed air and electricity, and since Mizora is a haven in the center of the earth, the "dreamy daylight" is produced by electricity.[72] As in Donnelly's work, the

Mizorians in Lane's novel rely on electricity to produce their food, utilizing electricity, carbonic acid gas, and hothouses to grow fruits and vegetables. In Mizora electricity sustains life, yet the precise source of it is unclear. Anna Bowman Dodd's *The Republic of the Future, Or, Socialism a Reality*, from 1887, uses electricity to send food great distances through "culinary conduits" and to run all of the machinery in the home.[73] As a visitor to the year 2050, Dodd's protagonist, Wolfgang, writes to his friend Christina, who lives in 1887: "I had noticed almost immediately on my arrival that throughout the city, not a chimney was to be seen. It naturally followed that, there being no chimneys, there was also no smoke, which therefore made this already sufficiently clear atmosphere as pure as the air on a mountaintop."[74]

Throughout these works, the utopian worlds are egalitarian, communalistic, and above all, electric. While these portrayals reflect a style of technological utopianism that positions coal and steam as technologies of a dystopian world, they are also forced to remove dynamos and further abstract energy and electrical generation. Unlike any of the other works discussed here, William Dean Howells came close to recognizing this issue when his protagonist, Mr. Homos from the utopian island of Altruria, explains: "It was long before we came to realize that in the depths of our steamships were those who fed the fires with their lives, and that our mines from which we dug our wealth were the graves of those who had died to the free light and air, without finding the rest of death. We did not see that the machines for saving labor were monsters that devoured women and children, and wasted men at the bidding of the power which no man must touch."[75] As with many of these other works, Howells does not address the source of Altruria's electric power, but the passage above does start to connect consequence to abstracted energy. The depths of the steamships, the mines far away, and the machines not seen in Howells's world directly equate to Adam's "dirty engine house" in Chicago and the growing space between power generation and consumption that are about to follow. While Howells begins to identify the issue, he falls into the same trap as the other works—their utopias need electricity, but there is no utopian method to provide the power they need. As a result, the future worlds deal with the provision of electricity through the means of power magically derived from the earth or atmosphere, or generation is not dealt with at all, suggesting to the reader that dynamos are unnecessary and will long be a thing of the past by the year 2000.

Beginning in the mid-1880s, the development and gradual adoption of alternating current technology allowed for increasingly larger distribution systems that placed more physical space between the generation and the consumption of electricity. Fully realized at the Chicago Columbian Exposition in 1893, this and other advances in electrical engineering created an imagined White City, void of steam and smoke, which reflected the possibilities of technological utopianism. As Chicago captivated both the public and the press, the promise of unlimited clean power from Niagara Falls contributed to a public sentiment that positioned electricity apart from coal, further abstracting the dynamo from usable electric power. In the press, speculation that electricity could be stored and would eliminate fire and that the ideal city could be realized continued to contribute to the idea that electricity was an energy panacea. By the end of the nineteenth century, societal views of electricity had undergone a shift. What was once a magical novelty was becoming a force that represented mankind's mastery over nature and was a social solution to smoke- and fire-based drudgery. In end-of-the-century American utopian novels, electricity as the featured technology solved problems of food production, transportation, and coal-based capitalism. While the forward-looking literature of the day influenced society's view of electricity as a savior, it also promoted the myths that grew out of the White City and the anticipation of Niagara, of unlimited electrical energy with no coal and no consequences. The idea that electricity was an exceptional energy source disassociated from smoke and fire remained part of American culture as the modern electrical grid began to take shape.

CHAPTER 7

TURBINES, COAL, AND CONVENIENCE

> There will be no further need of digging dirty coal, for cheap and clean electricity will light and warm the world and furnish motive power.
>
> **Walter J. Ballard**

Driving by 1111 W. Cermak Road in the Pilsen neighborhood of Chicago today is an uneventful experience. Situated between the South Branch of the Chicago River and a single-track railroad siding is an abandoned power plant once known as the Fisk Street Station. With locked chain link gates and a smokestack void of emissions, the plant is now quiet. The last load of coal delivered from Wyoming's Powder River coal region by rail arrived in midsummer of 2012, more than a century after the plant first went into service. At the time of its closing, the *Chicago Tribune* quoted the director of the Environmental Law and Policy Center in Chicago as saying that the closing "marks a turning point from Chicago's reliance on two highly polluting coal plants that use fuel from out of state to a cleaner energy future that's less polluting and uses more Illinois wind and other clean resources."[1] Celebrated in terms of environmental inconsequentiality when it opened in 1903, reporters praised the coal-fired plant in much the same way as they did Niagara Falls few years earlier. The plant was deemed "smokeless" and heralded as "One of the World's Seven Wonders" that would "diminish smoke throughout the city" due to its 205-foot smokestacks.[2] The Fisk Street Station was the brainchild of Samuel Insull, a protégé of Thomas Edison. While Edison's first plant in Manhattan twenty-one years earlier was significant as the first attempt at central station generation, Fisk Street had a far greater effect on the future of energy in the country. Fisk Street marked the beginning of an electrical generation and transmission paradigm that made coal-derived energy invisible, established coal as the nation's prime mover, and contributed to the belief that electricity was a clean and modern technology.

The physical structure of the modern electrical grid began to emerge in the early decades of the twentieth century. Along with the establishment of technological systems that would remain in place, social views of energy consequentiality and consumption had already begun to form and were equally enduring. Having passed through stages of energy abstraction that went from the mysterious to the utopian, electricity was widely adopted in American society, eventually becoming the sine qua non of progress and modernity. As the twentieth century began, a radical disruption occurred within previous models of power generation and distribution by the development of steam turbines and the deployment of large regional transmission systems made possible by alternating current. This emerging paradigm became the model for energy distribution for the next one hundred years and further separated power generation from power consumption geographically.

Simultaneous to the technical turn, a cultural shift was underway. As forces of consumerism and Progressivism took hold in an expanding American middle class, an ever-increasing faith in technology along with the rise of advertising positioned electrification as a gateway to modernity. With the demand for electricity growing and the economies of scale made possible by steam turbine power plants such as Fisk Street, the cost of electricity decreased and energy consumption rose dramatically. By 1930, over 80 percent of households in the nation were electrified, the conscious disassociation of coal from electricity accelerated, and as electricity became inextricably tied to American consumer culture, unlimited power consumption was encouraged.[3] While both marketers and intellectuals passed along celebratory cultural messages informing the public that the Age of Electricity had arrived and the Age of Coal had passed, the nation consumed more coal than ever before.

As the twentieth century began, electrification in the United States was in a state of flux. Since the startup of Edison's

Pearl Street Station in 1882, the methods and technology behind electrical generation and transmission had evolved asynchronously, which led to systemic discontinuities. Characterized by a mix of existing direct current systems and emerging alternating current systems, electric power distribution was a nested structure of subsystems, characterized by what historian Thomas Hughes refers to as "reverse salients."[4] Hughes defines these as components in a system that do not "march along harmoniously" with other components.[5] If the system is to proceed, the reverse salient requires correction or resolution. In the closing years of the nineteenth century, expansion of electrification was hampered due to its basis on an Edisonian direct current paradigm, characterized by small municipal or private power plants providing electrical power to confined areas. The main focus for Edison, Westinghouse, and others was to sell equipment, lightbulbs, appliances, power generation systems, and franchises. Within these small systems, electrical current was often sold on a per-lamp basis—a carryover from the captive arc-lighting systems of Brush and others.[6] The shift away from direct current began in 1893 with Tesla's innovations, the adoption of alternating current technology at Niagara, and the subsequent beginnings of long-distance transmission of electrical power. While these technical advances were significant, the method of power generation went largely unchanged, and electricity remained an energy source primarily derived from the burning of coal.

Between 1894 and 1912, a radical disruption in technology altered the way electricity was generated and distributed in the United States. In the process, power generation became farther removed from power consumption, the electrification infrastructure became less visible, and coal became established as the primary fuel source for the generation of electricity for a century to follow. While names such as Thomas Edison, George Westinghouse, and Nikola Tesla loom large in the history of technology, the long-term impact of Samuel Insull had a greater effect on how Americans perceived and consumed electricity. Under the direction of Insull, Chicago Edison built a model of power generation, distribution, and marketing that the entire country eventually adopted, displacing existing systems that had been in operation since the 1880s. This process of change began at the Fisk Street Station.

Prior to the late 1890s, electricity in the country was produced by generators driven by coal-fired reciprocating steam engines, an engine design that had been fundamentally unchanged since its invention by Matthew Boulton and James Watt a century earlier. Although there are significant differences in reciprocating steam engines, at the core are pistons and valves, and the familiar up-and-down motion that is converted to a circular motion as in a locomotive's drive wheels. In the early days of power generation, the rotary motion of the steam engine was connected to a generator with a drive belt that turned an armature to create electrical current. The first electrical generation stations were of this design, including Edison's Pearl Street Station in Manhattan. From a technological standpoint, this pairing resulted from the fact that reciprocating steam engines were established prior to the invention of the generator, and the two contrivances became adapted to create a power generation system. At best, reciprocating designs were 20 percent efficient, meaning that only 20 percent of coal's chemical energy was converted into reciprocating motion.[7] The lack of efficiency meant that more coal had to be burned to produce a megawatt of electricity, and since the variable cost of plant operation is mostly in fuel, the cost of electricity was high.

In 1884, Charles Parsons of England perfected a steam turbine generator or "turbogenerator" that altered the calculus of coal-to-electricity efficiency. Compared to a reciprocating engine, a steam turbine is smaller and lighter per unit of horsepower, and rotates at a higher speed, gaining efficiencies of up to 80 percent.[8] The operation of a steam turbine is straightforward: injected under pressure, steam flows onto enclosed rotor blades, causing them to spin (the principle is broadly similar to that of a pinwheel), where moving air creates rotary motion. Because there is no conversion from reciprocal to rotary motion, and because more of the potential thermal energy can be utilized, turbines gain both efficiency and speed. The turbine design eliminated a separate engine and drive belt system entirely, as steam-driven turbine blades were integral to the generator's shafting. All modern power plants use steam turbines—coal, nuclear, or natural gas, and all are methods of heating water to produce steam to drive turbines. One of the first successful installations of a steam turbine was that of a small Parson-type seventy-five-kilowatt generator in England at Newcastle in 1890, and the first large-scale generation plant went online in 1899 in Eberfield, Germany, with a capacity of 1 megawatt, followed by 2.5-megawatt units in Frankfurt in 1901.[9] In 1895, New York Edison's West 39th Street plant installed the first team turbine in the United States.[10] While the first American-built units were small, with capabilities to generate about 500 kilowatts of power, by 1900 Westinghouse had manufactured and installed a medium-capacity 1,500-kilowatt unit at the Hartford Electric Company in Connecticut.[11] (One megawatt [MW] is equal to one thousand kilowatts [kW].) These two early US installations represented an experimental stage of turbine technology; it was not until 1903 that Insull deployed turbines on a large scale at the Fisk Street Station.

Insull did not invent the steam turbine, nor was he the first to utilize it, but he was the first to build high-capacity regional central stations. Insull also consolidated small neighborhood stations, which were artifacts of the Edisonian direct current model and leveraged the economies of scale that resulted from larger generation plants. When Insull became the president of Chicago Edison in 1892, the technological momentum for the wider adoption of electricity was well underway, and few were more experienced in the burgeoning electric power industry at the time. Starting his career as Thomas Edison's secretary in the 1880s, Insull was present for the startup of the Pearl Street operation and he remained in New York until J. P. Morgan consolidated Edison's business and transformed it into General Electric. In 1892 Insull sought new opportunities and interviewed with the board of directors of the fledgling Chicago Edison Company for the position of president. Despite the impression of an electric utopia at the Chicago Columbian Exposition in 1893, outside of the fairgrounds the electrical infrastructure of Chicago was patchwork, with more than forty-five electric companies operating independently.[12] As one of the forty-five operations, Chicago Edison was a small player in a disjointed infrastructure whose territory covered fifty-six square blocks in the downtown loop district.[13] A shrewd businessman who was able to take advantage of the economic downturn in 1893, Insull bought a number of competitors in the Chicago market, and by 1898 Chicago Edison had a virtual monopoly on electrical generation in the nation's second-largest city.[14] Insull was not a crusader with a desire to provide a cleaner, safer source of power to the masses; he was cut from the mold of Gilded Age capitalists, poised to exploit a new technology as profitably as possible. At the core of Insull's strategy was scale: larger generation plants that could produce more power at a lower cost. While this yielded more profit for Chicago Edison, it also allowed the company to sell electricity to the consumer at a lower cost.

Insull's focus on maximizing profitability in electrical generation was obvious, and along with many other power plant operators, he believed that coal generation was the most profitable method, even before the implementation of steam turbines. Although Niagara had demonstrated the feasibility of hydropower, the electric interests had always favored coal as the most cost-effective way to generate power. At the National Electric Light Association convention in 1898, Insull listened as Mr. W. M. Walbank presented a paper on the cost of producing electricity by hydropower at the Lachine Rapids installation in Montreal.[15] After Walbank explained various aspects, including capital costs to build the plant, generation capacity, and cost of water rights, he concluded, "From the foregoing, the writer trusts that he has shown that where reliable water power can be obtained within reasonable distance from power centres it can be made to produce cheap electric current, to say nothing of the great advantages the city must derive therefrom, not only commercially, but viewed from a sanitary standpoint as well, as the use of electric power thus generated is the best smoke consumer yet invented."[16] The debate that ensued after Walbank's presentation centered on the relative cost and merit of electrical generation with a hydropower plant versus a steam and coal plant. American utility interests in the room espoused the lower cost of steam; standard steam plants at the time cost much less to build than hydropower plants, and the cost of the coal fuel was offset by the lower capital costs of construction. The issue of smoke—Walbank's mention of the sanitary standpoint—was not addressed in the debate. Comments by Insull and other plant owners focused purely on cost to produce a kilowatt-hour of electricity.

With a keen focus on profits, Insull was naturally interested in the efficiency possible in steam turbines, and during a 1901 European vacation, he first saw the large German installations.[17] Intrigued by the efficiency and potential profitability of the units, Insull approached General Electric (GE) about the possibility of supplying him with a five-megawatt steam turbine for a plant Chicago Edison was planning to build. Although GE had encouraged him to take on a smaller, one-megawatt unit, Insull persisted and guaranteed to take a portion of the risk if the unproven design failed.[18] In the fall of 1903, the five-megawatt turbine went online at Fisk Street, and within a year and a half, Insull scrapped the five-megawatt units for turbines of thirty-five megawatts. By 1906 the total output of the station was 156 megawatts.[19] Insull realized that lowering the cost of producing electricity not only resulted in greater profits but also gave Chicago Edison the ability to offer electricity at lower rates than competitors and allowed him to market his energy as inexpensive. The adoption of steam turbines for generation led to a major shift in how electricity was produced, and Insull's move set the trend. Within a year after the construction of the Fisk Street plant, General Electric and Westinghouse had manufactured and sold steam turbines across the country that represented a total generation capacity of 540 megawatts.[20] The age of the coal-fired steam turbine for the generation of electricity had arrived.

Just four years after Fisk Street went online in 1903, the cost of coal as a percentage of total operating costs of large central generation stations had dropped by 3 percent, a trend that continued as turbines increased in size.[21] In addition to the cost of coal itself, the economies of scale achieved from the steam turbines came from a number of factors, including reduced capital costs relative to generation capacity and plant efficiency.[22] Before the advent of steam turbines, reciprocating-piston-type steam engines achieved a thermal efficiency of 3 to 5 percent. Simply stated, this means that only 3–5 percent of the heat energy produced is utilized for work, while the remaining 95–97 percent is wasted. Early steam turbines improved thermal efficiency by a factor of three to five times by achieving efficiencies of 15 percent.[23] For those considering relative costs of alternative fuels such as petroleum, natural gas, and ethanol, which were rarely used at the time, nothing came close to coal for low-cost energy generation.[24] A US Department of Agriculture report from 1908 found that "it was possible to buy eight times as much energy in the form of cheap coal" when compared to most other fuels.[25] Although hydropower garnered considerable excitement in the press and among engineers who were attracted to a potential fuel cost of zero, energy executives were well aware of the high cost of hydropower plant construction, maintenance, and the interest on debt to finance their construction.[26] In addition, those in the power industry feared interruption by natural forces such as drought or floods and laws that discouraged the development of hydropower. Legal obstacles such as gaining permission for transmission right-of-ways, public domain rights, and other legislative hurdles were burdens not inherent in unregulated steam plant construction.[27] With coal plants already being less expensive to build and more profitable to operate, the consideration of mine-mouth plants—steam turbine plants built directly proximal to coal mines—further added to the promise of coal for future profits by eliminating the freight costs of coal.[28]

As coal cost and supply became critical to the operation of profitable electrical generation, Insull invested in coal to ensure a stable supply. Francis Peabody, an aspiring coal magnate in the early years of the twentieth century, needed considerable capital to grow his company. Insull had capital and needed coal. The two men struck an agreement in 1913 for Peabody to supply Chicago Edison with all the coal that it needed for the foreseeable future at cost, plus a small profit.[29] With the contract in hand, Peabody bought additional mines to supply the coal that Insull required. Whereas the power companies may have had the biggest incentive to use coal due to its profitability, capitalists such as Insull and Peabody were not the only parties responsible for locking in coal as the nation's ultimate source of electricity. Mine owners, especially Peabody, and labor made sure that the coal supply was steady and inexpensive. After Peabody won his first contract to supply Chicago Edison with coal in 1913 for half a million tons per year from mines in southern Illinois, he negotiated with John L. Lewis of the Illinois mine workers' union.[30] Peabody agreed to support safety laws for the mines and in exchange Lewis agreed that all contracts between the mines and the union would expire on April 30 of each year—just prior to the summer months, when the demand for coal and electricity was at its lowest.[31] From the late 1890s until World War I, the average price of bituminous coal rose more slowly than the wholesale price index and remained lower and more stable than crude petroleum and anthracite coal.[32]

The profitability realized due to the construction of large steam turbine plants and inexpensive coal was occurring not only in Chicago. In 1906, reciprocating steam engines began to be replaced by five-kilowatt steam turbines at the Twin City Rapid Transit Company plant in Minneapolis, building on the success of installations in Chicago and New York.[33] In the emerging power grid in the United States, larger turbine plants served more distant regions, further separating electrical generation from consumers.[34] For example, in 1913 a five-megawatt steam turbine plant in Missouri Valley, Iowa, displaced three smaller, unprofitable regional plants. A similar coal-burning plant built near Galena, Illinois, served customers in a two-hundred-square-mile area. Missouri's Empire District Electric Company began servicing a scattered population of over 150,000 people and 165 miles of interurban railway via a central station with over one hundred miles of high-voltage transmission lines.[35] In all of these instances, economies of scale realized by efficient steam turbines, an inexpensive coal supply, and capital costs spread over an increasing customer base kept the cost of electrical production down and helped to embed a coal-based model that became widely adopted during the early twentieth century. While independent operators duplicated Insull's model of larger plants, Insull himself expanded his holdings—by 1907 he owned twenty additional utility companies and exploited the scalability of steam turbine generators and alternating current transmission to control the entire electric supply in Chicago. In 1911 he established the Public Service Company of Northern Illinois and controlled thirty-nine more electric companies; in 1912 he formed Middle West Utilities to acquire more electric companies throughout the Midwest.[36] By the second decade of the twentieth century the steam turbine had completely changed the calculus of electrical generation in the country. Insull established the model for large regional systems serving consumers increasingly distant from the plants that supplied them with power, and the nascent power grid evolved with coal and steam at the core.

As the total electrical generating capacity in the United States increased from 2,987 megawatts in 1902 to 10,980 by 1912, the majority of the increase came from coal-fired turbine plants, firmly indicating the acceptance of the technology. The adoption of the steam turbine, along with the confidence in the future of hydropower, came at the expense of research into alternate sources of energy. As John Adolphus Etzler in the early 1800s and John Ericsson in the mid-nineteenth century discovered, power companies had no incentive to pursue anything other than power generation by large coal or water turbine installations. Along with the socially driven momentum of electrification, the steam turbine had taken on a momentum of its own, as research and development concentrated on engineering bigger and more efficient turbines. Insull, for example, scrapped the original turbines installed at Fisk Street in favor of larger turbines when "the progress of the art was such that practically the same boiler room arrangements" were able to operate turbines with a much higher capacity.[37] Even though there is evidence of interest in pursuing wind-driven electricity generation, neither General Electric or Westinghouse—the two major generator manufacturers in the country—had any reason to pursue it.

Ironically, it was in the West, atop some of the nation's largest coal reserves, where one of the most serious early pursuits of wind power occurred. In April of 1913, Frank Bosler, a rancher outside of Laramie, wrote to General Electric's manufacturing division to inquire about harnessing the wind to generate electricity for a regional power system he planned to build. Responding to Bosler, the company stated that "they had not developed any particular apparatus for wind generation," and were positive that wind would not work for electricity generation due to the inconsistent nature of wind speeds.[38] Bosler responded that the wind in Laramie was constant, and he pursued his idea by exploring the possibility of rigging together windmills with belt-driven dynamos and using batteries to store power. A letter from the Electric Storage Battery Company of Philadelphia to Bosler echoes the position of General Electric, that wind was an "unreliable energy source."[39] Bosler continued to experiment with wind power until 1916, after which time he began to pursue both hydropower and coal-fired plants. With the adoption of coal-fired steam turbine technology on a broad scale, the development of and interest in alternative energy sources such as wind were largely dismissed for nearly a century.

By 1912, every state in the country with the exception of Delaware and Utah had operable central station coal-burning steam turbine generation plants, and five states—Illinois, New York, California, Pennsylvania, and Massachusetts—garnered the majority of their electricity from large turbine plants.[40] As turbine sizes increased, the number of coal-fired steam generation plants decreased as per-plant capacity increased—this did not mean that less coal was consumed; it simply meant that more coal was consumed in fewer plants. Because of their capacity, coupled with alternating current, turbines allowed for the building of bigger generation plants, which in turn could serve more consumers in a wider geographic area. Older, inefficient plants were converted to substations, which did not generate power but stepped it down to lower voltages appropriate for domestic use.[41] As plants farther away replaced older stations in populated areas, fewer consumers witnessed the smoke of power generation, which in turn added to the invisible quality of electrical power. While the statistics are incomplete for the years prior to 1920, the number of generation plants in the country fell from 2,422 in 1920 to 1,600 by 1930, a trend that reflected the move to large regional power plants that continued into the latter part of the twentieth century.[42]

Despite the reality that the capacity of coal-fired plants was increasing across the country, the myth of Niagara—that waterpower would become the main source of the growing demand for electrical power—persisted. A 1912 census report noted:

> One of the most important matters affecting the electrical industries is the use of water as a primary power. The development in electrical appliances for converting water power into electric energy, which by transmission lines is made available over large areas, together with the economies of production, indicates a continued increase in this form of primary power and a probability that it will to a still greater extent take the place of primary power derived by the use of fuel.[43]

The forecast that waterpower would outpace coal-based steam for power generation was not totally unreasonable at the time, as waterpower's share of total electric production had increased from 25 percent in 1907 to about 35 percent in 1912.[44] This trend did not continue, as by 1930 waterpower supplied less than 30 percent of the country's electrical generation, and this number declined further, making the years between 1912 and 1920 the peak years for hydro-derived electricity in the United States.[45] While many may have believed that waterpower would replace coal for the generation of electricity, plants like Fisk Street consumed 2.5 tons of coal and 1,700 tons of water, and discharged 62 tons of "waste gases and heated" from its five smokestacks, every *minute*—and this was a plant that the *Chicago Tribune* heralded as "smokeless."[46]

The dissonance in the fact that a plant such as Fisk Street could consume two tons of coal a minute while being deemed smokeless was the result of another development that occurred simultaneously to the adoption of steam turbine generation.

Automatic stokers, which carefully regulated the draft and smoke of burning coal in power plants, eliminated observable smoke, and in turn converted the airborne effluent of combustion into an invisible state.[47] "Perfect combustion means smokeless combustion" was the mantra of power plant managers as they deployed stokers to eliminate visible smoke and raise the efficiency of coal plants.[48] Like the myth of hydropower, the apocryphal nature of the smokeless coal plant took on a life of its own. A steam plant planned for Saint Paul was noted for being "a smokeless plant to which the health commissioner may point with pride. The five big boilers are equipped with special furnaces, and the competency of the stoking equipment and the facilities for handling ashes and cinders may be best appreciated by consideration of the fact that one foreman will handle it all."[49] Engineers promoted the notion of smokeless coal even more.[50] A number of experts in the field reported that "there is no longer any necessity of polluting American cities with volumes of smoke . . . experts assert that they are operating smokeless plants and making steam economically with a coal heretofore regarded as refuse and delivered to stations for 88 cents per ton."[51] While individual power plant operators were quick to point out that their plants were not public nuisances, the federal government reinforced the public's notion that coal was harmless if burned properly. In 1913, Samuel Flagg, an engineer with the United States Bureau of Mines, declared, "Coal can be burned smokeless, if you give coal the proper chance to burn."[52] Authors of a 1909 government publication, *The Smokeless Combustion of Coal in Boiler Plants*, took the position that the use of coal could be harmless and would make possible a "clean and comfortable city," and thanked the Peabody Coal Company, the Westinghouse Machine Company, and the Underfeed Stoker Company of America for providing illustrations in the book.[53]

Stokers and so-called smokeless plants did not eliminate greenhouse gases.[54] The use of stokers and turbine power plants at the same time was not part of a conspiracy to hide smoke from the public at the turn of the century. Knowledge of greenhouse gases, mercury, and other pollutants at the time was mostly limited to what people could observe, which was black smoke. The goal for engineers was simply to make black smoke go away; stokers were one way of achieving the goal, along with recommendations that coal-consuming plants be removed from areas of congested populations.[55] Between the use of stokers and the new capability of high-capacity steam turbines and alternating current transmission systems, the electrical infrastructure began to become less visible. Coal-generated electricity became more abstract and less salient with the reduction of visible smoke. Experts in the field, engineers, and the press shaped public opinion by characterizing new plants as smoke-free. The disassociation of coal from electricity increased with the removal of visible smoke from power plants in the beginning of the twentieth century. At the same time that power plants and transmission systems were becoming part of the landscape, consumer demand was expanding exponentially. The economies of scale realized by power companies led to less-expensive electricity to consumers—a calculated incentive on the part of producers to maximize generation capacity—which led to more widespread adoption of electrical power. At the same time, a rising progressive middle class saw electrification as a gateway to modernity, reinforced by the newly developed art of advertising and consumer credit, which united to create an electrified consumerism, eventually leading Americans to become the highest-energy-consuming society in the world.[56]

William Leach's 1993 cultural history, *Land of Desire: Merchants, Power and the Rise of a New American Culture*, traces the formation of consumer culture in the nation primarily between the years 1890 and 1930. Showing how entrepreneurs, manufacturers, bankers, clergymen, and government leaders produced a culture of consumers, Leach concludes that the consumer capitalism that developed produced "a culture almost violently hostile to the past and to tradition, a future-oriented culture of desire that confused the good life with goods."[57] From a standpoint of periodization, paralleling Leach's study was the widespread electrification among the rising urban middle class in the country, to whom, Leach observed, "electric light was the radiant core of the consumer revolution."[58] In Leach's analysis, inexpensive electricity, first pioneered by Insull in Chicago, "disproved the widely held claim that such light would remain a luxury."[59] The effect of cheaper electricity was felt not only in Chicago; a report on a Nebraskan housewife published in the 1920 *National Electric Light Association Bulletin* provides evidence of how new economies of scale affected consumers.

> A Nebraska housewife has sent to the Nebraska Committee on Public Utility Information a graphic comparison of the cost of necessities in the home covering the period of her married life. In February, 1898, twenty-two years ago, she bought for a company Sunday dinner, six pounds of potatoes, a thirteen-pound turkey, three pounds of coffee, some raisins, mince meat, olives, celery, two pounds of tomatoes, a pound of rice and a can of asparagus. Her bill showed that this particular grocery order cost $4.74 in 1898, but that on the same date in February of this year it cost $10.82 to duplicate the order. Upon request she looked up her electric light bill of twenty-two years ago and found that she paid $11.40, as against $2.09 in the same month of 1920, and she adds, "There is no comparison in the quality of electric service now and then, when we used the old yellow light globes and knew nothing about electric irons, percolators or washing machines."[60]

In the woman's account, it can be observed that not only did the price of electricity drop considerably, electric appliances began to play a major role in the home.

Consumerism in the United States was only possible because of electrification, from electric lighting in the new class of department stores such as Wanamaker's in Philadelphia and Marshall Field's in Chicago to electric signage to the light bulbs, lamps, and household appliances now run by invisible power transmitted by wire. However inextricably tied together consumerism and electrification were, the relationship between the inconsequential consumption of electricity and the waning years of the Progressive Era runs deeper than merely contrivances and brightly lit salesmanship. David Noble, in *America by Design*, ties together the practical application of technology and capitalism in the era and demonstrates how the electric industry was "the vanguard" of not only science-based industrial development in the country but also a growing confidence in engineers and technology.[61] Electrification was the prototypical Progressive technology; it fed into the orderliness of networks and was a rational, technical solution that represented an improvement in society, especially when contrasted to fire and coal. As an advanced technology, starkly different from past energy sources, electricity meshed well with the Progressive propensity toward technical solutions to problems such as smoke. As a building block of consumerism, electrification helped to raise the standard of living across a broad swath of social classes, from J. P. Morgan to the housewife in Nebraska.

Cultural messages derived from the press, in advertising and literature, celebrated the benefits and convenience of electrical appliances and other contrivances in the home. Hoping to take advantage of consumer desires and promote electricity consumption, Insull opened the "Electric Shop" in Chicago in 1909. Catering mostly to the well off, Insull's store was devoted to the sale of electrical appliances. The shop sold a variety of appliances, including toasters, corn poppers, curling irons, heating pads, and gadgets claiming to have medical powers.[62] For those in the power production business, the forming of a new group of electrified consumers did not go unnoticed. In a 1906 issue of *Cassier's Magazine*, which catered to engineers, an article offers plant owners suggestions on how to increase central station business by stimulating demand. The author used examples such as advertising campaigns and letters soliciting the sale of electrical appliances, porch lights, and other power-consuming conveniences.[63]

As electric utilities began to team up with Madison Avenue and the rapidly refining art of advertising, the pitching of electrical appliances became more provocative, especially as it focused on women, the home, and family. In 1925 a newspaper advertisement from Insull's Commonwealth Edison calling for electrical mechanization of the home asked, "How Long Should a Wife Live?"[64] In a *Good Housekeeping* article of 1918, "We Recommend Electricity," the author promoted the use of a plug adapter that would allow for "a portable lamp, a chafing dish, toaster, percolator, and a fourth plug for the occasional use of an iron."[65] Electric consumerism was now in full swing, as women's magazines promoted more appliances and more outlets. Historian Ruth Swartz Cowan has theorized that by advertising to women, appliance sellers and power companies industrialized the household and shifted the burden of domestic work from adult men to mothers. Janice Williams Rutherford argues that electrification allowed women to be more efficient and preserved the virtuous home for women who wanted to succeed outside of the household.[66] The notion of gaining efficiency through electrical appliances inside the home ran concurrent to ideas about scientific management techniques closely tied to Progressivism. While advertising that promoted appliance sales and electricity consumption to women has been the subject of several historical studies such as Cowan's and Rutherford's, men were encouraged to buy electrical contrivances and consume power as well.

In a bulletin in 1920 from the National Electric Light Association, the electric industry's professional trade association, member companies were encouraged to advertise in a wide variety of magazines. Included in the bulletin's targeted list were magazines for boys and men along with most major women's magazines.[67] *Boys' Life* articles featured the latest discoveries in electronics such as the precursor to the television in 1920, and in *Popular Mechanics* during the same year a wide variety of products were featured, from electric bathtub heaters to arc welders.[68] Men's magazines featured a substantial number of electrical health-related devices as well, such as the "Vi-Rex Violet Ray" generator, which promised to, when rubbed on the body, cure asthma, headache, and neuralgia and restore "energy and vim."[69] The promise of electricity's potential curative powers was not just a popular phenomenon but was reflected in professional literature as well. Medical professionals promoted electricity as a therapeutic agent that could provide a cure for maladies ranging from impotence to tuberculosis. In 1907 Dr. Samuel Monell of New York published a work with the rather lengthy title *Electricity in Health and Disease; A Treatise of Au-*

thentic Facts for General Readers, in Which Is Shown How Electric Currents Are Made to Act as Curative Remedies, Together with an Account of the Principal Diseases Which Are Benefited by Them, which addressed the curative ability of electricity applicable in afflictions ranging from cholera to "the impaired voices of speakers and singers."[70] The extent of Monell's confidence in electricity as a vital component of a physician's toolkit is evident in his work's preface:

> The general public for the most part knows electricity simply as something for light, power, and commercial use. The Electrical Engineer knows his currents in phases, cycles, volts, and terms of copper. He works with mathematics and metals, neither of which have nerves. But the physician who prescribes electricity must know his currents in terms of tissues that feel, that breathe, and that work constantly in their wonderful ways to carry on the processes of life. To make these living tissues—nerves, blood-vessels, muscle fibres, secreting and excreting organs, heart, lungs, liver and kidneys—obey the laws of Nature and maintain health the trained physician whose curative resources are up-to-date must know electricity as the Artist knows his tools and what he can make them do.[71]

In 1919, Drs. George and Ralph Jacoby of Philadelphia published *Electricity in Medicine: A Practical Exposition of the Methods and Use of Electricity in the Treatment of Disease, Comprising Electrophysics, Apparatus, Electrophysiology and Electropathology, Electrodiagnosis and Electroprognosis, General Electrotherapeutics and Special Electrotherapeutics*, which showed equal promise in the therapeutic qualities of electricity in maladies ranging from psychoses to "paralysis of rectum."[72] While the effectiveness of various electric health devices and treatments was questionable, the claims reflect the fact that electricity itself was a new and unique force. In the early 1900s, companies advertised curative electric belts in a number of national magazines and sold them through popular catalogs such as Sears, Roebuck and Company's. Although the middle class was the intended market for the belts, historian Carolyn Thomas de la Peña has suggested that working-class Americans purchased electric belts as well. Although many did not have access to electricity, Thomas de la Peña's analysis indicates that electricity as a technology garnered a special status in American culture.[73]

With the claims that electricity was a curative force for a variety of health conditions, the technology had now reached an omnipotent status. Defined in terms ranging from divine to a solution for social issues since 1876, electrical energy was constructed as a cure-all for ill health and an agent for convenience by the 1920s. Consumption of electricity grew rapidly as middle-class urban homes became electrified in the 1920s. The percentage of urban homes with electricity doubled between 1920 and 1930, reaching 84 percent. Radios, refrigerators, vacuum cleaners, and other electrical devices drove appliance sales from $833 million in 1921 to $1.6 billion in 1927.[74] Adjusted for per-dwelling usage, consumption rose from 339 kilowatt-hours per dwelling in 1920 to 547 kilowatt-hours in 1930.[75]

Sounding hauntingly like Mrs. Leete from Edward Bellamy's *Looking Backward*, written a quarter of a century earlier, Helen Bartlett, a teacher of cooking at Salt Lake High School in Utah wrote in 1914, "Electricity does not poison the air. A candle uses up almost as much air as a person. Compare a candle with the burners of a gas stove and think what they do to the air."[76] A Chicago School of Sanitary Instruction noted in that same year, "When we sweep away dirty coals in favor of clean electricity for running factories, heating houses, and cooking food, we are likely to sweep away half the ills that human flesh is heir to at the same time."[77] As part of the proceedings during the National Conference of Social Work in 1926, one speaker boldly announced, "The future belongs to clean electricity and the mind can think as cleanly. We shall make little progress with programs until we learn to include electricity and the mind of the youth in these programs."[78] As electricity was increasingly associated with the notion of clean—"clean electric motors," "clean electric plants," "clean electric light"—it was increasingly evident that the association between electricity and coal, fire, and smoke had been severed in the mind of society.[79] While Americans celebrated "clean electricity," and "the sweeping away of dirty coals," electric utility companies' coal consumption rose from 31,640,000 tons in 1920 to 40,278,000 tons in 1930.[80]