INTRODUCTION

TOWARD A NEW ENERGY HISTORY

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IN 1973 THE ITALIAN NUCLEAR PHYSICIST CESARE MARCHETTI BEGAN FORmulating a "simple and predictive model describing energy markets for the last century." Four years later he produced one of the most iconic pictures in energy history: a schematic graph depicting energy systems rising and falling like clockwork over time. The age of wood replaced by the age of coal, then oil, then natural gas, and then, so he predicted, nuclear energy and solar power. "It is as though the system," Marchetti reflected, "had a schedule, a will, and a clock." All it took was time, and the right price. His imagery of regular transitions, unfolding smoothly without interruption, free from outside forces like politics or values, gripped experts around the world as they strove to change their nation's energy systems following the oil shock of 1973. Marchetti was working for the International Institute for Applied Systems Analysis (IIASA) in Austria, a think tank founded to bridge the Cold War divide with cutting-edge models for global problems. IIASA's ideas spread through Western Europe, North America, and the Eastern Bloc, and graphs strikingly similar in their assumptions informed policy across the Global North during the 1970s.[1]

A generation later, as global temperatures rise, sparking our glaciers to melt and our forests to burn, humanity stands before what could be the greatest collective challenge in history. In many respects, experts and politicians

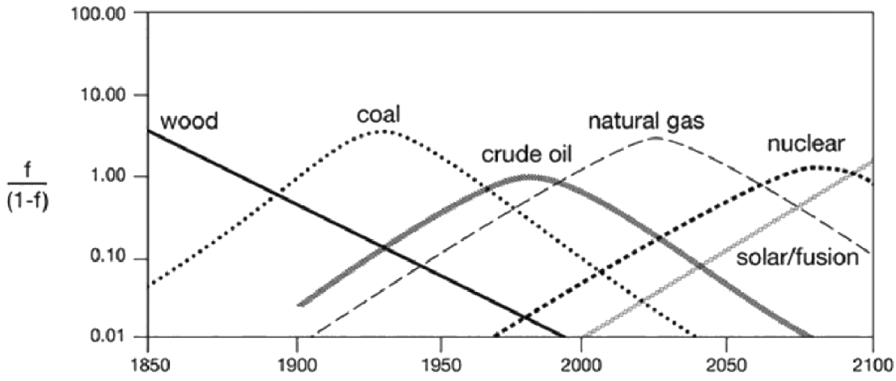

FIGURE I.1: Cesare Marchetti's model "Historical Evolution of the Primary Energy Mix for the World." 1850–2100. *f* = market fraction of an energy. *Source*: Cleaned image of Marchetti's diagram from Vaclav Smil, *Energy Transitions: Global and National Perspectives* (Santa Barbara, CA: Praeger, 2017), 84.

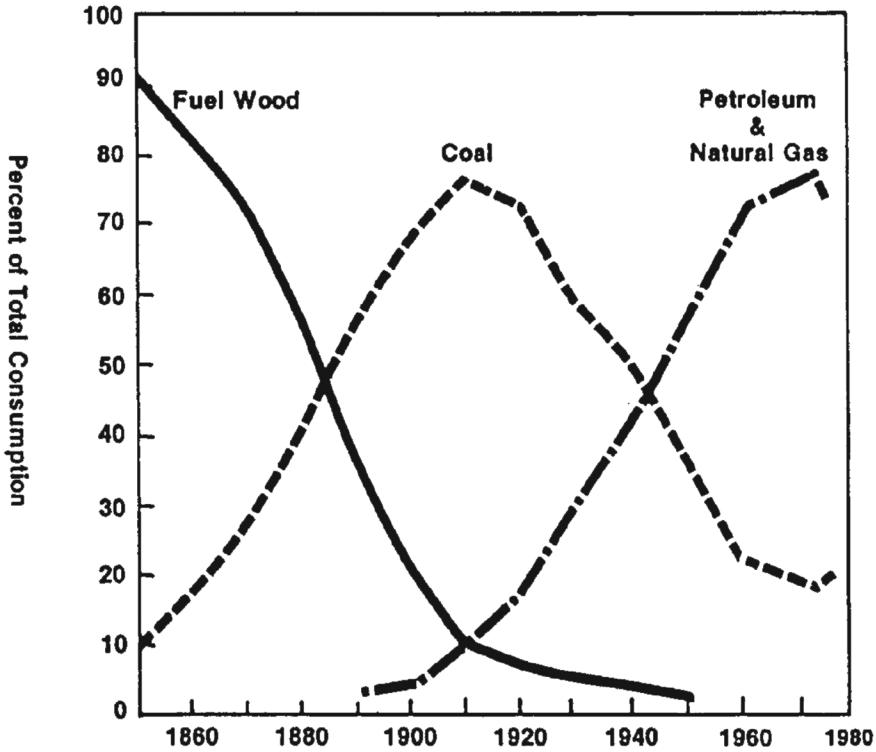

FIGURE I.2: Historical fuel shifts according to President Jimmy Carter's 1977 National Energy Plan. 1860–1980. *Source*: Frank Laird, *Solar Energy, Technology Policy and Institutional Values* (New York: Cambridge University Press, 2001), 114.

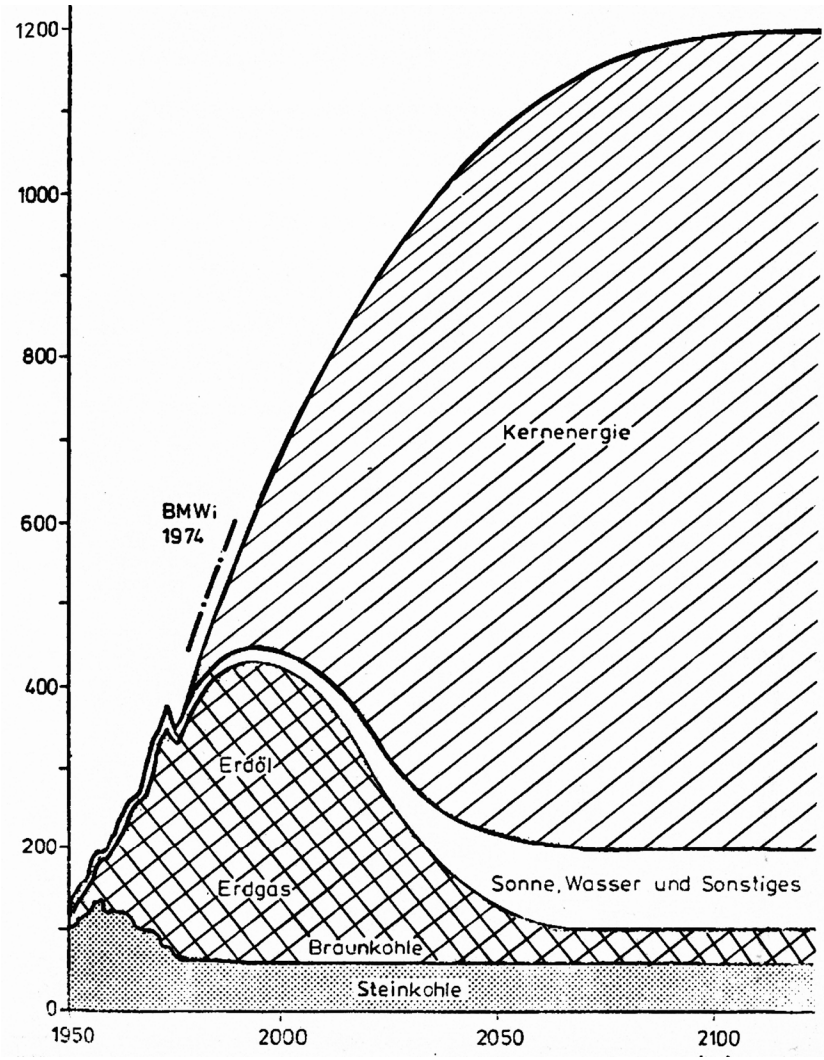

FIGURE 1.3: First scenario forecast for West Germany's primary energy consumption, in the Social Democratic Party's Energy Forum of 1977. 1950–2100. Million tons of hard coal equivalent. *Kernenergie* = nuclear power; *Sonne, Wasser und Sonstiges* = sun, water, and miscellaneous; *Erdöl* = oil; *Erdgas* = natural gas; *Braunkohle* = lignite coal; *Steinkohle* = hard coal. *Source*: SPD, *Energie: Leitfaden zur Diskussion* (Bonn: SPD, 1977), 52.

are approaching global warming with historical assumptions about energy that have changed little since the 1970s. One hopes for a transition toward renewable sources of power like the sun and the wind. But the models informing public debate today—whether historical, digital, or cognitive—bear an eerie

resemblance to earlier ones. In his famous appeal to repower the United States in 2008, former vice president Al Gore claimed the United States could adopt a carbon-free electricity network within decades. A year later Mark Jacobson and Mark Delucchi, engineers writing in *Scientific American*, suggested the world could achieve 100 percent renewable energy in twenty years. Ten years on they remained firm in their timeline, illustrating it with smooth curves of rising renewables and falling fossil fuels.[2] Many advocates of solar and wind claim this transition not only "mirrors" previous ones, but that the move from "fossil fuels to renewables has become inevitable" as costs fall. As Bruce Usher puts it, "Basic economic principles, primarily cost, are the main drivers of energy transitions. Cost is key."[3]

This narrative of grand sweeping curves, where transitions are defined by efficiency and price, is comforting: if only we can lower the cost of solar or wind, we can solve global warming. Or at least be on our way. But energy shifts are far more complex, far more human, and in fact far more interesting than lines on a graph, efficiency ratios, or prices. Historians have unearthed this complexity; they have a long tradition of studying the human side of energy in its many facets, even if histories of energy have often been fragmented into different wings of the discipline, from environmental history to the history of technology or diplomacy.[4] Despite this fragmentation, three points stand out in more nuanced histories of energy: (1) commercializing a new energy infrastructure involves protracted processes of political and economic change, (2) new energies almost never wholly replace old ones, and (3) the causes and effects of transitions reach far and wide, changing people's lives in unexpected and profound ways.

Since roughly 2010, diverse strands of historical study have been coalescing into a new field of energy history, a coalescence that motivated this volume. The chapters here explore the causes, courses, effects, and aftershocks of energy transitions in North America and Europe during the twentieth century. They not only historicize popular and economic notions of energy but also show how energy has reshaped everything from social life and economic organization to political governance. The volume draws on a range of historical approaches—including intellectual and cultural history, labor history, and political economy—to understand why some energy systems flourish while others do not, and to capture the cultural, intellectual, and political implications of new energy systems as they struggle to take shape. Over the past 250 years, energy transitions have occurred at a seemingly relentless pace—the rise of coal in the nineteenth century, the explosion of oil in the twentieth century, the nuclear utopianism of the 1950s and 1960s, and today the expansion of renewable power. These transitions have been as revolutionary as any

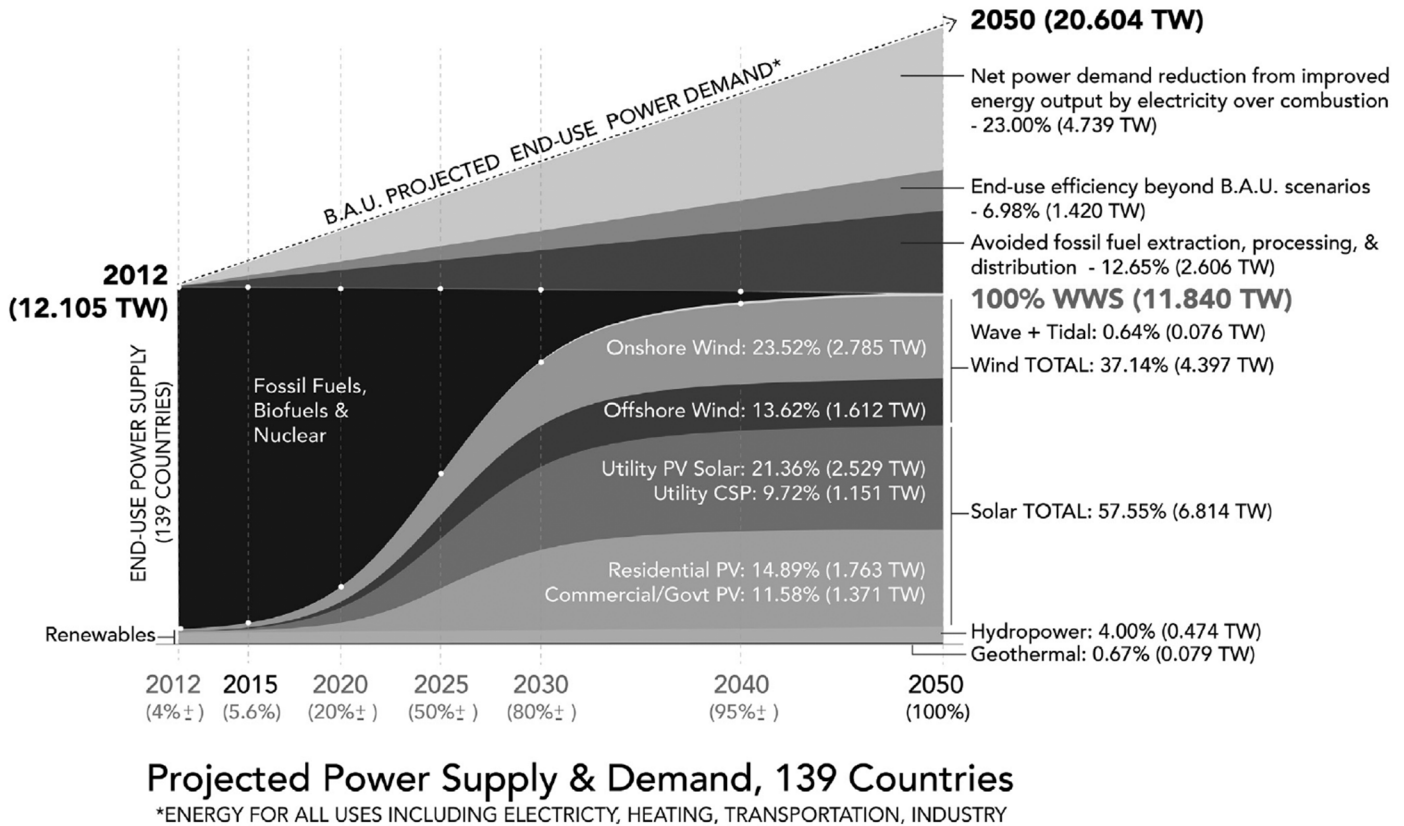

FIGURE 1.4: "Projected Power Supply & Demand, 139 Countries." From Mark Z. Jacobson et al.'s "100 Percent Renewable Energy Roadmap for the World, 2017." 2012–2050. *Source*: Mark Z. Jacobson et al., "100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World," *Joule* 1 (September 2017): 118.

political or economic upheaval, but they have rarely featured in the grand narratives of twentieth-century Europe and North America.[5] Given the urgency of global warming, historians have a twofold task, which we hope to advance with this volume. We must do more to integrate a history of energy transitions into broader narratives of political, economic, or cultural change. And we must do more to bring our knowledge of the complexity and humanity of energy to the current debate—shaped in large part by economists, engineers, and scientists—over what could be the most monumental energy transition ever: the shift away from fossil fuels. In doing so, we aim to steer the public away from, on the one hand, doom-saying narratives of the impossibility of meaningful transition and, on the other, stories of revolutionary technological fixes driven by heroic individual entrepreneurs. Only by attending to the socially complex and technologically messy histories of energy transitions as they occurred can we provide a past usable for the present moment.

WHY ENERGY NOW?

Since the turn of the twenty-first century, global warming has emerged as the world's most pressing challenge. This wicked problem has led scholars to craft not only a new geological label but also a new category of analysis, the "Anthropocene," a concept coined in 2000 by Paul Crutzen and Eugene Stoermer to describe how humans are becoming a force of nature in their ability to alter the environment. While there was a delay between the uptake of this term by the natural sciences and the humanities, with the publication of Dipesh Chakrabarty's "The Climate of History" in 2010, the Anthropocene as a historical concept arrived. Chakrabarty's work sparked a debate about the origins of the Anthropocene, with starting points ranging from humanity's very nature as an extinctive species, to the Agricultural Revolution or Industrial Revolution, to the advent of the atomic age.[6]

Embedded within this debate are fundamental questions about how to understand human-driven environmental transformations. Historians have a rich tradition of studying the environment. Until recently, however, energy existed at the relative margins of environmental history, often surpassed in importance by themes such as wilderness management, agriculture, urbanization, water use, and forestry.[7] The urgency of the Anthropocene, however, has foregrounded the study of energy. For if the Anthropocene elevated global warming as *the* challenge of our century, it also illustrated the importance of studying fossil fuel energy systems, because these have accounted for 70 percent of all of the carbon humanity has emitted since 1870. At the heart of environmental degradation and climate change is the extraction, distribution, and consumption of energy.[8]

The need to understand how energy-intensive, fossil fuel–centered, growth-oriented societies came to dominate the world is thus more important now than ever before. As Stephen Gardiner presciently underscored, global warming is "seriously backloaded," making it different from other historical events that diminish in importance the further they recede into the past. Carbon from human sources, by contrast, has flowed into the atmosphere in ever greater quantities since the Industrial Revolution, gaining transformative power as it intensifies in the atmosphere.[9] Historians, in other words, can offer a unique perspective to help understand how and why global warming began, how it accelerated, and why it is proving so difficult to halt. A wave of recent studies, what one might call a "New Energy History," have recognized this, placing energy extraction, production, transportation, distribution, ownership, and consumption at the center of their narratives.[10]

Energy has also gained new attention from historians for reasons entirely unrelated to climate change, like the renewed interest in capitalism and inequality. Even before the financial crisis of 2007–2008, historians returned to the economy to understand the formation of the great disparities of wealth that were becoming more apparent in the twenty-first century. They strove to integrate a study of ideas, values, and identities with material life and interest groups.[11] The financial crisis, the worst global economic downturn since the Great Depression, lent urgency to this task of historicizing the economy, a sentiment captured by Thomas Piketty's groundbreaking study on capital and inequality. Historians working in similar veins have sought to understand how markets were constructed over time intellectually as well as institutionally or politically, and thus to learn why they have gone horribly awry as often as they have yielded positive benefits: disempowering labor and minorities, forcing millions into unemployment through periodic crises, or polluting nature as much as they have lifted people out of poverty or stimulated technological advances.[12] Karl Polanyi and Karl Marx superseded Adam Smith as the channel through which historians approached capitalism, inspiring critical studies about the changing form of economic governance throughout the twentieth century—from classic liberal capitalism to Keynesian or social democratic capitalism to neoliberal capitalism.[13]

All varieties of twentieth-century capitalism, however, required vast amounts of energy. One does not have to be an energeticist like Frederick Soddy or Lewis Mumford—early twentieth-century thinkers who saw energy as the root of all value—to appreciate that capitalism has historically excelled at organizing different technologies, institutions, resources, and laborers to convert energy into economic work. The consumption of energy is, in fact, deeply correlated with wealth, and one of the most powerful markers of global in-

equality. Great Britain's pioneering transition to sustained economic growth in the eighteenth and nineteenth centuries hinged on the exploitation of coal on a new, mass scale. The United States' hegemonic position in the global capitalist order after World War II involved its astounding lead in energy consumption per capita: more than twice as much as its nearest rivals. In 2019 the average US resident consumed nearly eighty thousand kilowatt hours a year; those in Germany and France roughly forty thousand; those in Chad, Niger, Mali, or South Sudan less than one thousand. The reasons for such incredible disparities in energy consumption, of course, have a history.[14]

The perceived decline of the nation-state, meanwhile, encouraged historians to turn their attention to the new captains of globalization: corporations.[15] In American historiography, financial corporations often took center stage in this new history of capitalism.[16] Yet in many ways energy corporations, not banks, have been the largest, most influential, and most globalized companies of the twentieth century. Take ExxonMobil, itself a descendant of Standard Oil, one of the world's most powerful corporations before it was broken apart in 1911. Today, ExxonMobil has a market capitalization of over $300 billion, conducts business in dozens of countries, and builds infrastructure in dozens more.[17] It, and other energy multinationals, have constructed business models designed to shield operations from social control on the local level while obscuring profits from state control through interlocking "offshore" subsidiaries.[18] In the words of the oil industry's leading chronicler, firms like these belong to the "world's biggest and most pervasive business." In 2018 six of the world's ten largest corporations were energy firms, while two more were automobile manufacturers whose business models are unthinkable without gasoline. The production of energy stands as much at the heart of capitalism as does the flow of money: indeed, coal and oil have been called, with only a little hyperbole, the "mainspring of modern material civilization" or the "lifeblood" of modern economies. As historians have returned to capitalism as a subject, studies about energy production, distribution, and consumption, and the firms that control these channels have multiplied, yielding new insights about growth, inequality, class identity, and the geography of markets.[19]

From still a different angle, the history of commodities and the supply chains that bring them into shopping centers and homes has changed the way we think about global connections. Histories of salt, cod, pepper, coffee, paper, sugar, cotton, or even the T-shirt have lifted the hood of the engine of globalization to reveal intricate networks of production, distribution, and marketing. These studies have illustrated how the labor forms and the institutions used to produce and distribute a given commodity vary immensely depending on their position in a global supply chain, promoting democracy and wealth

and protecting nature in one region while undermining polities, impoverishing people, and damaging the environment in another.[20] This approach of following the flow of a commodity from start to finish reveals the points at which different actors can insert themselves in order to reap economic gain, achieve leverage over people or resources, and even shape the evolution of states and societies.[21] Many of the commodities studied in these histories are raw materials, taken from the earth and used in products and processes that we take for granted. In many ways, energy is the raw material par excellence because it is so essential to modern life, both industrial and postindustrial. It lends itself to spatial analysis as a variety of recent histories have illustrated, which trace the supply chains that render particular forms of energy useable, and which connect points in space or historical processes that have traditionally been considered in isolation.[22]

TOWARD A NEW HISTORY OF ENERGY TRANSITIONS

Together, global warming and the Anthropocene, the new history of capitalism, and the study of commodities have turned energy into a dynamic historical field. Fortunately, historians today have much to build upon, for there is a long precedent in showing how energy shaped human affairs. Already in the 1930s John Nef authored a two-volume study unsurpassed in its detail of showing how coal influenced everything from capitalism and political power to the ecology of forests in early modern Great Britain.[23] In 1983 Thomas Hughes traced the rise of massive new technological systems that brought electricity into the households and urban centers of North America and Europe. Understanding these energy networks, he hoped, would do nothing less than help scholars tackle the big questions of history, about "the ordering, integrating, coordinating, and systematizing nature of modern human societies."[24] And since the 1990s and 2000s, our understanding of the Industrial Revolution, or what many scholars now call the Great Divergence, has hinged not only on questions of imperialism, slavery, institutions, and trade, but also on coal.[25]

Yet "energy" as such was often not the object of these earlier, discerning studies. Instead, they focused on discrete forms of energy, like anthracite or wood, or on particular technologies or organizations that delivered energy, like multinational oil companies or electrical utilities. These earlier authors, in other words, were less interested in energy as a historical category or how contemporaries conceptualized energy than in exploring individual energy forms and using them to answer questions about other topics such as industrial development, the interconnectivity of "socio-technical arrangements," or economic institutions.[26]

Toward the end of the twentieth century, energy became its own catego-

ry of analysis, but with a few important exceptions it fell under the purview of economists.[27] After the oil crisis of 1973, economists revived frameworks for understanding the nature of exhaustible resources, and economics as a profession began including energy in their models alongside labor, capital, and land.[28] Quantitative economic historians followed this trend and began looking to the past for empirical evidence of how energy related to economic growth, the totem of post–1945 economic theory.[29] They put moments of transition between fuel sources at the center of their analysis about energy's causal role in historical changee. For the Industrial Revolution, arguably the seminal event of energy history in European and American historiography, the work of E. A. Wrigley, Robert Allen, Peter J. G. Pearson, and Roger Fouquet from the mid-1990s on defined a paradigm that placed price, scarcity, and technology at the heart of the story. Through the painstaking reconstruction of long-run data sets on population, gross domestic product (GDP), and the prices of wood, charcoal, and coal, they mapped the contours of British economic history in minute detail. In their hands, the Industrial Revolution was redefined as an energy transition, one of the most momentous in history, from an organic society fueled by wood, grain, and the muscles of animals to an inorganic economy driven by coal. And the mechanisms of change were straightforward. As population and the economy grew, wood and land—the dominant sources of energy before the eighteenth century—became scarce. Their prices rose, encouraging the substitution of new energies through new technologies. In Britain, so this argument went, rising wood and land prices induced producers and consumers to turn to coal on a grand scale.[30] The crucial breakthrough came when engineers, driven by price incentives, improved the steam engine so they could use coal not only for heat but also for mechanical power to run factories and power railroads. In the words of Robert Allen, "High wages and cheap energy were the distinctive features of the British economy during the Industrial Revolution . . . creating a demand for technology that substituted capital and energy for labour."[31] Expanding scope beyond Britain only seemed to confirm economic historians in their paradigm. In a lead editorial for the journal *Energy Policy*, for instance, Fouquet and Pearson could write that "a review of 14 past transitions indicated that, for a new energy source to become dominant, the energy services . . . it provided had been cheaper than the incumbent energy source."[32] Price and efficiency, in their hands, were the kings of transitions, and technology the queen.

Yet in the process of unearthing amazing statistical series that yielded new insights, these historians of transitions veered too far into the macro and the structural. The drama was gone. The human agency or conflict fell out of view in the face of impersonal forces. When these economic historians spoke of

lock-in—how energy systems once in place built their own momentum—they rarely discussed the producers, consumer groups, or businesses that lost out or reinvented themselves because they backed the "wrong" system.[33] When they traced the rise of new fuel sources, they rarely had a place for geopolitics, labor struggles, cultural shifts, or even states, which do "not seem to have played a highly proactive role in previous transitions."[34]

At the most extreme, a picture emerged of an almost steady progression through virtuous feedback loops toward ever more efficient fuels driving ever more energy-hungry societies: a stagism devoid of contingency. In 2012 a special issue on energy transitions in the leading journal for energy policy could even posit a historical pattern: "New technological combinations enabled entirely new, or vastly improved traditional services, at greater energy efficiency and ever falling costs in a virtual, self-reinforcing positive feedback loop."[35] The spirit of Cesare Marchetti, it seemed, was alive. So it should not be surprising that advocates of renewable power today who follow this paradigm place their hope in sending the right "price signal," that they speak of climate change as "fundamentally a technological challenge," or that they argue moving to wind, solar, and biomass will benefit everyone and generate little resistance.[36] "Increased deployment of clean energy technologies . . ." so the International Renewable Energy Council argues, "translates to increased economic opportunities. And everyone can find a way to support that."[37] Even ExxonMobil?

These accounts, however much they have expanded our understanding of past transitions, paint a narrow historical picture. This is, after all, the nature of models that aspire to aid policy for the future: they strive for simplification. But where is the conflict in energy transitions? Where are the politics? Where is the human agency—for or against transition? Where is the knowledge of energy—as a social category, a scientific object, or an instrument of power? These are all burning questions that historians have posed with ever more urgency since 2010, against the backdrop of global warming and financial crisis. Indeed, a range of new monographs written by historians in history departments, or by unorthodox social scientists, have challenged the narrative that emerged in the 1990s and 2000s, pointing the way toward a new approach to energy history that foregrounds struggle, ideology, class, knowledge, geopolitics, culture, and geography. New monographs that combine a history of capitalism with the environment around the theme of energy have forced us to rethink everything from Britain and the United States' industrialization, to the Cold War experience with nuclear power, to the very foundation of democracy itself.[38] New studies about struggles over labor, over language, or over political economy have helped turn "energy" into a category of analysis that

can bring together historians of various ilk to reopen some of the most basic questions about change in society, about the nation-state, globalization, politics, capitalism, and identity.[39] As even Pearson, a pioneer of the data-driven studies of the 1990s and 2000s, himself now writes, social scientists have come to appreciate the "multifaceted nature" of energy transitions. Past transitions cannot be explained by price alone; they have "co-evolved or been entangled with other broader socio-economic, demographic, technological and environmental changes and processes."[40]

WHAT IS AN ENERGY TRANSITION?

But what do we even mean by an "energy transition"? The concept itself evokes images of a linear shift from one stage to another. In fact, this was how it was first used and politicized in the 1970s. As a concept that initially related to the pure chemical transformation of one energy into another, *energy transition* was popularized by the technocratic response to the oil shock of 1973. Experts hoped to defend North America and Western Europe from the "oil weapon" deployed by the Organization of Petroleum Exporting Countries (OPEC) by facilitating an energy transition. President Jimmy Carter, the Trilateral Commission, and the European Economic Community (EEC) all used the language of transition to develop more hydrocarbons outside of OPEC territory.[41] But this is hardly the type of transition one hopes for in the age of global warming, and the term itself harbors the danger of obscuring the messiness of new energy systems by suggesting transitions can be rationally managed, or that they proceed in a linear or straightforward manner. In fact, some doubt the concept can fully capture the complexity of changing infrastructural, technopolitical, or knowledge systems around energy. Christophe Bonneuil and Jean-Baptiste Fressoz, for instance, argue that "if history teaches us one thing, it is that there never has been an energy transition . . . rather a successive *addition* of new sources of primary energy." Using *transition* as a concept, in their view, obscures the extent to which the old remains and the new merely brings forth ever more consumption of energy.[42]

Nevertheless, many historians use *transition* with care, and remain keenly aware that older systems never wither, and instead often adapt and expand.[43] Transition, moreover, is not merely a cover for some form of crisis—in an extant energy system or in society more broadly—as Bonneuil and Fressoz suggest, since in many cases societies incorporate new forms of energy and build new infrastructure during periods of stability. Natural gas is the most telling example, which much of Western Europe first began using before the shocks of the 1970s, and which the continent only fully integrated well after the effects of those shocks had passed, during the 1980s and 1990s.

More generally, the concept of energy transition adds value if one understands transition less as a discrete, punctuated shift from one stage or system or fuel to another, but rather—to draw from the new histories of capitalism—a layering and an "ongoing transformation" that leads to new and "hybrid" forms of energy provision, energy services, and energy consumption, a transformation that can reshape society in the process.[44] Much as transitions to capitalism or the nation-state have all been deconstructed, to show how elements of older systems persist, adapt, and become crucial to newer ones, so too should historians work to expose the less visible transformations that arise out of transitions, whether they be new economic geographies, new political values or morals, new knowledge systems or discourses, or even new temporal or mental frameworks.[45] All of this complexity is obscured if one abstracts energy transition into a line on a chart or a price for a fuel.

Using this broader approach, our volume emphasizes five pivotal themes of energy transitions, some of which have often been overlooked by earlier literature. Most fundamentally, energy on the scale required by modern societies has historically come through systems of vast complexity, a fact that informs most chapters in this volume. Energy production and consumption can be understood as a socio-technical system that includes humans, materials, technologies, and ideas, as well as the particular energy itself. The infrastructure needed to extract, refine, and transform energy into something usable—the networks of ships, roads, trucks, and pipelines that move energy from the point of extraction to the point of consumption—forms an interconnected system worth trillions of dollars of investments built up over decades. But beyond its physical presence, energy systems also shape how people "work, play, eat, and socialize, . . . how industries cluster, how cities and economies grow, and how nations conduct their foreign affairs."[46] The components of energy systems are so interlinked, moreover, that change in one often ripples through and affects other elements and participants, and crucially, other energy systems. As Clark Miller and others have underscored, the key decisions to study are often political, social, or cultural as much as they are technological or economic.[47]

Second, this volume shows how prices and technological efficiency, or producer and consumer desires alone, cannot fully explain why one energy rises, another falls, and another reinvents itself, as chapters by Joseph Bohling, Stephen Gross, Victor McFarland, Eva Oberloskamp, Sonja Schmid, and Benjamin Franta demonstrate. Energy systems are embedded in a broader political economy of interest groups that have their own networks and agendas, whether seeking profit, preserving the environment, or attaining geopolitical security. Energy transitions, put differently, are profoundly shaped by competition

between various groups to mobilize the levers of power at their disposal to advance one energy or restrict another, or to change the extant system. Price and profit are important to the success of any new energy, to be sure, since modern transitions have unfolded through a global capitalism in which energy providers must earn a return on their investments. Yet price and profit are never everything, for states, consumers, workers, experts, and environmental groups all use politics to reshape the economic playing field, and to pursue agendas that make little sense in the logic of the market. States in particular have interests that range from geopolitics to social security and prestige. These interests often overlap with the quest for inexpensive energy, but not always. Governments have historically favored geopolitically secure energy sources, sources that generate domestic employment and social stability, or sources that are considered part of the national culture, even when their costs are high. In any case, what is cheap and what is expensive is rarely determined by supply and demand alone, as markets are political constructs that require state-made rules to function, that are shaped by incentives created by states, and that are embedded in larger global markets. Who has access to the levers of government, or who has arguments that resonate with the voting public, thus matter immensely. Energy transitions cannot be understood apart from the constant ebb and flow among interest groups and political parties to shape energy policy.

Third, these chapters illustrate the staying power of older energy systems, showing how these have historically been reinvented in any number of ways to remain a vital part of modern societies, as chapters by Ryan Driskoll Tate, Trish Kahle, and Henning Türk show. This is so above all for coal. Merely looking at a different sort of graph than those used by Marchetti—graphs that display the total volume of energy consumed rather than their relative shares—one sees how voluminous the consumption of coal has been throughout the twentieth century. Even after oil became the dominant energy, coal retained a place at the heart of the industrial societies of Europe and North America, rising in absolute levels in the final quarter of the century. More coal was consumed on these continents in 2000 than in the 1960s.[48] Coal survived because firms, workers, governments, consumers, labor leaders, and international organizations reinvented it as an energy: shifting its geographical locus, revolutionizing the technologies used to produce it, changing people's attitudes toward it, reimagining its place in an evolving geopolitical landscape, and even altering the very nature of coal consumption. Coal's importance as a fuel for transportation or chemistry diminished in the face of oil's rise, but nevertheless it remained an essential part of the foundation of the high energy consumer society that emerged after World War II. Huge new coal-fired pow-

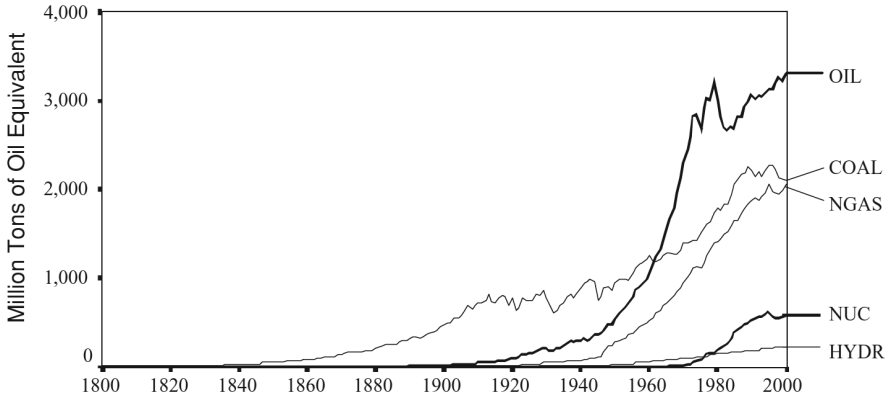

FIGURE 1.5: World Commercial Energy Production. 1800–2000. *Source*: Bruce Podobnik, *Global Energy Shifts: Fostering Sustainability in a Turbulent Age* (Philadelphia: Temple University Press, 2006), 6.

er plants located far from city centers facilitated mass electrification while at the same time making the production of energy, and much of the ecological degradation that came with it, seem invisible to many urban consumers. Novel machinery permitted the rise of new coal regions and eroded the power that labor organizations derived from coal, altering the very nature of coal's politics. Indeed, twentieth-century coal is an outstanding example of why we need a more capacious understanding of energy transitions, one that captures how old and new energy systems often exist side by side, and how their interaction can lead to mutual intensification and transformation.[49]

Fourth, energy transitions change the way we think, not just about energy itself but also about larger issues such as political representation, knowledge, and even time, as chapters by Trish Kahle, Natasha Zaretsky, Duccio Basosi, Thomas Turnbull, and Dolores Augustine demonstrate. Because energy transitions are contested processes, with winners and losers, the tensions they generate lead people to reevaluate long-standing assumptions that govern society. Entirely new costs associated with emergent forms of energy became apparent during transitions, costs that go beyond economic measures to include human life itself, or the lives of future generations, or the lives of people living in other political spaces in other parts of the world. How should representative democracies handle these spatial and temporal questions, given that only citizens who are currently alive have the right to vote? How should politics handle an energy like nuclear power, which has the potential to threaten not only individual lives but humanity as a species—a threat that first appeared with the atomic bomb in 1945? How should the concerns that emerged about

the danger nuclear power posed to the future shape our understandings of the future of global warming? Who, moreover, can be entrusted to provide the knowledge to guide such social decisions, given that established science has itself been one of the forces pushing fossil energy and nuclear power in the first place? These questions have defied easy answer, and the process of trying to answer them has historically transformed the nature of representation and expertise in Europe and North America.

Finally, energy transitions can transform the very political and economic geography of a nation or even the world, as chapters by Tate and Schmid demonstrate. Fossil fuels come from the earth, and thus the discovery of new sources can shift the center of production and transform the flow of these commodities as new networks arise to bring supplies to the consumer. Changes in energy geography, however, can affect more than just prices—they can lead to new political alliances, new ways of conceptualizing politics, new relations of dependency or influence, and new secondary effects that outlive the primary reason an energy source was tapped in the first place. The geographical relocation and technological transformation of mining in the United States during the 1960s and 1970s, for instance, transformed the politics of coal as the mining workforce migrated from the political Left to the Right. Nuclear energy promised to liberate states from previous forms of foreign influence, but in fact, it just as often created new channels of dependency after crucial parts of this complex technology were monopolized by powerful actors like the United States or the Soviet Union.

The concept of energy transition, in other words, if broadened to mean more than just the rise of a new fuel source, can capture the evolving way humans use energy to achieve their many goals. How this evolution fundamentally changes the nature of society, from the distribution of wealth, power, and inequality, to the way politics, time, and geography are imagined, lies at the heart of this book.

TRANSITIONS IN NORTH AMERICA AND EUROPE

Geographically, this volume focuses on North America and Europe. We chose these regions partly because they reflect the expertise of the two editors—one an Europeanist, the other an Americanist—and because we hoped to emphasize depth over breadth of coverage. Energy transitions in the twentieth century is an enormous topic, and by limiting the geographical scope we hoped to find energy stories that spoke to and built on one another. This constraint allows the volume to focus on questions of political economy, culture, and ideology in the high energy, consumer societies of the Global North, and on issues of labor mobilization related to the procurement and distribution of domestic

energy sources such as coal. Unfortunately, our geographical focus does rule out other important lines of inquiry that research into energy transitions can open up, above all about transnational entanglements and the flow of energy across space. There is a developing literature on the movement of hydrocarbons from the Middle East or Russia to Europe in the second half of the twentieth century, for instance, which traces how the transition to a high energy society in one region shaped extraction, labor relations, or the environment in another. More recently, understanding carbon outsourcing from North America and Europe to the most important energy region in the twenty-first century, China, has become increasingly urgent. Both sorts of flows—oil to Europe, energy-intensive manufacturing out of China—represent outstanding topics for future research that this volume set aside in its focus on political economy, culture, and ideas in Europe and North America.[50]

North America and Europe, though, share certain commonalities as the first regions to transform into energy-intensive consumer societies—what David Nye has called "high energy societies." There is a certain logic, in other words, for uniting histories of these two regions into a single volume on energy transitions. These two regions were the first to experience the energy transitions studied in this volume. Many of the new technologies driving these shifts, from thermal cracking of oil to controlled nuclear fission, were developed in either Europe or North America. More generally, these two continents have been at the forefront of energy consumption. At the turn of the twentieth century, North Americans and Europeans already used far more energy per capita than consumers in Asia, Africa, or South America. This gap only widened over the first two-thirds of the century as the economies of North America and Europe and their wealth per capita expanded dramatically, as they began burning oil in huge volumes, and as their consumer lifestyles and industrial systems came to depend on ever more energy. By the 1970s, these continents together accounted for over half of global GDP, and their GDP per capita was eight to ten times higher than much of Africa or Asia. These differences between the Global North and Global South appear even starker when examined through the lens of energy. As North America and Europe passed through an unprecedented phase of growth between 1950 and 1973—the so-called Great Acceleration that saw dramatic increase in many measures, from welfare to life expectancy to fertilizer usage to pollution—they widened the gap with other continents. By the 1970s, North Americans and Europeans consumed three-quarters of all energy produced in the world, even though they numbered less than a quarter of global population. And energy consumption corresponded closely with carbon emissions. Precisely because North America and Europe became the world's first high-energy, oil-soaked

societies, they also sparked the onset of global warming. By 1990, when scientists began to reach a consensus that fossil fuel use was warming the planet, North America and Europe together were responsible for three-quarters of the cumulative human-generated carbon in the atmosphere.[51]

These continents developed such massive carbon footprints because they followed a trajectory of growth that had been energy-intensive for two hundred years. In the eighteenth and early nineteenth centuries, new technologies of mining and the steam engine permitted the states of Europe and North America to tap energy on a grand scale that had had previously been converted by geological forces from organic matter into anthracite, bitumen, and lignite.[52] In the twentieth century, North America and Europe deepened this path of energy-intensive growth as they led some of the most important energy transitions: the rise of oil at mid-century and the concomitant transformation of coal, the technological revolution and state development that led to nuclear power, and after the 1980s the dispersion of new forms of decentralized, renewable power that potentially challenged fossil fuels.

These three twentieth-century transitions, plus the shock to the global oil network in the 1970s, are the organizing pillars of *New Energies*. These two continents, however, channeled energy transitions through different social, political, and cultural institutions, and herein lies part of the novelty of this volume—comparing the path and effects of energy shifts across space as well as time

Part I, "The Rise of Oil and the Transformation of Coal: Creation, Destruction, and Reinvention," explores the interaction between energy systems that were based on coal and oil, through an arc of time that stretches from the 1920s to the 1970s. Oil had been used as a fuel throughout history, but during the twentieth century it penetrated into vast new areas of consumer society. With the growth of the lamp oil industry in Burma in the 1800s, and the gusher of crude that exploded near Titusville, Pennsylvania, in 1859, entrepreneurs had started to commercialize oil on a grand scale. At first oil filled tertiary needs created by the coal-fired industrial order of the late nineteenth century—lubricating mining machinery, for instance, or providing lighting for cities heated by coal. But by the twentieth century oil began moving out of secondary markets that complemented coal to become a rival to many of coal's core markets—in industry, heating, and chemistry, but above all in transportation with the emergence of inexpensive, gasoline-powered automobiles.[53] By the middle of the twentieth century, the oil industry would grow to encompass the entire world with massive multinational petroleum corporations, what contemporaries dubbed the "oil majors," spreading their networks

across the Middle East, South America, sub-Saharan Africa, and Central and Southeast Asia.[54]

By mid-century, if not earlier, North America and Europe consumed oil on a larger scale than anywhere else, apart from particular oil-producing countries like Mexico or Saudi Arabia, and economies with entire ecosystems of industry, transportation, and consumer products that revolved around oil first took root. In the process, this new hydrocarbon network reshaped coal systems by putting them under stress. Chapters 1–4 dive into key problematics stemming from this energy transition and interaction between oil and coal, exploring the political economy of interest groups that navigated the rise of oil in France, Germany, and the United States, and tracing how coal producers and workers reacted to the onslaught of this cheap new energy. At first, crude oil had to contend with other rivals to fuel the internal combustion engine, above all biofuels, as Joseph Bohling illustrates in chapter 1. As oil use spread, in some instances coal as an energy system actually declined, as Stephen G. Gross describes in the case of hard coal mining in Germany's Ruhr in chapter 2. In many other instances, however, coal evolved in response to the new energy landscape, changing in terms of its geography, its uses, and even in how it was extracted and imagined, as Trish Kahle and Ryan Driskell Tate recount in chapters 3 and 4, respectively. And in important respects, coal thrived: as oil brought more growth and accelerated the rise of a high energy society, coal powered the expanding grid that supported new consumer lifestyles. High energy society, in fact, revolved around two icons—one rooted in oil; the other in coal—the car and electricity.

Part II, "Oil Transition in Crisis: The 1970s," follows how the high energy societies of North America and Europe navigated an unprecedented peacetime shock to their energy systems. By the early 1970s, both continents had come to depend on oil for roughly half their total primary energy needs. This fuel facilitated the incredible growth experienced by both sides of the Atlantic after World War II. And by the 1970s, much of this oil came from the Middle East and North Africa: production there influenced prices around the world and provided most of the petroleum consumed in Western Europe. But in the fall of 1973, the foundation of this system was put into question when countries in the Middle East and elsewhere used their newfound market power vis-à-vis international corporations to raise the price at which they sold crude on the global market fourfold, advancing a bid to wrest back sovereign control over this resource found in their own territory. Chapters 5–8 explore how North Americans and Europeans responded to this "oil shock," the shadow of which lasted into the 1980s.[55] For the crisis posed not only economic and geo-

political challenges to the states of these continents, as Victor McFarland and Henning Türk illustrate in chapters 5 and 7, respectively. It also opened a window of opportunity for these societies to imagine and conceptualize a transition away from fossil fuel–centered, energy-intensive growth, as recounted by Duccio Basosi and Thomas Turnbull in chapters 6 and 8, respectively. While this window closed before such a shift could occur, developments in the 1970s nevertheless laid the foundation for later efforts to build a post-petroleum world.

Part III, "A Stalled Transition? Nuclear Energy's Dilemmas and Possibilities," explores a twentieth-century energy transition that was never fully realized: the turn toward nuclear power. As with the spread of oil and the transformation of coal, North America and Europe commenced a nuclear energy transition before other regions, by crafting the scientific networks, political institutions, and infrastructure to commercialize this new source of electricity. American and European scientists first theorized about splitting the atom before World War II; they weaponized these ideas with the atomic bomb during the war; and after 1945 they, along with the Japanese, first linked nuclear reactors to the grid. As a result, these societies were some of the first to grapple with the unprecedented nature of atomic power, which posed an existential threat to humankind while at the same time offering hope of radically improving life, satisfying the world's energy needs at all times, and opening pathways for resource-poor states to achieve geopolitical autonomy from the fossil fuel networks that had emerged over the preceding century. The contributions by Sonja D. Schmid, Natasha Zaretsky, and Dolores L. Augustine in chapters 9, 10, and 11, respectively, explore the contradictions generated by this new energy, following the rise of nuclear utopianism in the 1950s, the vast plans for nuclear expansion in the wake of the oil shock, and the erosion of that momentum as a result of cost problems, safety issues, and grassroots movements. These chapters provide a counterview to conventional narratives by illustrating how atomic power generated new anxieties that revolved around human reproduction, and focusing on issues often left unexplored in traditional energy histories, such as political representation, gender, the nature of expertise, and the path dependencies generated by technological transfers.

Part IV, "The Transition off Fossil Fuels: Challenges and Possibilities," completes the volume by discussing the origins and challenges of what could be the next great energy transition, the shift off fossil fuels toward renewables. Even though solar and wind power have histories that began well before the twentieth century, environmental historians often portray the 1970s as the decade of origin for modern renewable energy.[56] The dramatic spike in oil prices,

the fears of resource exhaustion, and the surging environmental movement led certain groups to seek salvation in new sources of energy that could be replenished. But as chapters 12 and 13 illustrate, this process was far more complex and less linear than most narratives suggest, and here again, questions of price and efficiency are only part of the story. In fact, the 1980s and the 1990s emerge as crucial decades in the history of renewables and their relationship with fossil fuels. For the initial desire to cultivate wind and solar in the 1970s came more from fears that the world would run out of hydrocarbons, not that burning hydrocarbons would generate catastrophic climate change from too much fossil fuels. When a wave of new oil discoveries shattered the market power of OPEC in the early 1980s, causing oil prices to plummet, this initial raison d'être for renewables disintegrated. But, as Benjamin Franta recounts in chapter 12, well before this moment the oil industry realized global warming was a likely outcome of their business model, and they began generating knowledge to counteract the moment when climate change would become politicized. That moment came in the 1980s with the consolidation of scientific knowledge that showed fossil fuel–induced global warming was real. Only in the 1990s, however, with the emergence of social movements, political institutions, and interest groups to support renewables, as these Eva Oberloskamp illustrates in chapter 13, did the transition toward solar and wind gain momentum. This story is still being written, with its most pivotal chapter yet to come, since fossil fuel consumption in much of North America and Europe, and the world for that matter, remains undiminished by solar and wind. Indeed, what distinguishes the hoped-for transition to renewables from most previous transitions is that to actually address global warming, the new system must not just transform, but radically dismantle the old energy system. This has few precedents in history.

Overall, the aim of *New Energies* is to move beyond a narrow and linear conception of energy transitions. We hope to show how energy transitions are a rich, multifaceted line of inquiry that can bring different types of history together, and how those studying contemporary energy affairs can benefit from a more detailed understanding the complex, nonlinear, and highly contested nature of energy transitions from the past. This volume illustrates how transitions are long affairs that take decades to unfold, rarely have finite starting and ending points, and are characterized by advances as well as backtracking and changes in entirely unpredictable directions. It underscores the persisting influence of older energy forms, like coal, whose supporters have historically found ways to overcome challenges and adapt to new circumstances. It shows how important interest groups, coalitions, counter-experts, states, and grassroots actors have been to the success of new energy systems—that

all does not hinge on technology and price. It shows how particular moments or constellations of circumstances have emerged to create the opportunity for change, and how quickly those moments can vanish. Lastly, it highlights just how profoundly our experience with energy shapes almost every facet of life, from democratic governance to the environment that surrounds us to even how we think about human reproduction.