# Renewable Energy, Energy Poverty, and Climate Change: Opportunities and (Many) Challenges

Michaël Aklin

The Oxford Handbook of Comparative Environmental Politics
*Edited by Jeannie Sowers, Stacy D. VanDeveer, and Erika Weinthal*

Subject: Political Science, Comparative Politics Online Publication Date: Feb 2022
DOI: 10.1093/oxfordhb/9780197515037.013.23

## Abstract and Keywords

Renewable energy has the potential to reduce energy poverty in environmentally more friendly ways than fossil fuels. Given these benefits, observers often assume that the deployment of renewable energy should continue unabated, especially as its costs continue to decline. Yet, in practice, the growth of renewables has been uneven and several setbacks continue to plague such growth. The challenges faced by renewables are often political in nature. Given this context, this chapter briefly reviews the role played by renewable energy at the intersection of environmental, energy, and economic policies; clarifies how political, economic, and social factors shape the prospects of renewable energy deployment and how these factors vary within and across industrialized and emerging countries; and investigates the issues faced by renewable energy in the present and the future. These include problems of high costs to consumers, limited ability to raise living standards in developing countries, and struggles faced by the renewable energy industry under high political uncertainty.

Keywords: energy access, energy poverty, renewable energy, renewable electricity, energy policy

# Introduction

Over the past two centuries, the world economy has grown at a historically unprecedented pace (Jones 2016, p. 8). Living standards have increased across the world. Yet a range of factors have trapped some populations in poverty and have widened inequality (Milanovic 2016). Lack of access to energy is one of these factors. Energy poverty—the lack of affordable access to modern energy technologies—can affect the ability to live a dignified and productive life. Any kind of economic activity requires energy as an input. Households are also dependent on it: lighting, refrigerating, cooling, and heating are all ingredients to a comfortable home. Using cell phones or internet connections requires reliable access to power. Thus, energy poverty constitutes a major impediment to welfare and economic growth (Barnes 2018).

At the same time, energy consumption can also be excessive, in the sense that its side effects harm populations beyond what they deem acceptable and without their consent. The use of fossil fuels—the most commonly used sources of energy since the Industrial Revolution—has several nefarious consequences, ranging from air pollution to climate change (Perera 2017). To the extent that energy consumption reduces social welfare, it becomes a problem of collective action. In the absence of political oversight, unconstrained economic growth can lead to unfettered environmental degradation.[1]

Thus, the world faces two connected problems. First, many people, especially those among the most vulnerable, are energy poor. Billions lack access to reliable electricity or clean cooking fuels, with negative consequences for their livelihoods. Improving energy access would reduce barriers to economic growth. Second, many countries generate excessive greenhouse gas (GHG) emissions as a by-product of their energy consumption, thereby contributing to climate change. De-carbonizing energy systems would make future growth more environmentally sustainable. Renewable energy offers a promising solution that can, in theory, simultaneously reduce countries' climate footprint while addressing the energy needs of millions of people across the world. But will it do so? Using an interdisciplinary lens, this chapter has three aims. First, I briefly review the role played by renewable energy at the intersection of environmental, energy, and economic policies. Second, I clarify how political, economic, and social factors shape the prospects of renewable energy deployment. Success and failures in the deployment of renewables depend heavily on public policies. Comparative studies of political actors, institutions, and the societies in which they are embedded are therefore crucial to understand why and when renewables can succeed. Throughout, I focus primarily on their role on renewables in electricity generation and, occasionally, on cooking. This choice is motivated by the fact that renewables play the most advanced role in electricity. In the last two sections, I investigate the barriers faced by renewable in the present and the future. I discuss how some of the lessons learned in the case of electricity apply (or not) to other areas such as transportation.

# Energy Poverty and Sustainable Development

Any form of productive activity necessitates energy. Eras of human history coincide with the development of sophisticated ways to unleash increasing amounts of it (Smil 2010, p. 48). After using their own muscles, humans gradually used others—animals, rivers and seas, and machines—do the work for them. The development of the steam engine in the early nineteenth century expanded in an unparalleled fashion the realm of what humans could do and where they could go (Smil 2017, p. 235). The steam engine made use of the high energy potential of fossil fuels to generate movement on demand—a useful feature for all kinds of industrial activities. The transition to electricity further expanded the range of services that energy could provide, such as convenient lighting and refrigeration. In some countries, electricity also facilitates cooking and heating. Later developments, such as nuclear power, contributed to the provision of electricity in large quantities and at a low marginal cost.

As a result, energy in general, and electricity in particular, play a fundamental role in modern economies. The revolutionary nature of modern energy and its social impact were recognized early on. Friedrich Engels noted that the “steam engine … gave rise, as is well known, to an industrial revolution, a revolution which altered the whole civil society” (Engels 1943). Though there is debate over the validity of this claim (Clark and Jacks 2007), several scholars have argued that access to energy was an essential impetus for the Industrial Revolution (Pomeranz 2000, p. 66).

Recent studies confirm that economic welfare and energy are closely linked. At the macro level, shocks to the oil supply can cause recessions (Baumeister and Hamilton 2019). At the micro level, several studies show that getting access to energy (and electricity) increases people’s welfare. In a study in Bangladesh, Khandker, Barnes, and Samad (2009) find that electrifying rural households increases their income by up to 30 percent. Another study focusing on India identifies some of the mechanisms that explain these gains. Among others, access to electricity reduces the need for fuelwood and therefore frees household members (especially women) from spending time collecting it (Khandker et al. 2014). These findings are echoed by Dinkelman’s (2011) study of an electrification program in South Africa. She shows that electricity access helped women enter the labor force and create new small firms. Even larger firms suffer from poor electricity supply: blackouts in India have been estimated to reduce a typical plant’s yearly revenues by 5 to 10 percent (Allcott et al. 2016, p. 587).

Thus, high living standards require access to affordable and reliable energy. Yet many people are deprived from the benefits of modern energy technology. The concept of “energy poverty” characterizes households and individuals that find energy either too costly to use or entirely unavailable (Pachauri et al. 2004; Nussbaumer, Bazilian, and Modi 2012; Bouzarovski and Petrova 2015; Aklin et al. 2018). Energy poverty can affect all facets of energy usage. The concept itself originated in the recognition that many British households faced dauntingly high heating costs (Bouzarovksi 2018, p. 10). But energy poverty is particularly problematic in the case of electricity and cooking. According to the IEA (2019, p. 1), about 1 billion people lack access to electricity. This number has been declining, notably thanks to rapid progress made in South Asia. Yet challenges remain. In countries such as India, newly grid-connected households often find that electricity is available for much less than 24 hours a day. Wealthy countries themselves also must cope with many people living in energy poverty. In the United States, millions of people are disconnected every year from the grid because they struggle to pay their bills (Bednar and Reames 2020). Likewise, millions of European households are believed to face difficulties meeting their energy needs (Bouzarovksi, Petrova, and Sarlamanov 2012).

The situation is even worse with respect to clean cooking technology. About 3 billion people cook with solid fuels, such as wood or charcoal (IEA and World Bank 2017). Using these fuels indoors contributes to household air pollution. Such pollution has been estimated to cause the premature deaths of 4 million people per year (WHO 2016, p. ix). Women and children, who often spend more time indoors, are particularly exposed. Using solid fuels has also an opportunity cost: it must be collected, which, in the absence of easy access to good transportation systems, can be time-consuming (Malla and Timilsina 2014, p. 18).

There are, therefore, compelling ethical reasons to make access to energy cheaper and easier (Sovacool et al. 2016). Electricity and cooking both shape a household's and country's welfare. Beyond this, affordable transportation and heating are also essential to expand individuals' opportunities and comfort. Where access does not yet exist, governments and private agents ought to invest in it. Where access is feasible but out of reach of the poorest, public policy ought to make it cheaper.

Thus, energy has long been primarily a political problem rather than a technical one. From the construction of large electric dams in the nineteenth century to the deployment of tiny solar panels in the twenty-first century, governments shaped the provision of this essential input (Moe 2010; Smil 2017, Aklin et al. 2018). Understanding energy poverty requires us to study why some governments actively tried to expand energy access whereas others failed to do so. I will discuss this in greater details in a later section.

At the same time, there exist strong reasons to worry about generating increasingly more energy. Energy usage produces about 75 percent of global greenhouse gas emissions (IPCC 2014, p. 9). Electricity generation represents about a third of this (25 percent of total GHG), most of which stems from coal power plants. Fossil fuels not only contribute to climate change, but they also create localized air pollution (Wei et al. 2018), which causes a myriad of health issues (Levy et al. 2009). Using solid fuels for cooking is inefficient and strips forests, thus representing another source of climate change (Smith et al. 2000; IPCC 2014, p. 846).

This is not to say that we have not become more careful with our use of energy. The energy intensity (energy consumed per unit of GDP) of modern economies has declined over the past decades (Chen, Huang, and Zheng 2019). But *total* energy consumption has steadily increased (Figure 23.1). Thus, even though we are becoming more efficient, we continue to consume more. This is good news from the perspective of the energy poor (assuming they get part of this growing pie), but it raises the question of the environmental sustainability of past and current practices.

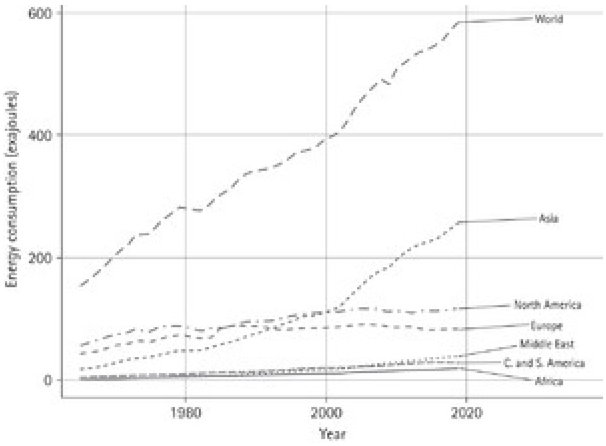


*Figure 23.1* Energy consumption by region.

Source: BP (2020).

It is then clear: how countries and regions decide to power future growth will have important implications for our environment in general and for climate change in particular. Future economic development supported by fossil fuels is unlikely to be environmentally sustainable. If we want simultaneously to address the needs of the energy poor and reduce our collective impact on the environment, then new energy infrastructures will be necessary.

# The Prospects of Renewable Energy: Untapped Potential?

In theory, renewable energy could provide energy in a sustainable manner. In practice, renewable energy has already become ubiquitous. Millions of rooftops have been plastered with solar photovoltaic (PV) panels, and wind turbines are a common sight across the planet (Mildenberger, Howe, and Miljanich 2019). Yet renewables' contribution to our energy needs remain below what is required to decarbonize modern energy systems. This section examines the current state of affairs and reaches the conclusion that, despite rapid progress, renewables have yet to represent the core fuel for any country's energy system. A later section discusses the reasons that led us to this situation.

By renewable energy, I refer to energy sources that are replenishable within a human time horizon. Historically, water (rivers) has offered the most successful type of renewable energy. Water mills were known in Ancient Greece at the latest (Smil 2017, p. 146). Wind power has also long been used by civilizations across the world, whether via windmills or sails. More recently, solar power has been harnessed to generate electricity. Solar PV produces power by using sunlight to generate electric currents. In the future, *perovskite cells* may offer yet another way to use the sun to electrify our homes and our industries.

Yet despite promising developments, renewables remain a small play when we consider primary energy consumption writ large. Neither in relatively rich countries of the Organisation for Economic Cooperation and Development (OECD; 7 percent) nor in relatively poorer non-OECD countries (3.5 percent) do renewables represent a dominant source of energy (Figure 23.2). Even in the European Union, which has generally been the most aggressive proponent of new renewable technologies, the share of renewables barely surpasses 10 percent.

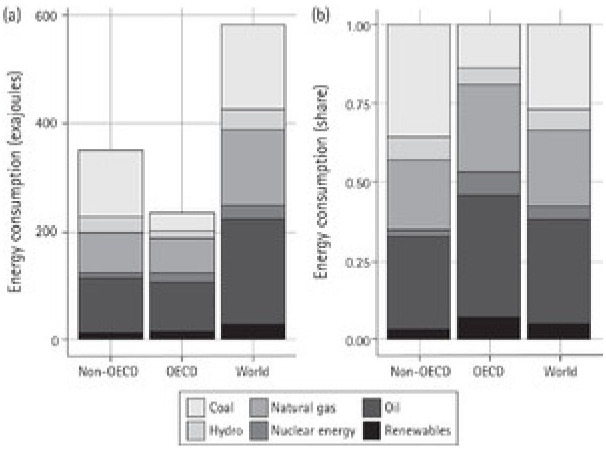


*Figure 23.2* Primary energy consumption by source in 2019. Panel A: Total consumption. Panel B: Share of energy consumed from each source.

Source: BP (2020).

This picture is, however, somewhat misleading. If we focus more narrowly on electricity, where policy action has been the most effective, then we note that renewables have experienced considerable amounts of success over the past two decades (Figure 23.3). The share of electricity from new renewable sources (primarily wind and solar PV) has increased virtually everywhere. Some countries, such as Denmark, have been lauded for their success with renewables. Others, such as Kenya, have received less coverage (Aklin et al. 2018). On average, since 2000, the share of renewables has increased on average by 0.33 percentage points per year.[2]

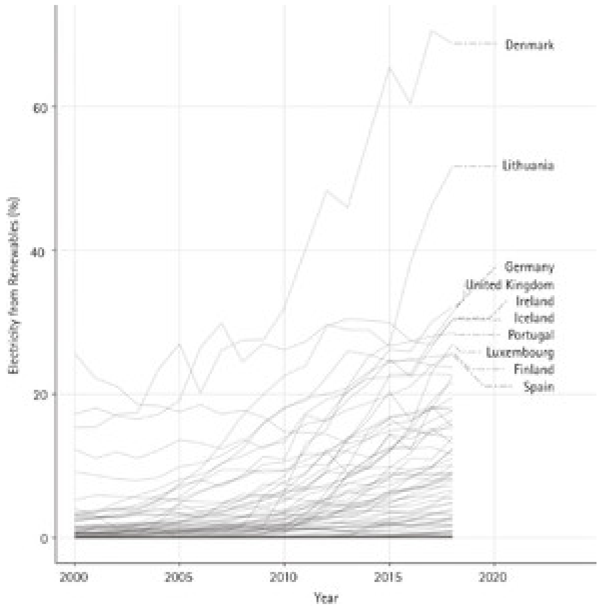


*Figure 23.3* Percentage of electricity generated from renewable sources (including wind, geothermal, solar, biomass, and waste), by country. Countries listed on the right are those with a share greater than 25 percent.

Source: BP (2020).

Renewable energy offers several benefits. It generally can be used in a way that minimizes the amount of GHG emissions. Lifecycle assessments typically find that the most commonly used types of renewable technologies generate considerably fewer emissions over their entire lifespan than do fossil fuels (Sathaye et al. 2011, p. 732). Even nuclear sometimes performs worse over its lifecycle. This is not to say that renewables are unambiguously clean from an environmental standpoint. Biomass, for instance, is renewable and yet can be produced in an unsustainable manner. Yet, in general, renewables outperform fossil fuels in general, and coal in particular, by a wide margin in terms of their climatic impact. Renewables are also often environmentally friendlier on other dimensions. For instance, renewable energy consumes less water (Lohrmann et al. 2019) and its generation generally does not contribute to air pollution (with biomass being occasionally an exception) (Hertwich et al. 2015).

Renewable energy can also address energy poverty—in theory, at least. The “fuel” used for turbines and PV systems is free. Costs are almost entirely concentrated in the assembly, installation, and maintenance of infrastructures. In general, these costs have declined significantly. The International Renewable Energy Agency (IRENA) estimates that the leveled cost of onshore wind projects declined by 39 percent between 2010 and 2019 (IRENA 2020, p. 22). Solar PV declined even more abruptly, by about 80 percent. Utility-scale renewable electricity has, as a result, become extremely competitive. IRENA (2020, p. 37) estimates that onshore wind and solar PV can generate utility-scale electricity more cheaply than coal. Thus, renewables may be able to provide electricity in the future where it is currently too expensive to be generated from fossil fuels.

Furthermore, renewables can be extremely flexible. In the case of electricity, they can be used to power the grid or in a decentralized manner (or "off-grid"). In the latter, electricity is produced and consumed on the spot, reducing the need for expensive transmission lines. A major impediment to the extension of the grid is that it is very costly and only economically profitable if the number of new customers is high enough. As a result, for sparsely populated areas, the prospects of getting the grid are rather bleak. Instead, off-grid technology powered by renewable sources can represent a viable alternative. Since their arrival on markets several decades ago, a wide range of distributed technologies have been developed, including solar home systems, mini-grids, micro-grids, and so forth. Thus, off-grid technology powered from renewable sources can help provide a modicum of energy access (Urpelainen 2014).

Renewables therefore hold considerable promise. Yet their deployment, in the past and now, has been uneven and this, I argue, is essentially a matter of politics. The energy sector is characterized by seemingly every possible type of market and political failures. This implies that the successes and failures of renewables depend on the degree to which states are able to overcome collective action issues. In the next section, I draw the lessons from the development of renewables from an infant technology to its present state. My focus will be comparative in nature. I will study how individuals, organized interests, political parties, and institutions shape renewable energy policy. The story that emerges is a complex one in which voters have ambivalent views over the benefits of clean energy, whether they live in wealthy North American suburbs or in poor rural India (Stokes 2016; Aklin et al. 2017). It is a story in which activists and fossil fuel lobby political parties of all ideological inclinations and where unions simultaneously must consider whether to support declining fossil-based industries or support emerging green ones (Mildenberger 2020). And it is a story where emerging powers such as India and China must reconcile sometimes competing objectives ranging from providing cheap energy to their population, expanding their industrial interests abroad, and addressing pressing environmental issues at home (Rodrik 2014; Min 2015). These factors, taken together, help us understand the variation observed in Figure 23.3.

# Past and Present Challenges: Why So Slow?

If renewable energy offers such appealing benefits, what is holding it up? By 2016, only 10 percent of electricity globally was generated from modern renewables (i.e., renewables aside from hydro, which is a mature technology).[3] Some countries, such as Denmark, scored higher, but, even there, electric systems remained far from decarbonized. The contribution of renewables outside of electricity is even smaller. Clearly, the world is not yet close to rely entirely (or even primarily) on renewables. What are the obstacles that prevent a full clean energy transition?

The history of the electric grid offers interesting lessons to understand the challenges faced by renewables. To help make sense of the growth of renewables, it is helpful to break this history down in the key critical stages that any new product typically faces. Pioneered by Everett Rogers (2003), the *S-curve of innovation* posits that new products undergo distinct phases before they saturate a market. An innovation is first used by early adopters. If it finds sufficient demand, it will then take off and spread. As time passes, it will gradually reach the last reluctant customers.

This logic can be modified and adapted to understand the obstacles to renewables (Schilling and Esmundo 2009). The original S-curve model is a model free of politics. It makes no explicit assumptions about the political environment in which new technologies grow. Yet these contextual factors are essential to understand the tremendous amount of variation in the deployment of renewables across the world. In what follows, I use the S-curve model as a starting point and explain how variation in political and socioeconomic factors interacts with it. It offers a convenient way to identify the critical phases of the deployment of renewables. Yet, as I argue in the rest of this chapter, the problem of renewable energy is intrinsically a political one.

In the first phase of the development of a new product, its proponents must figure out efficient ways to produce it. It is poorly known among the public and must find a customer base of enthusiastic early adopters. This initial phase is critical to demonstrate the future viability of this product. Investors are unlikely to be patient if the product cannot prove that it can reach enough people to be viable.

This phase turned out to be critical for renewables on two grounds. As a source of electricity, renewables were not a new product per se. Rather, they were competing with well-established technologies. A unit of electricity from wind turbines “looks” the same as a unit of electricity from coal. Mature electricity sources, having benefited from decades of investments, could provide the same product at a cheaper price. On top of this, the entire electric infrastructure had been tailored to accommodate fossil fuels and nuclear power. This fundamental advantage has been labeled by observers as a “carbon lock-in” (Unruh 2000). Thus, facing a steep cost disadvantage, renewables faced an uphill battle: Why would anyone invest in renewable energy?

The other problem in this early phase was related to intellectual property and returns on investments. Any technological improvement was bound to reduce costs across the industry. Thus, absent robust patenting mechanisms, investments in research would be a public good. Yet profits, if they were ever to materialize, would only be pocketed in the distant future. In fact, they may never materialize at all. Fossil fuels and nuclear power benefited from such a head start that it was difficult to imagine that renewables would catch up any time soon. Furthermore, established technologies did generally not have to face the costs of the negative externalities that they generated, while renewables were not in a position to be rewarded for the positive externalities that they created. In the late 1970s, there were therefore few reasons to expect that investing in renewables would be lucrative any time soon.

Thus, the prospects of renewables depended heavily on sympathetic governments. State support was critical because it did not have to follow an investor's logic. A government could invest in research and development even if it did not expect a return in the short run. Technically, the state played a crucial role of providing public goods in the form of investments in research (Stiglitz 1999; Loiter and Norberg-Bohm 1999).

In the case of renewable electricity, the impetus for states to provide such support came from the 1970s oil shocks and several nuclear incidents (Aklin and Urpelainen 2018). Rising costs of oil and declining public trust in nuclear power incentivized governments across the world to try out new technologies. Public opinion decisively turned against fossil fuel in several countries and gave the impetus for strong investments in clean energy (Jacobsson and Lauber 2006, p. 261). Elites joined in as well. The two oil crises led to a deep economic crisis with declines in real income and a rapid increase in unemployment across much of the non–oil producing world. Not all countries were similarly at risk, however, and it is those countries such as Denmark and the United States that initially showed the most interest in renewables. It is not a coincidence that Jimmy Carter opened what would later be the National Renewable Energy Laboratory in the midst of the oil shocks (it was established in 1974, one year after the first oil crisis; it opened as the "Solar Energy Research Institute" in 1977). In comparison, elites in France decided to favor the development of nuclear power because they could capitalize on nuclear expertise that had been accumulated in support of its foreign and industrial policy (Hecht and Callon 1998).

The case of the United States also underscores how fickle state support can be. After Ronald Reagan's arrival at the White House, public investments in renewables R&D plummeted. The logic was political and not driven by science: fossil fuel interests moved aggressively against a potential competitor, and the Republican party, which was growing in several fossil fuel–producing areas, was sympathetic to their arguments. By contrast, despite initial pushback from conservative politicians in Germany, strong popular support and the Chernobyl catastrophe limited the rollback of R&D resources (Jacobsson and Lauber 2006).

Thus, maintaining reliable government support is the first critical challenge for the deployment of a technology that generates positive externalities and faces stiff competition. Without it, the business environment will generally be too harsh for newcomers to enter the market. Depending on domestic political factors, including (but not necessarily limited to) public opinion, the ideological inclination of ruling parties, the preferences of existing interests, vulnerability to fossil fuel shocks, and favorable legal and research environments, some countries were more likely to undertake these initial steps that proved to be so important for renewable energy. German, Denmark, and the United States were among those countries. Others, such as France, went down a different path. This had little to do with differences in entrepreneurship or tastes. Instead, variations in political factors are essential to understand these diverging paths.

In the second phase, a new product spreads within and across markets—if it is positively received by consumers. At this stage, customers become increasingly familiar with the product and it reaches an audience beyond early insiders. As costs decline, average consumers can start considering acquiring this product.

In the case of renewables, this stage marks the many success stories observed since the late 1990s. Newcomers such as Spain and Portugal became the latest leaders in renewable electricity generation. But the landscape expanded even further. With some exceptions, such as Kenya, renewable energy had so far mostly been a topic in a small set of industrialized countries. Now, renewables turned into a global phenomenon (Kammen 2006; Martinot et al. 2002). They were not only increasingly visible in wealthy countries. Some of the poorest countries, such as El Salvador, with its rich biomass reserves, also became leaders in low-carbon energy systems.

Renewable electricity faced several challenges during this second phase. The first stemmed from worried incumbents. These include a range of actors, from fossil fuel producers to heavy industries and utilities. Renewables posed little threat as a niche technology favored by a few early adopters in California or Denmark. The situation looked different if, for instance, renewables were suddenly able to displace coal in a country like Germany. Likewise, renewables would be more menacing if they upended the business model of utilities. During this stage, utilities, fossil fuel producers, and other related interests mobilized to push back against pro-renewable policies (Aklin and Urpelainen 2018; Stokes 2020). On the opposite side, supporters of renewables created their own lobbies, built ties to the nascent green parties, and engaged in the political process as well (Wüstenhagen and Bilharz 2006; Laird and Stefes 2009).

Incumbents were not the only actors that pushed back against renewables. In some cases, consumers were (and still are) reluctant to support them. Social acceptance, here understood as people’s tolerance for a product, has long played an important role in many countries in the deployment of new energy technologies (Ramana 2011). For instance, public skepticism slowed down projects for new nuclear power stations in the United States and elsewhere (OTA 1984, p. 214). Events such as the Chernobyl catastrophe or the question of nuclear waste disposal reinforced public concern on health grounds (Assefa and Frostell 2007). In Germany, for instance, such concerns were sufficient to lead the center-left SPD to abandon its pro-nuclear stance (Jahn and Korolczuk 2012).

Public hostility can also hurt renewables, albeit for different reasons (Walker 1995; Wüstenhagen, Wolsink, and Bürer 2007). While renewables are generally popular at the national level, local development projects often encounter fierce resistance by local stakeholders (Jobert, Laborgne, and Mimler 2007; Stokes 2016). Partly, social hostility relates to people’s familiarity with the product. Individuals might simply exhibit distaste over a given product. Worries about the reliability of renewables may feed concerns and reinforce the (fossil fuel-based) status quo. Other factors leading to social hostility are sociocultural (Assefa and Frostell 2007). People may be reluctant to modify their lifestyle. This may explain, for instance, the low adoption rate of modern cookstoves: while they are highly efficient compared to traditional cookstoves, they poorly fit the customs of local users (Mobarak et al. 2012). Hostility, in turn, has many sources, many of which are political in nature. Some studies suggest that social acceptance of a new technology like modern cookstoves could change with better tailored education policies, which themselves depend on how countries set up their educational systems (Harding and Stasavage 2014; Sharma, Parikh, and Singh 2019).

Social acceptance also stems from the financial impact of renewable electricity. Wind turbines, notably, are often met with skepticism by the communities that are asked to host them. They need space and they modify the landscape. This may depress real estate prices and feed into public discontent (Jensen et al. 2018; Aklin 2021b). A study by Stokes (2016) in Ontario, Canada, suggests that voters dislike such top-down imposed projects enough to punish officials at the next elections. Variation in deployment of infrastructures such as wind farms, then, depends on factors ranging from legalistic planning laws to the ability of communities to organize in favor (or against) such projects. Again, the prospects of renewables hinge on local and national political factors.

Strategies to mitigate social hostility exist. Project developers can ensure that local actors derive some benefit from newly installed facilities (Stigka, Paravantis, and Mihalakakou 2014). Bottom-up initiatives may also be more likely to succeed (Maruyama, Nishikido, and Iida 2007). And opposition tends to decline over time (Hoen et al. 2019). Yet, in all cases, the prospects of renewable electricity projects still depend on local buy-in.

In this second phase, government support remains important, but its nature changes. It shifts from focusing primarily on research and development to providing support for the physical deployment of renewable electricity (Breetz, Mildenberger, and Stokes 2018). Renewable electricity benefited tremendously from policies such as *feed-in tariffs* that created profit opportunities for investors (Smith and Urpelainen 2014). Other green policies may also indirectly raise the cost of its competitors, reducing the cost gap between fossil fuels and renewable technology (Meckling, Sterner, and Wagner 2017; Matsuo and Schmidt 2019).

This second phase is particularly critical for the long-term prospects of renewables. In countries such as Denmark, the pro-renewable interests (voters and the wind industry) managed to overcome pushback and established themselves as too big to fail. Vestas and Ørsted are flagship companies that have a global reach and create a heavy interest for renewables. Germany is also an illustrative case. Initial support began to wane in the 1980s and 1990s, as the conservative CDU government began considering dismantling supportive policies. Yet new coalitions and interest groups mobilized to counter these plans ( Laird and Stefes 2009). Farmers were enticed to support renewables by the authorities allowing them to host small-scale hydro plants. Joining the nascent green movement, the research community lobbied as well to fight in favor of investments into renewables. In countries in which these coalitions were strong enough, renewable energy policy became less sensitive to electoral luck.

In other countries, failure to maintain sufficient support led renewables to remain marginalized. In the United States, cuts in public support led the renewable electricity industry to remain a secondary player (with notable exceptions in some states, such as Texas). Pro-renewable coalitions were unable to fend off pushback from fossil fuel interests. The Reagan administration overturned several initiatives launched by Jimmy Carter. Bill Clinton, dealing with a mostly hostile Congress, was not able to push for the kind of policies that Germany adopted during the 1990s. And George Bush's hostility to environmental regulations was well known. Thus, political elites were either unwilling or unable to overcome congressional obstruction against renewables.

Yet this is not just a story about fossil fuel lobbies and Congress. Other actors proved crucial in the stagnation of the American renewable sector. Utilities used their influence in state legislatures to protect their business models against requirements to use renewables (Stokes 2020). Furthermore, hostility against renewables was rampant not only among Republicans but also among some Democrats, where parts of organized labor actively undermined new climate regulations under both the Clinton and the Obama administrations (Mildenberger 2020). Thus, despite localized success, the United States gradually lost the leadership it had shown at the end of the 1970s.

Lack of success at this stage condemns the renewable electricity industry to remain dependent on the goodwill of governments (Aklin 2018). Worse, even sympathetic governments may be constrained by political institutions. In these countries, renewable energy policy remains a disputed topic, and support is only safe when veto players are either aligned with the interests of the renewable sector or neutralized. As a result, the lock-in of a renewable energy system remains beyond reach. New elections, unfriendly legal decisions, or disputes within political coalitions can be crushing for the renewable industry. Thus, progress in these countries remains slow.

# The Path Ahead

At the time of writing, countries around the world are located at various points along the second phase of renewables deployment. Renewable energy can be found everywhere. But it is not equally present in all countries. To a limited degree, the discrepancy in the deployment of renewables can be attributed to geographical and economic factors. To a much larger degree, it is tributary to differences in political features across and within countries: what people, interest groups, and political elites want, and how institutions mediate these demands. The last step in the completion of a clean energy transition offers a new set of challenges, which I discuss next.

There are reasons for cautious optimism that renewables may still help promote economic development while reducing energy poverty. Globally, the average cost of renewables has declined to the point where maintaining public support for fossil fuel infrastructure, such as coal power plants, is becoming extremely costly and politically unsustainable. Yet, from an environmental and climatic standpoint, the critical question is perhaps not whether renewables will power our future economies, but how quickly we will get there. What could slow down the completion of the third phase?

First, cost remains a concern. While the cost of renewables has declined, building up (where it does not exist) or replacing the entire generating capacity of a country with renewables remains a much more difficult task. Doing so appears technically feasible, but the costs it would impose remain quite high (Clack et al. 2017). Beyond this, analysts may want to distinguish between the cost of renewables (which has declined) and the bills faced by customers (which can remain high). Consumers who blame renewables for their high bills, whether rightfully or not, may be less inclined to support further expansion. Thus, costs matter because they make renewable energy politically salient and thus affect future policies enacted by governments. Yet costs are also under the indirect control of governments. The distribution of costs varies considerably from one country to another. In Germany, for instance, the cost of renewables primarily falls onto households (Cludius et al. 2014). Large and influential industries are exempts from most surcharges. One may conjecture that the structure of a country's political system, and the varying levels of influence that firms and individuals have on the political process, may be an important predictor of the distribution of costs under a clean energy transition.

Second, success stories should not hide the challenges faced by the renewable energy industry. While utility-scale solar or wind power has become extremely competitive, this represents only a fraction of the promotion of renewable electricity. For instance, off-grid technology providers often struggle with an unstable business environment and demanding customers (Lighting Global 2020, p. 221). Finding a reliable business model has eluded many actors in this sector. To be successful, off-grid technologies must prove that they can meaningfully meet the needs of both households and firms.

This may be a challenging task. For better or for worse, the renewable energy sector relies heavily on private actors (Schmidt 2014; Aklin 2021a). Most renewable energy technology producers are privately held for-profits. They must raise resources on capital markets, and those that are publicly listed must also pay heed to the wishes of their main shareholders. This creates a fundamental tension: the energy poor are unlikely to be the most financially valuable customers. It also raises the importance of political institutions. The deployment of renewables, especially in an off-grid form, is unlikely to be successful in countries in which firms are at risk of losing their investments. We may expect renewables to do better in countries with more robust legal institutions. Yet this, in turn, means that those who need cheaper energy access might be left out (Aklin 2021a).

The management of the electric grid raises many questions as well. In Europe and elsewhere, utilities must deal with oversupply and vanishing profit margins.[4] At the same time, home-produced electricity might reduce demand. Utilities might thus further dig in their heels against renewables. Take Ohio, where FirstEnergy, a local utility, lobbied successfully (and, as it turns out, illegally) in favor of a bill in 2019 that reduced support for renewable energy.[5] This highlights the ability of carbon interests to slow down the progress of renewables, at least under political systems that give more influence to concentrated interests.

What will the grid sector look like in the future? Declining costs alone will probably not suffice for renewables to displace fossil fuel. In countries such as India, coal remains a politically influential sector, partly because hundreds of thousands of workers depend on jobs in the coal industry (Pai et al. 2020). Even in the United States, coal has primarily declined because of the competition from natural gas—another fossil fuel with its own lobby and concentrated interests (Neville et al. 2017). As long as the renewable energy sector is rooted in the private sector, economic and political uncertainty will remain threats that may jeopardize its future growth.

Third, as discussed earlier, the development of the renewable energy sector responded to a political logic. In a few key countries, renewable energy became a matter of industrial policy. Making renewables a jointly political and private venture (rather than purely a private sector one) was necessary to overcome the entrenched position of fossil fuels. To do so, renewable energy had to create its own political power (Schattschneider 1935; Pierson 1992). Yet this, in turn, could create roadblocks for even newer developments. Firms that entered the renewable sector in the 1990s and 2000s seek to recoup their investments. As newly political and politicized actors, they may be disinclined to encourage new innovations that could undermine their current *modus operandi* (Sivaram 2018, p. 164). This may slow innovation. In the United States, for instance, renewable lobbies have pushed for policies that supported their (narrower) interests without paying much attention to funding possibly even more efficient new technologies (Sivaram 2018, 166).

Finally—and perhaps most importantly—electricity and cooking represent only part of the emissions stemming from energy. Transportation and buildings (which includes heating and cooling) account for 20 percent of GHG emissions (IPCC 2014, p. 9). Agriculture and land-use changes account for another 24 percent. Renewable energy in these areas lags behind compared to its role played in electricity. There is, however, gradual progress being made in these areas as well. Electric vehicles (which can be powered with electricity from renewable sources) have had some success in recent years, and energy efficiency programs could reduce the emissions from old buildings. The case of electric vehicles illustrates again the influence of politics. The ambition of public policy over electric cars has been shown to depend on the presence of a sizable car production workforce as well as on the kind of relations between governments and large industrial interests (Mikler 2009; Wesseling 2016).

Yet much remains to be done to crowd out fossil fuels. Remember Figure 23.2: if we consider energy in general, rather than electricity, we realize that there is considerable work to do. Even in countries such as Germany, which has been at the forefront of renewables, the latter's share represents only 16 percent of primary energy consumption. In the emerging world, renewables contribute a paltry 3.5 percent of demand. Given the urgency of reducing GHG emissions, the (relative) success of renewables in the provision of electricity must not obscure the steep hill ahead to decarbonize energy generation writ large. Some of the challenges in these areas echo what happened to the electricity sector. Take, for instance, the transportation sector. Issues such as social acceptance may play an important role (Sovacool 2017). Likewise, incumbent industries (such as gasoline car producers) play a role that could mirror that of utilities (Meckling and Nahm 2019). Thus, lessons learned in the case of electricity could help understand the challenges in these other sectors. Undoubtedly, though, new challenges will arise.

# Conclusion

In many respects, the history of renewable energy is remarkable. Against all odds, renewables transformed the electricity market and became a key contributor to national power systems in several countries. A sober analyst in the 1990s would have been skeptical about the prospects of renewable energy. Traditional energy sources had too much of a head-start—technologically and politically—to be displaced. And yet, in several countries, renewables are on the cusp of achieving widespread use.

To succeed, renewables had to mature. This process, far from solely being an engineering problem, depended just as much on politics. Savvy policy-makers and activists (and occasionally luck) helped break the carbon lock-in (Unruh 2002; Aklin and Urpelainen 2018). In the coming years, millions of people trapped in energy poverty should benefit from energy powered from renewable sources.

This was not self-evident, nor did renewables succeed everywhere. We still have a lot to learn from the politics of renewable energy. I see three areas, in particular, that warrant continued attention. First, we still struggle to understand the conditions under which renewable energy increases people’s welfare. This is particularly true for the off-grid sector in emerging countries, where the renewable energy industry has devoted considerable efforts to design systems that meet people’s demands. Yet most studies find limited effects of off-grid power on income and economic growth (Burlig and Preonas 2016; Aklin et al. 2017). If renewables want to maintain and expand public support, they will need to have visible benefits. Comparative studies can help us identify the causal factors that make renewable energy more effective.

Second, how well will our knowledge of the politics of renewable electricity travel to other areas, such as agriculture and transportation? Recent years have seen a growing body of literature about electric vehicle policies. Undoubtedly, there are similarities between electricity and the car industry. Both have (or had) incumbent actors that had to find ways to deal with a challenger. Both are often produced in the same countries (Germany, Poland, the United States, etc.). Yet there are differences, too. Some could make the obstacles in the transportation sector less challenging. For instance, several car manufacturers have tentatively tried to move ahead of the curve and invest in electric vehicles. I am not aware of a coal producer that has invested in solar panels. But others will make the situation more difficult. Germany, for instance, employs about 800,000 people in the car sector and many more along the sector's supply chain. It only employs 30,000 in coal.[6] Clearly, the political challenge there is of a different magnitude.

Third, there remains considerable uncertainty regarding what a future carbon-free energy system will look like. On the one hand, one may envision an entirely decentralized system, with energy produced and consumed locally, possibly in the spirit of cooperative ventures. On the other hand, we may also imagine an integrated energy system at the supranational level, where electricity produced by solar panels in, say, North Africa and dams in Norway all contribute to a system that powers everything from cars to kitchens across a continent. Which of these two extreme scenarios is most likely is uncertain. Countries and communities will continue to experiment along the way. Learning lessons, especially costly ones, will be especially important to complete transitions away from fossil fuel. Some lessons will be about local experiences and how renewables can be promoted at the micro level. Others will be systemic and focus on big questions: What role is there for further state-led development of renewables? Can a system that relies more heavily on the private sector meet expectations of quality and fairness?

The path ahead remains a thorny one. There remains a gap between an idealized carbon-free energy system and the messy real-world infrastructures we must deal with. Ultimately, the key question will not be *whether* the transition happens, but *how fast* can it be concluded. Speeding it up will require even better technology. Beyond this, it will require thinking creatively about new political alliances and coalitions to break the remnants of carbon interests. As climatic deadlines loom, speed is of the essence.

## References

Aklin, Michaël. "Re-Exploring the Trade and Environment Nexus Through the Diffusion of Pollution." *Environmental and Resource Economics*, 64, no. 4 (2016): 663–682.

Aklin, Michaël. "How Robust Is the Renewable Energy Industry to Political Shocks? Evidence from the 2016 US Elections." *Business and Politics*, 20, no. 4 (2018): 523–552.

Aklin, Michaël. "The Off-Grid Catch-22: Effective Institutions as a Prerequisite for the Global Deployment of Distributed Renewable Power." *Energy Research & Social Science* 72, no. 101830 (2021a): 1–9.

Aklin, Michaël. "Do High Electricity Bills Undermine Public Support for Renewables? Evidence from the European Union" *Energy Policy* 156, no. 112400 (2021b): 1–7.

Aklin, Michaël, Patrick Bayer, S. P. Harish, and Johannes Urpelainen. "Does Basic Energy Access Generate Socioeconomic Benefits? A Field Experiment with Off-Grid Solar Power in India." *Science Advances* 3, no. 5 (2017): e1602153.

Aklin, Michaël, Patrick Bayer, S. P. Harish, and Johannes Urpelainen. *Escaping the Energy Poverty Trap: When and How Governments Power the Lives of the Poor*. Cambridge, MA: MIT Press, 2018.

Aklin, Michaël, and Johannes Urpelainen. *Renewables*. Cambridge, MA: MIT Press, 2018.

Allcott, Hunt, Allan Collard-Wexler, and Stephen D. O'Connell. "How Do Electricity Shortages Affect Industry? Evidence from India." *American Economic Review* 106, no. 3 (2016): 587–624.

Assefa, Getachew, and Björn Frostell. "Social Sustainability and Social Acceptance in Technology Assessment: A Case Study of Energy Technologies." *Technology in Society*, 29, no. 1 (2007): 63–78.

Barnes, Douglas F. *Electric Power for Rural Growth: How Electricity Affects Rural Life in Developing Countries*. London: Routledge, 2018.

Baumeister, Christiane, and James D. Hamilton. "Structural interpretation of vector autoregressions with incomplete identification: Revisiting the role of oil supply and demand shocks." *American Economic Review*, 109, no. 5 (2019): 1873–1910.

Bednar, Dominic J., and Tony G. Reames. "Recognition of and Response to Energy Poverty in the United States." *Nature Energy* (2020): 1–8.

Bouzarovksi, Stefan. *Energy Poverty: (Dis)Assembling Europe's Infrastructural Divide*. Cham: Palgrave Macmillan, 2018.

Bouzarovski, Stefan, and Saska Petrova. "A Global Perspective on Domestic Energy Deprivation: Overcoming the Energy Poverty–Fuel Poverty Binary." *Energy Research & Social Science* 10 (2015): 31–40.

Bouzarovski, Stefan, Saska Petrova, and Robert Sarlamanov. "Energy Poverty Policies in the EU: A Critical Perspective." *Energy Policy* 49 (2012): 76–82.

BP. Statistical Review of World Energy. June 2020. **http://www.bp.com/statisticalreview**.

Breetz, Hanna, Matto Mildenberger, and Leah Stokes. "The Political Logics of Clean Energy Transitions." *Business and Politics*, 20, no. 4 (2018): 492–522.

Burlig, Fiona, and Louis Preonas. "Out of the Darkness and Into the Light? Development Effects of Rural Electrification." Energy Institute at Haas Working Paper 268, 2016.

Chen, Zhongfei, Wanjing Huang, and Xian Zheng. "The Decline in Energy Intensity: Does Financial Development Matter?" *Energy Policy* 134 (2019): 110945.

Clack, Christopher T. M., Staffan A. Qvist, Jay Apt, Morgan Bazilian, Adam R. Brandt, Ken Caldeira, Steven J. Davis, Victor Diakov, Mark A. Handschy, Paul D. Hines, and Paulina Jaramillo. "Evaluation of a Proposal for Reliable Low-Cost Grid Power with 100 Percent Wind, Water, and Solar." *Proceedings of the National Academy of Sciences* 114, no. 26 (2017): 6722–6727.

Clark, Gregory, and David Jacks. “Coal and the Industrial Revolution, 1700–1869.” *European Review of Economic History* 11, no. 1 (2007): 39–72.

Cludius, Johanna, Hauke Hermann, Felix C. Matthes, and Verena Graichen. “The Merit Order Effect of Wind and Photovoltaic Electricity Generation in Germany 2008–2016: Estimation and Distributional Implications.” *Energy Economics* 44 (2014): 302–313.

Dinkelman, Taryn. “The Effects of Rural Electrification on Employment: New Evidence from South Africa.” *American Economic Review*, 101, no. 7 (2011): 3078–3108.

Engels, Friedrich. *The Condition of the Working-Class in England in 1844*. London: Allen & Unwin, 1943.

Grossman Gene M., and Alan B. Krueger. “Economic Growth and the Environment.” *Quarterly Journal of Economics* 110, no. 2 (1995): 353–377.

Harding, Robin, and David Stasavage. “What Democracy Does (and Doesn’t Do) for Basic Services: School Fees, School Inputs, and African Elections.” *Journal of Politics*, 76, no. 1 (2014): 229–245.

Hecht, Gabrielle, and Michel Callon. *The Radiance of France: Nuclear Power and National Identity After World War II*. Cambridge, MA: MIT Press, 1998.

Hertwich, Edgar G., Thomas Gibon, Evert A. Bouman, Anders Arvesen, Sangwon Suh, Garvin A. Heath, Joseph D. Bergesen, Andrea Ramirez, Mabel I. Vega, and Lei Shi. “Integrated Life-Cycle Assessment of Electricity-Supply Scenarios Confirms Global Environmental Benefit of Low-Carbon Technologies.” *Proceedings of the National Academy of Sciences*, 112, no. 20 (2015): 6277–6282.

Hoen, Ben, Jeremy Firestone, Joseph Rand, Debi Elliot, Gundula Hübner, Johannes Pohl, Ryan Wiser, Eric Lantz, T. Ryan Haac, and Ken Kaliski. “Attitudes of US Wind Turbine Neighbors: Analysis of a Nationwide Survey.” *Energy Policy* 134 (2019): 1–11.

IEA. *World Energy Outlook*, 2019.

IEA and the World Bank. “Progress Towards Sustainable Energy: Global Tracking Framework 2017.” Washington, DC: World Bank, 2017.

IPCC. *Climate Change 2014: Mitigation of Climate Change*. New York: Cambridge University Press, 2014.

IRENA. *Renewable Power Generation Costs in 2019*. Abu Dhabi: International Renewable Energy Agency, 2020.

Jacobsson, Staffan, and Volkmar Lauber. “The Politics and Policy of Energy System Transformation: Explaining the German Diffusion of Renewable Energy Technology.” *Energy Policy* 34, no. 3 (2006): 256–276.

Jahn, Detlef, and Sebastian Korolczuk. “German Exceptionalism: The End of Nuclear Energy in Germany!” *Environmental Politics* 21, no. 1 (2012): 159–164.

Jensen, Cathrine Ulla, Panduro, Toke Emil, Lundhede, Thomas Hedemark, Nielsen, Anne Sofie Elberg, Dalsgaard, Mette and Thorsen, Bo Jellesmark. “The Impact of On-Shore and Off-Shore Wind Turbine Farms on Property Prices.” *Energy Policy* 116 (2018): 50–59.

Jobert, Arthur, Pia Laborgne, and Solveig Mimler. “Local Acceptance of Wind Energy: Factors of Success Identified in French and German Case Studies.” *Energy Policy* 35, no. 5 (2007): 2751–2760.

Jones, Charles. “The Facts of Economic Growth.” In *Handbook of Macroeconomics*, edited by J. B. Taylor and Harald Uhlig, pp. 3–69. Amsterdam: Elsevier, 2016.

Kammen, Daniel M. “The Rise of Renewable Energy.” *Scientific American*, 295, no. 3 (2006): 84–93.

Khandker, Shahidur R., Douglas F. Barnes, and Hussain A. Samad. “Welfare Impacts of Rural Electrification: A Case Study from Bangladesh.” World Bank Policy Research Working Paper 4859, 2009.

Khandker, Shahidur R., Hussain A. Samad, Rubaba Ali, and Douglas F. Barnes. “Who Benefits Most from Rural Electrification? Evidence in India.” *The Energy Journal* 35, no. 2 (2014).

Laird, Frank N., and Christof Stefes. “The Diverging Paths of German and United States Policies for Renewable Energy: Sources of Difference.” *Energy Policy* 37, no. 7 (2009): 2619–2629.

Levy, Jonathan I., Lisa K. Baxter, and Joel Schwartz, Joel, 2009. “Uncertainty and Variability in Health-Related Damages from Coal-Fired Power Plants in the United States.” *Risk Analysis* 29, no. 7 (2009): 1000–1014.

Lighting Global. *The 2020 Global Off-Grid Solar Market Trends Report*. Washington, DC: Lighting Global and World Bank Report, 2020.

Lohrmann, Alena, Javier Farfan, Upeksha Caldera, Christoph Lohrmann, and Christian Breyer. “Global Scenarios for Significant Water Use Reduction in Thermal Power Plants Based on Cooling Water Demand Estimation Using Satellite Imagery.” *Nature Energy*. 2019. **https://doi.org/10.1038/s41560-019-0501-4**.

Loiter, Jeffrey M., and Vicki Norberg-Bohm. “Technology Policy and Renewable Energy: Public Roles in the Development of New Energy Technologies.” *Energy Policy* 27, no. 2 (1999): 85–97.

Malla, Sunil, and Govinda R. Timilsina. “Household Cooking Fuel Choice and Adoption of Improved Cookstoves in Developing Countries: A Review.” World Bank Policy Research Paper 6903, 2014.

Martinot, Eric, Akanksha Chaurey, Debra Lew, José Roberto Moreira, and Njeri Wamukonya. “Renewable Energy Markets in Developing Countries.” *Annual Review of Energy and the Environment*, 27, no. 1 (2002): 309–348.

Matsuo, Tyeler, and Tobias S. Schmidt. “Managing Tradeoffs in Green Industrial Policies: The Role of Renewable Energy Policy Design.” *World Development* 122 (2019): 11–26.

Maruyama, Yasushi, Makoto Nishikido, and Tetsunari Iida. “The Rise of Community Wind Power in Japan: Enhanced Acceptance Through Social Innovation.” *Energy Policy* 35, no. 5 (2007): 2761–2769.

Meckling, Jonas, and Jonas Nahm. “The Politics of Technology Bans: Industrial Policy Competition and Green Goals for the Auto Industry.” *Energy Policy* 126 (2019): 470–479.

Meckling, Jonas, Thomas Sterner, and Gernot Wagner. “Policy Sequencing Toward Decarbonization.” *Nature Energy* 2, no. 12 (2017): 918–922.

Mikler, John. *Greening the Car Industry: Varieties of Capitalism and Climate Change*. Edward Elgar, 2009.

Min, Brian. *Power and the Vote: Elections and Electricity in the Developing World*. New York: Cambridge University Press, 2015.

Milanovic, Branko. *Global Inequality*. Cambridge, MA: Belknap Press, 2016.

Mildenberger, Matto. *Climate Captured*. Cambridge, MA: MIT Press, 2020.

Mildenberger, Matto, Peter D. Howe, and Chris Miljanich. “Households with Solar Installations Are Ideologically Diverse and More Politically Active Than Their Neighbours.” *Nature Energy* 4, no. 12 (2019): 1033–1039.

Mobarak, Ahmed Mushfiq, Puneet Dwivedi, Robert Bailis, Lynn Hildemann, and Grant Miller. “Low Demand for Nontraditional Cookstove Technologies.” *Proceedings of the National Academy of Sciences* 109, no. 27 (2012): 10815–10820.

Moe, Espen. “Energy, Industry and Politics: Energy, Vested Interests, and Long-Term Economic Growth and Development.” *Energy* 35, no. 4 (2010): 1730–1740.

Neville, Kate J., Jennifer Baka, Shanti Gamper-Rabindran, Karen Bakker, Stefan Andreasson, Avner Vengosh, Alvin Lin, Jewellord Nem Singh, and Erika Weinthal. “Debating Unconventional Energy: Social, Political, and Economic Implications.” *Annual Review of Environment and Resources* 42 (2017): 241–266.

Nussbaumer, Patrick, Morgan Bazilian, and Vijay Modi. “Measuring Energy Poverty: Focusing on What Matters.” *Renewable and Sustainable Energy Reviews*, 16, no. 1 (2012): 231–243.

OTA. *Nuclear Power in an Age of Uncertainty*. Washington: Office of Technology Assessment, 1984.

Pachauri, Shonali, Adrian Mueller, Andreas Kemmler, and Daniel Spreng. “On Measuring Energy Poverty in Indian Households.” *World Development*, 32, no. 12 (2004): 2083–2104.

Pai, Sandeep, Hisham Zerriffi, Jessica Jewell, and Jaivik Pathak. “Solar Has Greater Techno-Economic Resource Suitability Than Wind for Replacing Coal Mining Jobs.” *Environmental Research Letters* 15, no. 3 (2020): 034065.

Perera, Frederica P. “Multiple Threats to Child Health from Fossil Fuel Combustion: Impacts of Air Pollution and Climate Change.” *Environmental Health Perspectives* 125, no. 2 (2017):141–148.

Pierson, Paul, 1992. “When Effect Becomes Cause: Policy Feedback and Political Change.” *World Politics* 45 (1992): 595–628.

Pomeranz, Kenneth. *The Great Divergence: China, Europe, and the Making of the Modern World Economy*. Princeton, NJ: Princeton University Press, 2000.

Ramana, M. V. “Nuclear Power and the Public.” *Bulletin of the Atomic Scientists* 67, no. 4 (2011): 43–51.

Rodrik, Dani. “Green Industrial Policy.” *Oxford Review of Economic Policy*, 30, no. 3 (2014): 469–491.

Rogers, Everett. *The Diffusion of Innovations* (5th ed.). New York: The Free Press, 2003.

Sathaye, J., O. Lucon, A. Rahman, J. Christensen, F. Denton, J. Fujino, G. Heath, S. Kadner, M. Mirza, H. Rudnick, A. Schlaepfer, and A. Shmakin. “Renewable Energy in the Context of Sustainable Development.” In *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*, edited by O. Edenhofer, R. Pichs-Madruga, Y. Sokona, et al., pp. 707–790. New York: Cambridge University Press, 2011.

Schattschneider, Elmer Eric. *Politics, Pressures and the Tariff: A Study of Free Private Enterprise in Pressure Politics, as Shown in the 1929–1930 Revision of the Tariff*. New York: Prentice-Hall, 1935.

Schilling, Melissa A., and Melissa Esmundo. “Technology S-Curves in Renewable Energy Alternatives: Analysis and Implications for Industry and Government.” *Energy Policy* 37, no. 5 (2009): 1767–1781.

Schmidt, Tobias S. “Low-Carbon Investment Risks and De-Risking.” *Nature Climate Change* 4, no. 4 (2014): 237–239.

Sharma, Ashutosh, Jyoti Parikh, and Chandrashekhar Singh. “Transition to LPG for Cooking: A Case Study from Two States of India.” *Energy for Sustainable Development* 51 (2019): 63–72.

Sivaram, Varun. *Taming the Sun: Innovations to Harness Solar Energy and Power the Planet*. Cambridge, MA: MIT Press, 2018.

Smil, Vaclav. *Energy Transitions: History, Requirements, Prospects*. Santa Barbara, CA: ABC-CLIO, 2010.

Smil, Vaclav. *Energy and Civilization: A History*. Cambridge, MA: MIT Press, 2017.

Smith, Kirk R., R. Uma, V.V.N. Kishore, Junfeng Zhang, V. Joshi, and M.A.K. Khalil. “Greenhouse Implications of Household Stoves: An Analysis for India.” *Annual Review of Energy and the Environment*, 25, no. 1 (2000): 741–763.

Smith, Michael G., and Johannes Urpelainen. “The Effect of Feed-in Tariffs on Renewable Electricity Generation: An Instrumental Variables Approach.” *Environmental and Resource Economics*, 57, no. 3 (2014): 367–392.

Sovacool, Benjamin K. “Experts, Theories, and Electric Mobility Transitions: Toward an Integrated Conceptual Framework for the Adoption of Electric Vehicles.” *Energy Research & Social Science* 27 (2017): 78–95.

Sovacool, Benjamin K., Raphael J. Heffron, Darren McCauley, and Andreas Goldthau. “Energy Decisions Reframed as Justice and Ethical Concerns.” *Nature Energy* 1, no. 5 (2016): 1–6.

Stigka, Eleni K., John A. Paravantis, and Giouli K. Mihalakakou. “Social Acceptance of Renewable Energy Sources: A Review of Contingent Valuation Applications.” *Renewable and Sustainable Energy Reviews* 32 (2014): 100–106.

Stiglitz, Joseph E. “Knowledge as a Global Public Good.” In *Global Public Goods: International Cooperation in the 21st Century*, edited by Inge Kaul, Isabelle Grunberg and Marc Stern, pp. 308–325. New York: Oxford University Press, 1999.

Stokes, Leah C. “Electoral Backlash Against Climate Policy: A Natural Experiment on Retrospective Voting and Local Resistance to Public Policy.” *American Journal of Political Science*, 60, no. 4 (2016): 958–974.

Stokes, Leah C. *Short Circuiting Policy: Interest Groups and the Battle Over Clean Energy and Climate Policy in the American States*. New York: Oxford University Press, 2020.

Unruh, Gregory C. “Understanding Carbon Lock-in.” *Energy Policy* 28, no. 12 (2000): 817–830.

Unruh, Gregory C. “Escaping Carbon Lock-in.” *Energy Policy* 30, no. 4 (2002): 317–325.

Urpelainen, Johannes. “Grid and Off-Grid Electrification: An Integrated Model with Applications to India.” *Energy for Sustainable Development* 19 (2014): 66–71.

Walker, Gordon. “Renewable Energy and the Public.” *Land Use Policy* 12, no. 1 (1995): 49–59.

Wei, Peng, Fabian Wagner, M. V. Ramana, Haibo Zhai, Mitchell J. Small, Carole Dalin, Xin Zhang, and Denise L. Mauzerall. “Managing China’s Coal Power Plants to Address Multiple Environmental Objectives” *Nature Sustainability* 1 (2018): 693–701.

Wesseling, Joeri H. “Explaining Variance in National Electric Vehicle Policies.” *Environmental Innovation and Societal Transitions* 21 (2016): 28–38.

WHO. *Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children*. Geneva: WHO, 2016.

Wüstenhagen, Rolf, and Michael Bilharz. “Green Energy Market Development in Germany: Effective Public Policy and Emerging Customer Demand.” *Energy Policy* 34, no. 13 (2006): 1681–1696.

Wüstenhagen, Rolf, Maarten Wolsink, and Mary Jean Bürer. “Social Acceptance of Renewable Energy Innovation: An Introduction to the Concept.” *Energy Policy* 35, no. 5 (2007): 2683–2691.

## Notes:

(1) This logic has been hotly debated. The “environmental Kuznets curve” posits a negative relation between economic output and pollution at high levels of income (Grossman and Krueger 1995). This line of thinking has been criticized on several grounds, including the fact that rich countries tend to outsource their pollution to poorer countries and therefore appear more sustainable than they are in reality (Aklin 2016).

(2) This estimate is based on a regression of the share of renewables (excluding hydropower) on a time trend and country fixed effects.

(3) IEA Data and Statistics, available at https://www.iea.org/data-and-statistics/?country=USA&fuel=Renewables%20and%20waste&indicator=%20Renewable%20share%20(modern %20in%20final%20energy%20consumption%20(SDG%207.2)%20 (accessed on July 1, 2020).

(4) “How to Lose Half a Trillion Euros,” *The Economist*, October 15, 2013.

(5) “GOP Ohio House Speaker Arrested in Connection to $60 Million Bribery Scheme,” *Washington Post*, July 22, 2020.

(6) On the number of car jobs, see “German Car Industry Faces ‘Day of Reckoning,’” *Financial Times* December 1, 2019. On coal jobs, see “Bye Bye Lignite: Understanding Germany’s Coal Phaseout,” *Deutsche Welle* January 16, 2020.

**Michaël Aklin**

Department of Political Science, Political Science