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Chapter 7

Accelerating and Smoothing the Clean Energy Transition

Responding to the severe risks of climate change ranks among the most important and difficult challenges facing the United States. Levels of heat-trapping carbon dioxide in the atmosphere are higher than they have been in millions of years, causing gradually increasing temperatures and sea levels and worsening the catastrophic consequences of hurricanes, wildfires, and other extreme events. Along with the governments of other major greenhouse-gas-emitting countries, the Biden-Harris Administration has declared the United States' intention to rapidly reduce greenhouse gas emissions to avoid the worst consequences of climate change.

Because three-quarters of human-caused U.S. greenhouse gas emissions come from burning fossil fuels for energy, the most important step in reducing emissions is to shift from carbon-intensive to clean sources of energy (U.S. Energy Information Administration 2021a)—in short, to pursue a clean energy transition. A large and robust economics literature shows how policies can accelerate this energy transition by encouraging cost-effective emissions reductions. Completing this transition by mid-century would constitute a transformation of the energy system at a pace without precedent, and mark a giant achievement in human history, given the scale of the avoided damage to current and future generations (Newell and Raimi 2018).

President Joseph R. Biden has also committed to build a clean energy supply chain stamped "Made in America," reflecting the considerable economic opportunities and associated challenges presented by the energy transition. One challenge is how to support America's continued industrial strength and energy security. Doing so will require government actions that enable U.S. firms to compete on a level playing field in emerging global industries, especially given the degree to which other countries are supporting their own domestic firms.

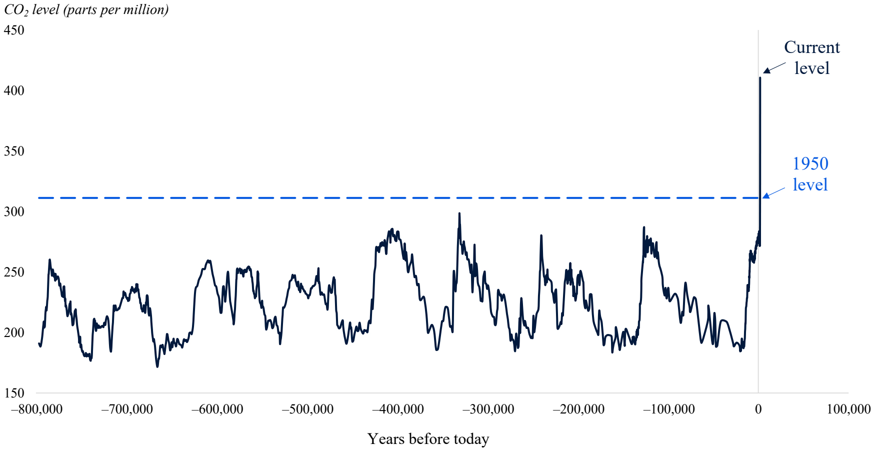
Another challenge presented by the transition is how to best support the communities across the United States that depend on carbon-intensive industries for jobs and tax revenue. In the past, when American communities have faced employment losses due to economic shocks—such as recessions, trade with China, and automation—workers and their families largely have not moved to communities where jobs are more plentiful, raising the important policy question of how to help people in the places where they are.

This chapter highlights what economics can tell us about effective policy strategies to accelerate and smooth the United States' clean energy transition. The first section provides background on climate risks, global progress in mitigating these risks, and the policies that will accelerate the transition. The second section describes the opportunities and challenges of supporting those domestic industries and communities that are most affected by the transition. The chapter concludes by highlighting the interdependency between the strategies to accelerate and to smooth the transition.

Accelerating the Energy Transition

The widespread adoption of fossil fuel energy technologies powered the steamships and factories that made the Industrial Revolution possible, and has helped spur economic growth for over a century (U.S. Energy Information Administration 2011; Friedrich and Damassa 2014). The burning of fossil fuels has also led to the rise in human-made carbon dioxide (CO_2) emissions, which is changing the composition of the atmosphere and, with it, environments around the globe. Over the 800,000 years before the 20th century, the atmospheric concentration of CO_2 vacillated between 150 and 300 parts per million, creating a climate hospitable for the world's development, as detailed in figure 7-1. In early 2022, CO_2 concentration levels are well above 400 parts per million and are continuing to grow. Because CO_2 is a heat-trapping greenhouse gas, rising levels in the atmosphere have led

Figure 7-1. Atmospheric CO_2 Level Across the Millennia to 2019



Source: NASA (2021).
Note: CO_2 = carbon dioxide.

to increasing temperatures, higher sea levels, more acidic oceans, and more frequent and severe cases of extreme weather and climate events (Zickfield, Solomon, and Gilford 2017; Bijma et al. 2013; Stott 2016).

Climate change poses considerable risks to the global economy. Climate-driven extreme events and biodiversity loss can result in cascading damage to such critical and interconnected systems as energy, public health, water, and food (Garcia et al. 2018; Porter et al. 2021). In the United States, estimated damage from storms, floods, wildfires, and other extreme weather events has grown to about $120 billion a year over the past five years (Smith 2021). Climate change disproportionately harms low-income and historically marginalized populations, because vulnerable individuals lack the resources to adequately prepare for or cope with extreme weather and climate events (U.S. Global Change Research Program 2018).

Because the rapid increase in greenhouse gases in the atmosphere is an ongoing planetary experiment, future damage from climate change is difficult to forecast precisely, and empirical estimates cover only a subset of likely effects. A 2017 meta-analysis finds that an increase in global tem-peratures of 5.4 degrees Fahrenheit (3 degrees Celsius) over preindustrial levels—a threshold that could be surpassed later in this century absent strong policy interventions—could cause economic damage equivalent to 7 to 11 percent of global gross domestic product (GDP) (Howard and Sterner 2017). In addition, studies that estimate the economic effects of climate change often fail to account for important aspects of climate change's impact on public health, including temperature-related mortality (Bressler 2021) and the deaths and sicknesses caused by local pollution from fossil-fuel-related emissions (Shindell et al. 2018; Scovronick et al. 2019).

Global Efforts to Reduce Greenhouse Gas Emissions

Average global temperatures have already risen about 1 degree Celsius above preindustrial levels (NASA 2021). CO_2 remains in the atmosphere for centuries, so our continued emissions will cause temperatures to continue to increase (Archer et al. 2009).

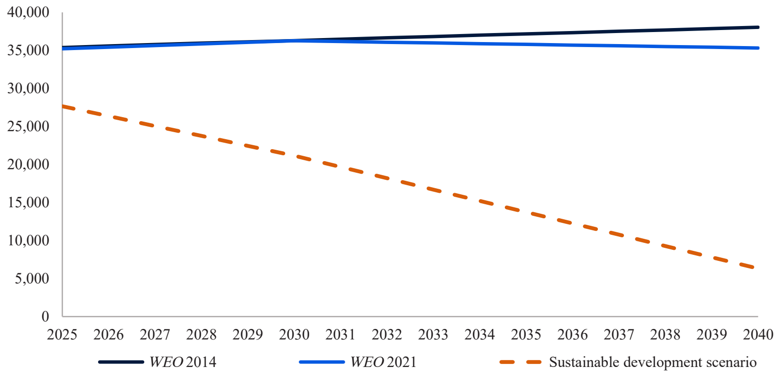
We can slow the pace of temperature increases by reducing global emissions, but halting global warming requires achieving net zero CO_2 emissions (Net Zero Climate 2022). Considerable momentum toward this goal is building worldwide. The world's major countries committed in the 2015 Paris Agreement to keep global warming well below 2 degrees Celsius above preindustrial temperatures, which is likely to require net zero emissions at the global level between 2050 and 2070 (UNFCCC 2021). Many countries, including the United States, have coalesced around a goal of net zero emissions by 2050. President Biden has additionally committed the United States to halve its net greenhouse gas emissions by 2030 (using a 2005 baseline) (McCarthy and Kerry 2021). In the European Union, the United Kingdom, and Japan, mid-century net zero emissions targets are stipulated by law (European Commission 2021a; Climate Change Committee 2021; Jiji Press 2021). The world's largest emitter of greenhouse gases—China—has com-mitted to net zero emissions by 2060 (Myers 2020). Many of the world's largest companies have also made pledges to cut emissions to net zero, including financial institutions responsible for over $130 trillion in assets (Glasgow Financial Alliance for Net Zero 2022).

Global annual CO_2 emissions have begun to level off after centuries of increasing, partially as a consequence of this momentum (Our World in Data 2020). A recent United Nations report declares that the peaking of annual global emissions by 2030 is within reach (UNFCCC 2021). The projections of future global CO_2 emissions by the International Energy Agency (IEA), displayed in figure 7-2, also show annual global emissions peaking and then beginning to decline in the decades ahead.

But to achieve the climate goals specified seven years ago in the Paris Agreement, the energy transition will need to accelerate markedly from current trends: a recent study estimates that without additional policy actions, there is less than a 10 percent probability that temperatures will stay below 2 degrees Celsius above preindustrial temperatures by 2100 (Ou et al. 2021). Figure 7-2 shows that in 2040, global emissions under currently announced or implemented policies are projected to be seven times higher than emissions under a scenario in which the world is on pace to achieve net zero emissions by mid-century (IEA 2021b).

Figure 7-2. Global Carbon Dioxide Emission Projections, 2025–40

Million metric tons



Source: International Energy Agency (IEA 2014, 2021), *World Energy Outlook* (*WEO*).
Note: The WEO 2014 and WEO 2021 scenarios reflect projections that assume existing policy frameworks and announced policy intentions. The IEA's Sustainable Development Scenario outlines how the world can deliver on the three main energy-related goals: achieving universal access to energy, reducing the severe health effects of air pollution, and tackling climate change.

Accelerating the Energy Transition in the United States

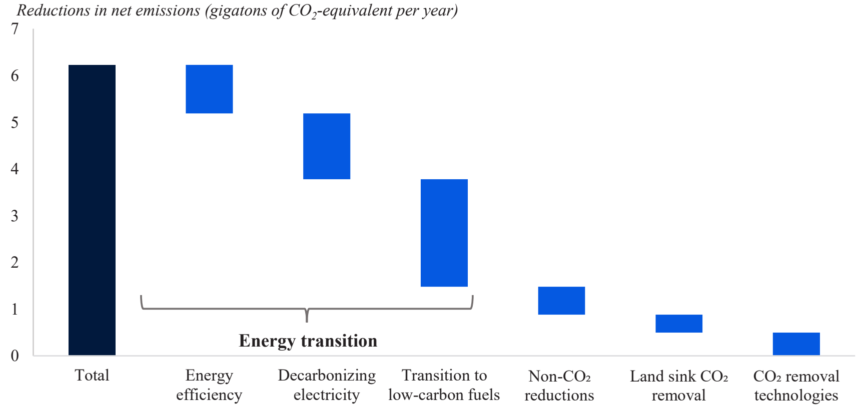
An effective response to climate change requires policy actions around the globe, starting here at home. The United States' annual greenhouse gas emissions are surpassed only by those of China, and our cumulative emissions are larger than those of any other country (Ritchie and Roser 2020; Our World in Data 2020).

Shifting from carbon-intensive to carbon-free energy systems is the major challenge to achieving net zero emissions in the United States (see figure 7-3). While reducing deforestation and other actions outside the energy sector are also critical to slowing climate change, the production and consumption of energy are responsible for about three-quarters of U.S. emissions (Ge, Friedrich, and Vigna 2020; Climate Watch 2021).

Successfully transitioning the U.S. economy to clean energy necessitates a large shift in economic activity. Americans spend over $1 trillion annually on energy, or about 5 to 10 percent of U.S. GDP in recent decades (U.S. Energy Information Administration 2018). Natural gas- and coal-fired power plants produce the majority of U.S. electricity, while petroleum products are the dominant fuel to transport people and products. Houses and buildings are often heated with furnaces and boilers that burn natural gas and oil, and the products Americans buy, the food we eat, and the sidewalks we walk on have carbon embedded in their production processes (White House 2021a). In 2019, 83 percent of the country's energy demand was satisfied by coal, oil, and natural gas, down from about 87 percent in 2000 (Ritchie and Roser 2020).

Meeting domestic and global climate targets means substantially stepping up the pace of clean energy deployments over the next decades,

Figure 7-3. Representative Pathway to Meet Net Zero Emissions in the United States, 2005–50



Source: U.S. Long-Term Climate Strategy.
Note: CO_2 = carbon dioxide.

as shown by a recent IEA analysis that details a pathway to net zero emissions by 2050 (see table 7-1) (Bouckaert et al. 2021). Though the world is not decarbonizing at the pace of this IEA scenario, recent trends and expert forecasts do tell a story of an explosive growth of clean energy technologies. In the United States, wind turbine technicians and solar energy installers are two of the five fastest-growing occupations, and over 80 percent of new electricity generation capacity built here in the first three quarters of 2021 was wind or solar (U.S. Bureau of Labor Statistics 2021a; Shahan 2021).

Although many details about the energy transition are impossible to know in advance, the road map to meeting the energy demands of a growing economy with clean energy has become much clearer in recent years. Dozens of "deep decarbonization" studies point to a similar recipe: produce electricity with carbon-free sources and shift energy uses to this carbon-free electricity and other low-carbon fuels (National Academies 2021).

A rapid energy transition will not occur without the implementation of a host of policy measures. If market prices fail to account for the damage caused by emissions, then consumers and producers will continue buying and selling too many artificially inexpensive, carbon-intensive goods and services. Carefully designed policies can change this behavior by raising the relative price of carbon-intensive goods and services compared with cleaner alternatives, which provides a financial incentive to shift away from the carbon-intensive products (Serrano and Feldman 2012).

Such carbon prices could be implemented directly via carbon taxes, indirectly through a cap on emissions and tradable permits, or through other similar policy tools. Government revenues from the carbon price can be used

Table 7-1. Global Clean Energy Deployments in 2020 and 2030 Consistent with Net Zero Emissions by 2050

Type of Clean Energy	2020	2030
Global wind installations	114 GW per year	390 GW per year
Global solar energy installations	134 GW per year	630 GW per year
Electric vehicles	5% of global car sales	60% of global car sales
Heat pump installations	180 million per year	600 million per year
Captured carbon	40 mt per year	1670 mt per year

Source: Bouckaert et al. (2021, tables 2.5, 2.6, 2.9).
Note: GW = gigawatts; mt = metric tons.

to compensate consumers for increases in energy prices or to invest in other societal priorities.

Carbon prices of some form exist at the national level in 45 countries, including those that have been successful at sustaining emissions reductions, such as the United Kingdom (see box 7-1) (World Bank 2021). Canada's federal carbon price is scheduled to increase from 50 Canadian dollars per metric ton of CO_2 in 2022 to 170 dollars in 2030 (Government of Canada 2021). However, many countries have failed to implement carbon prices at the scale and scope needed to achieve large emissions cuts (OECD 2021). In the United States, Federal-level carbon pricing proposals have stalled in Congress for over 30 years, including legislation that passed in the House of Representatives in 2009 but failed in the Senate (Center for Climate and Energy Solutions 2021).

Even in the absence of these political challenges, carbon prices are just one of many policy measures needed to cost-effectively accelerate the energy transition. After all, in addition to the failure of market prices to account for the damages caused by emissions, various other barriers stand in the way of a rapid, equitable, and low-cost transition. Complementary policies can make it cheaper or easier to conserve energy or to shift away from carbon-intensive products.

Policy measures are needed for situations in which consumers cannot or do not fully respond to price signals; for example, tenants are often responsible for paying utility bills but have no control over what landlords could do to effectively reduce energy consumption (Ryan et al. 2011). Well-designed incentives and standards can encourage broader use of energy-efficient products and other energy-conserving actions.

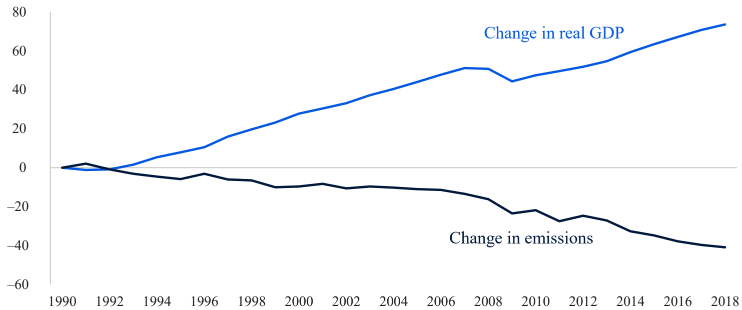
Measures that foster innovation are also necessary to reduce the costs of the clean energy transition. Private firms are likely to underinvest in technological progress because the benefits of their investments in emerging technologies partially accrue to society writ large. In addition, new products struggle to compete on a level playing field with established products due to

Box 7-1. The United Kingdom's Emissions Have Fallen Rapidly While Its Economy Has Grown

The United Kingdom passed a major climate change law in 2008 and implemented a combination of emissions pricing, regulations, subsidies, and spending on clean energy (London School of Economics 2020). Its emissions fell by about 20 percent between 2009 and 2019, as shown in figure 7-i; the trends shown are not due to swapping domestic production of carbon-intensive products for imports (i.e., "offshoring" emissions); in fact, between 2009 and 2019, emissions from imported goods decreased by more than emissions from exported goods (Ritchie and Roser 2020).

Figure 7-i. Changes in U.K. Greenhouse Gas Emissions and Real GDP since 1990

Percent change since 1990



Sources: Climate Watch; U.K. Office for National Statistics; CEA calculations.
Note: Real GDP is reported in chained 2019 pounds. Greenhouse gases are reported in megatons and use production-based accounting

a host of competitive disadvantages, which include access to capital and the difficulty of acquiring the talent, materials, and customer bases necessary to scale up production. Well-designed policies can help encourage investments at all stages of the innovation process, from research to demonstration projects to initial commercialization (Gundlach, Minsk, and Kaufman 2019).

Finally, even with these policies in place, the widespread adoption of cost-effective clean energy solutions requires building the necessary public infrastructure and regulatory structures that enable them to compete with more established products. For example, regulators can require financial institutions to assess climate risks in their investments, and Federal agencies can set guidelines to ensure that emerging technologies, such as carbon capture and storage, are deployed effectively and equitably (White House 2021b; Council on Environmental Quality 2021).

More broadly, policies that accelerate the transition can be designed to prioritize equity. Currently, lower-income households are often disproportionately harmed by higher energy bills. Further, energy infrastructure investments have historically led to environmental degradation in marginalized communities. Policies can be designed to lessen rather than exacerbate these equity concerns; for example, the Biden Administration has committed to devoting a substantial portion of Federal investments in clean energy development to disadvantaged communities through the Justice40 Initiative (White House 2021c). In many places that have implemented carbon prices (e.g., Canada's federal carbon pollution pricing system), the revenues are returned to lower-income households so that they receive more in government payments than they pay in higher prices of goods and service (Government of Canada 2022).

A Smooth Transition to Clean Energy

The need to shift to clean energy is paramount to lessen the severe threats of climate change. However, an equitable transition to a clean energy economy requires more than efforts to reduce emissions. This section highlights the need for public policies that support certain domestic industries and vulnerable communities in response to two key challenges posed by the energy transition.

First, domestic clean energy industries will become increasingly important for the Nation's security and global economic position. Currently, the United States' energy industry is carbon-intensive and a source of eco-nomic productivity and stability (U.S. Environmental Protection Agency 2021). For example, our domestic production of natural gas helps to keep costs low for American consumers and firms (U.S. Energy Information Administration 2021b). However, as the global energy transition progresses, the innovation and production of clean technologies will grow in impor-tance. Fortunately, the United States has the needed resources, institutions, and workforce to support globally competitive clean industries. However, other nations are rapidly ramping up investments in clean energy and sup-port for their domestic industries. Without strong and sustained Federal Government support, U.S. firms that can supply a clean economy are likely to struggle to compete in global markets.

The second portion of this section describes the challenges the energy transition poses to communities across the United States where jobs, income, and tax revenues depend on carbon-intensive industries, such as the production of fossil fuels or downstream products like automobiles. Fossil fuel-dependent communities across the country are already facing economic challenges, and the energy transition poses additional risks to communi-ties that are not well prepared and supported (Interagency Working Group

2021). In the past, workers and their families largely have not moved to find jobs when faced with the loss of major employers in their communities. Strategies to support these groups of Americans through the energy transition therefore require policies that target fossil fuel-dependent local economies.

Although economists largely agree on the policy recipe for accelerating the energy transition, no similar playbook exists on how to smooth the transition for U.S. firms and communities. In fact, economists have long pointed to the risks of government interventions that advantage certain industries or geographic regions over others. However, the economic literature highlights ways to minimize policy risks and capitalize on the economic opportunities of creating global-leading firms and revitalizing local economies.

The First Challenge: Supporting Domestic Industries

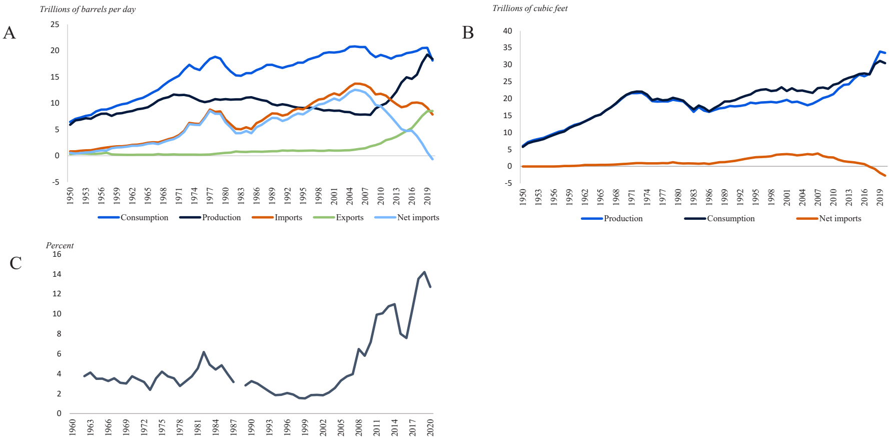
This subsection describes the need for policy measures that support domestic clean industries, and the opportunities and risks of government interventions that can enable U.S. firms to compete in global markets that are growing rapidly during this energy transition.

The domestic energy sector is important to the U.S. economy. Energy production is an important component of U.S. economic strength and stability. The United States is the world's largest producer of petroleum and natural gas, surpassing Saudi Arabia in petroleum production in 2018 and Russia in natural gas production in 2011 (U.S. Energy Information Administration 2019). Despite being the world's largest consumer of oil and natural gas, American producers are also now large exporters of these fuels (U.S. Energy Information Administration 2021c). Net imports of petroleum products (about three-fourths of which come from crude oil) fell from about 10 million barrels a day in 2000 (roughly half of U.S. consumption) to below zero by 2019; meanwhile, net imports of natural gas fell from about 4 trillion cubic feet in 2000 to about -2 trillion cubic feet in 2019 (U.S. Energy Information Administration 2021b, 2021c).

The United States is also the world's largest exporter of refined petroleum products and liquefied national gas (Observatory of Economic Complexity n.d.; U.S. Energy Information Administration 2021d). The value of fuel exports as a fraction of the total value of merchandise exports increased from about 2 percent in 2000 to 13 percent in 2020, indicating that fuel exports alone account for about 1 percent of U.S. GDP (World Bank 2020) (figure 7-4).

In addition to fossil fuels, American firms are large producers and exporters of many other energy- and carbon-intensive products, including chemicals and steel (DeCarlo 2017; U.S. International Trade Administration 2020; IEA 2022a). The carbon-intensive auto industry makes up 3 percent

Figure 7-4. U.S. Fossil Fuel Consumption for Selected Years



Sources: U.S. Energy Information Administration; World Bank.
Note: Figure panels, from left to right: A, U.S. petroleum consumption, production, imports, exports, and net imports, 1950–2020; B, U.S. natural gas consumption, dry production, and net imports, 1950–2020; C, U.S. fuel exports as a share of merchandise exports, 1960–present.

of GDP, more than any other manufacturing sector (American Automotive Policy Council 2020).

Despite the harmful effects of the United States' reliance on fossil fuels, the reality is that we currently benefit in certain ways from our domestic energy production. In the winter of 2021–22, Europe was immersed in an energy crisis, including historically high natural gas prices caused by a series of shocks that led to increased demand and constrained supply, due in part to the continent's dependence on natural gas from Russia (Cohen 2021; Stapczynski 2021; Sabadus 2021). The United States is somewhat insulated from turmoil in natural gas markets abroad due to our domestic production and the lack of a fully integrated global market—natural gas prices in Europe rose to over 10 times higher than prices in the United States in December 2021 (Reed 2021).

In contrast, the global oil market is highly integrated, with a group of countries that essentially set prices (Fattouh 2007) and a mixture of state-owned and private producers with widely varying costs of production (*Wall Street Journal* 2016). American consumers of oil are therefore vulnerable to geopolitical turmoil and the decisions of policymakers in petrostates. The uninterrupted availability of affordable energy is a national security concern for the United States (IEA 2022b). Ensuring the security of our energy supply will require policy measures that diversify our energy sources and supply chains, and that build resilience into the energy system as a buffer against future shocks (Yergin 2006).

The energy transition is an economic opportunity, but policies are needed to help build strong domestic clean industries. American oil

Box 7-2. The History of U.S. Government Support for Domestic Carbon-Intensive Energy Industries

As industry and consumers ramped up their use of fossil fuels in the early 20th century, experts became concerned that the country would run out of oil unless new oil fields were found and brought online (Olien and Olien 1993). In 1913, the Federal Government added the intangible drilling oil and gas deduction into the tax code, which allowed companies to deduct from their taxes most of the costs of drilling new wells, reducing the high up-front expenses that could discourage exploration (Center for a Responsible Federal Budget 2013). This deduction remains in place today; at $2.3 billion a year, it is the single largest production tax benefit for the fossil fuel industry (Roberts 2018).

The U.S. government has periodically intervened in markets to ensure stable prices in the face of turmoil. For example, in 1930 in East Texas, an enormous new oil field known as the "Black Giant" was discovered by the oilman Dad Joiner (Loeterman 1992). Thousands of independent producers (known as wildcatters) flocked to the area, flooding the market with supply and driving the price of oil down to as low as $0.02 a barrel, well below the cost of production. Faced with a possible collapse of the oil industry, the Governors of Texas and Oklahoma declared martial law in 1931, halting production and stabilizing the price (Goodwyn 1996). President Franklin D. Roosevelt's Secretary of the Interior, Harold Ickes, led an effort to work out quotas and regulations with producers in the area. Three decades later, the founders of OPEC would look to that system as their model (Loeterman 1992). In 1959, President Dwight D. Eisenhower imposed a quota system restricting oil imports that would remain in place until 1973 (Council on Foreign Relations 2021).

The U.S. government has also intervened to help American companies access energy sources around the world. For example, in the 1940s and 1950s, the U.S. Department of State worked with U.S. oil companies to negotiate profit-sharing agreements with oil-producing nations, including Venezuela and Saudi Arabia, to be as favorable as was feasible to U.S. companies (Council on Foreign Relations 2021). In a 1950 agreement with Saudi Arabia, negotiators cut a deal in which oil companies increased the taxes they paid to Saudi Arabia while reducing the taxes they paid in the United States (Ross 1950). This agreement allowed money to flow to Saudi Arabia outside the formal Congressional approval process. When the Mossadeq government in Iran nationalized the Anglo-Iranian Oil Company, the U.S. and U.K. govern-ments launched Operation Ajax, which helped overthrow Mossadeq in 1953 (Allen-Ebrahimian 2017), In the aftermath, the five major U.S. oil companies, along with British and French companies, were given access to Iranian oil fields as part of the Iranian Consortium Agreement of 1954; the companies were also given control over production levels (Heiss 1994).

Government support comes in the form of boosting energy infrastructure and supply chains as well. A notable example is the Federal Highway Act of 1956, which built the networks necessary for fossil fuels to dominate personal and freight transportation in the United States, while potentially crowding out lower-carbon alternatives such as rail.

producers are also vulnerable to decisions made in petrostates. Though the United States is currently the world's largest oil producer, if the world moves to rapidly limit carbon and therefore reduce oil demand, state-owned oil producers in countries like Saudi Arabia may increasingly find it in their interest to maintain their production levels by setting prices closer to production costs than they are now, at the expense of higher-cost producers that include U.S. firms (U.S. Energy Information Administration 2021f). This means that while global oil demand may decrease only gradually in the coming decades, the effect on the U.S. oil industry may be more abrupt. Indeed, two recent projections show the oil market shares of the members of the Organization of the Petroleum Exporting Countries (OPEC) increasing from roughly one-third in 2021 to about one-half or two-thirds by 2050 in a net zero scenario (Bouckert et al. 2021; Mercure, Salas, and Vercoulen 2021).

At the same time, the rapid growth of the demand for carbon-free products globally creates massive—but possibly fleeting—opportunities for U.S. firms. A key question is how the economic productivity and energy security of the United States will be affected as countries transition to clean energy. Will U.S. firms be able to compete in emerging global carbon-free industries? If not, the energy transition could lead to our reliance on imports of the batteries, heat pumps, low-carbon steel, and other critical inputs to a clean energy economy.

Consider the transition from internal combustion engine (ICE) vehicles to electric vehicles (EVs). Cars are a major source of greenhouse gas emissions, and President Biden has announced a goal to increase the share of new passenger vehicle sales that are EVs and other zero emissions vehicles from 2.4 percent in 2020 to 50 percent in 2030 (Bui, Slowik, and Lutsey 2021). There are nearly 1 million workers in the U.S. automotive industry, and over 3 million in the car dealer industry (U.S. Bureau of Labor Statistics 2021b). The motor vehicle and parts industry has an annual output of over $500 billion (U.S. Bureau of Economic Analysis 2022). Reducing harmful emissions from vehicles will entail the reduction in output and employment related to ICE vehicles, but enormous growth in EVs—the value of the global EV market is expected to grow from $163 billion in 2020 to over $800 billion by 2030, according to one expert's forecast (Jadhav and Mutreja 2020).

Over the past century, the combination of automaker innovations, workers' unions, and labor laws have made ICE vehicles a staple of middle-class families—and in the process creating good jobs, new methods of production, and a strong domestic automobile industry. The United States has the resources and capital required to rapidly scale up a domestic EV industry that can satisfy the growing and changing nature of transportation needs. But this will not occur at a pace consistent with our climate goals without a policy strategy that encourages the redirection of capital and workers across the auto industry supply chain.

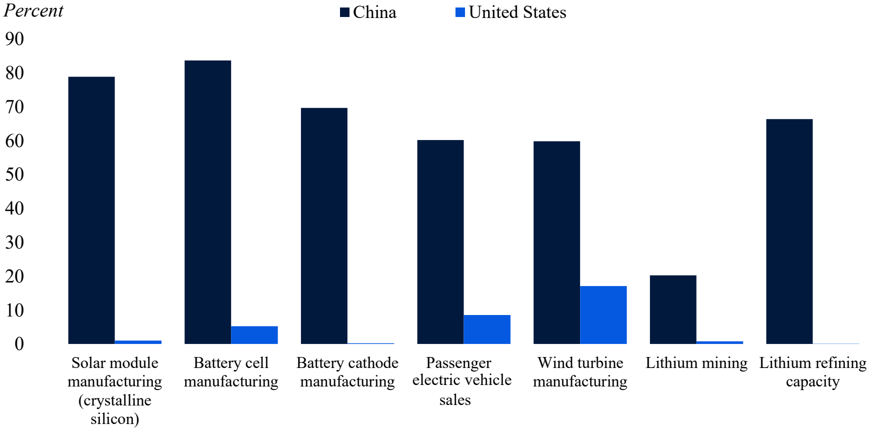
More broadly, the United States is well positioned to incubate leading-edge clean energy firms (Rodrik 2014; Cleary et al. 2018)—with a highly educated population (National Center for Education Statistics 2021) and institutions that have enabled global leaders in Silicon Valley, biotech, pharmaceuticals, and other industries. Further, a unique endowment of natural resources makes certain United States' geographic regions ideally suited to become hubs of carbon-free energy production (National Academies 2021).

However, U.S. firms will require support to compete in emerging global markets for clean products. The inability to capture the full societal benefits of innovation has led to insufficient private sector investments in emerging clean technologies, inhibiting the expansion of clean industries (Council of Economic Advisers 2021). For example, a first-of-its-kind demonstration facility for low-carbon cement production may provide large societal benefits but also have a cost and risk profile that the private sector is unwilling to take on without government support.

Even after a new technology has been successfully developed and demonstrated, its producers often face additional barriers competing with more established technologies. Established firms receive a range of benefits from the existence of a mature industry with extensive supply chains, agglomeration effects (i.e., interactions between innovation and production), and networks of consumers, whereas chicken-and-egg problems hinder emerging technologies. For example, the uptake of EVs is slowed by a lack of a nationwide charging network, and a nationwide charging network has not been built because there are not enough EVs on the roads (Wei et al. 2021).

The robust industrial policy strategies of other countries can also be an obstacle to emerging clean industries in the United States. In an efficient global market, each country would provide its domestic firms with only the support required to overcome the types of hurdles described above, which should enable the most productive firms worldwide to become market leaders. In reality, if the U.S. government fails to provide domestic firms with sufficient support, or if other governments overcompensate their own

Figure 7-5. The United States' and China's Percentages of the Market across Clean Technology Industries



Source: BloombergNEF.

domestic firms, American firms may not be able to compete in global markets, regardless of their potential competitive advantages.

The Chinese government has made a concerted and successful effort to build domestic industries that can supply a global clean energy economy (Liu and Urpelainen 2021). Therefore, Chinese firms dominate clean energy manufacturing worldwide. Chinese companies product about 60 percent of the world's wind turbines and about 80 percent of its solar module cells (see figure 7-5).

In addition, China now produces over 80 percent of the world's battery cells used to power EVs. Ceding such industries to China is not only a lost opportunity for U.S. firms but also a risk to U.S. consumers, given the potential for the monopolization of important supply chains (see also chapter 6). Building a domestic battery industry—as well as other components of the EV supply chain, such as key critical minerals—that can compete with firms in China and other countries is a key challenge for the U.S. economy over the next decade—and a major economic opportunity, given the growing global demand for EVs.

China and Russia are also making large bets on nuclear energy, another source of clean energy with the potential to grow rapidly in a global energy transition (Berthélemy and Cameron 2021). A recent study by the International Atomic Energy Agency projects nuclear energy capacity could grow between 17 and 94 percent worldwide by 2030 (IAEA 2013). In contrast, the growth of nuclear energy has stalled in the United States due to concerns related to costs, safety, and waste, although the Bipartisan Infrastructure Law and other Biden-Harris Administration proposals include substantial incentives to support the domestic nuclear energy industry

(Bordoff 2022; U.S. Energy Information Administration 2021g). Ceding the global-leading positions in the nuclear industry to China and Russia, whose companies are now supplying reactor technologies to other parts of the world, would forgo not only economic opportunities for U.S. firms but also the potential for the U.S. government to influence nonproliferation efforts in other countries with nuclear energy facilities (Bordoff 2022).

Our allies are developing industrial policy strategies as well. For example, the European Union is the world's leader in subsidizing renewable electricity generation (Taylor 2020), and it recently introduced a new strategy to support domestic industries with increased access to financing, reduced regulatory burdens, and capacity building for the transition to sustainability and digitization (European Commission 2020). The EU has also provided substantial support to key emerging technologies such as batteries and clean hydrogen, positioning European clean energy firms to be the global leaders in potentially game-changing technologies (European Commission 2021b, 2022).

Strategies for Supporting Domestic Industries through the Energy Transition

The world's most advanced economies, including the United States, have implemented policy measures with the aim of industrial development (Goodman 2020). For over a century, U.S. policymakers have provided support to the fossil fuel industry, recognizing that a strong domestic energy industry is important for economic competitiveness and national security (Johnson 2011). Yet government interventions are not without risk; after all, market forces can improve the economic efficiency of decisions. The challenge for policymakers, then, is to design a fulsome strategy that maximizes the economic opportunities of the clean energy transition while minimizing the risks.

Although there is no established playbook for green industrial policy, economists have offered numerous general principles (Vogel 2021; Rodrik 2014; Mazzucato, Kattel, and Ryan-Collins 2019). First, the government should provide domestic industries with *transparent, high-level goals*. National governments can launch national missions to confront the largest challenges facing societies, including climate change (Mazzucato, Kattel, and Ryan-Collins 2019). For example, during the Space Race of the 1960s, funding for the U.S. National Aeronautics and Space Administration reached nearly 4.5 percent of Federal spending, which fueled domestic industries like computer chip production and spawned a new generation of engineers and scientists (Chatzky, Siripurapu, and Markovich 2021). In contrast to high-level missions, supporting specific companies or technologies over others comes with demanding informational requirements on policymakers, and government actors do not have complete information on the potential benefits, costs, and risks of each investment (Schultze 1983). Instead, the government may (at least partially) let political considerations influence investment decisions, which raises the odds of wasteful government spending.

Another recommendation is that government should *focus support on technologies that are not fully mature*—from research and development to demonstration projects to initial commercialization. Without government support, firms that produce emerging technologies often cannot compete with firms that produce mature technologies. Many of the largest industrial policy success stories have come from investing in innovative technologies that exhibit a wide range of potential (and often unforeseen) applications (Goodman 2020). In contrast, subsidies for fully mature technologies can cause long-term declines in allocative efficiency, largely by untethering prices and output allocations from underlying economic conditions (Kim, Lee, and Shin 2021). Importantly, it may not be possible or desirable to avoid supporting specific emerging clean energy technologies, despite the associated challenges noted above.

Governments need to balance the potentially conflicting needs to *foster collaborations with industry while avoiding its undue influence on the policy process*. Successful public policies often require considerable interaction between government officials and industry stakeholders, so that the government officials understand the businesses and technologies on which public policies focus (Rodrik 2014). Such interactions naturally heighten the concerns of political capture—whereby government officials put their own interests and the interests of industry stakeholders who lobby them above the interests of their constituents—because policy decisions are made by political actors (Gregg 2020). Indeed, whenever subsidies and tariffs are on the table, moneyed interests will lobby for the adoption and retention of their preferred policies, making these policies difficult to eliminate when they become unnecessary or counterproductive. For example, fossil fuel subsidies were first paid in the 1910s, and agriculture subsidies were first paid in the 1930s (Center for a Responsible Federal Budget 2013; Comparative Food Politics n.d.); in both cases, the subsidies have lasted to the present day due in large part to interests that benefit from them. Approaches to balance the needs to collaborate with industry, while avoiding their undue influence, include government institutions with some degree of independence from the political process and restrictions on a revolving door between government service and industry.

Another way to maximize the effectiveness of government interventions is to *make the regulatory environment as certain as possible*. Ensuring that the parameters and duration of government support are clear and concrete will give firms confidence about future technological and market opportunities, catalyzing investment and innovation that would not otherwise occur. In contrast, uncertain regulatory environments are not conducive to attracting private sector investments. For example, the periodic expiration (or near-expiration) of the production tax credit for renewables in the United States has inhibited investments in wind and other clean energy technologies and thus has inhibited the growth of these emerging industries (Sivaram and Kaufman 2019).

Finally, just as an investor may be wise to consider a diversified portfolio rather than a concentrated set of individual stocks, the government should *invest in a broad portfolio of clean energy solutions* (Rodrik 2014). An important role of government is to take on risks that the private sector will not bear; a diverse portfolio accommodates such risks, even in the presence of the inevitable failed investments. For example, the Department of Energy's Loan Programs Office was established to provide financing for innovative energy projects in the United States, including access to debt capital that private lenders cannot or will not provide (U.S. Department of Energy, Loan Programs Office 2017). The program has funded a few companies that went bankrupt—most notably the solar producer Solyndra—but those bankruptcies have not prevented the formation of a highly successful overall portfolio of investments (Rodrik 2014). The program has propelled the growth of game-changing companies, including Tesla (U.S. Department of Energy, Loan Programs Office 2017). The Federal Government should be willing to lose money to achieve such benefits; but instead, the monetary losses from the Loan Program have been less than one-third of the interest paid to the government on the loans to date (U.S. Department of Energy, Loan Programs Office 2021).

Following this playbook, President Biden has announced a goal for 50 percent of passenger vehicle sales by 2030 to be EVs, along with helping to build a domestic supply chain to support EV production (White House 2021d). Moreover, the Federal Government is investing in the infrastructure needed to entice consumers to purchase EVs; there are currently only about 5,000 of the fastest EV chargers in the United States for public use, and these chargers are clustered in a few regions, including in the Northeast and on the West Coast. The 2021 Bipartisan Infrastructure Law is investing billions of dollars in building a domestic supply chain for batteries and nationwide network of EV charging stations (White House 2021d, White House 2021e).

Previous attempts to support domestic industries in global markets have mixed track records (see box 7-3). Many failed investments might have been avoided with better processes for strategically targeting industrial policy opportunities. Perhaps more important than avoiding failed invest-ments is creating the conditions where failures are expected and accepted as a learning experience, including with data collection, information sharing,

Box 7-3. Industrial Policy Successes and Failures

Governments worldwide have had many successes and failures supporting domestic industries. Perhaps the most prominent examples are in the context of economic development. South Korea is an often-lauded success story, due to its subsidies for a targeted set of industries that helped build a series of large, family run business conglomerates called the Chaebol, including well-known brands like Hyundai and Samsung (Albert 2018; Westphal 1990). One study found that targeted industries grew more than 80 percent more than nontargeted ones from 1973 to 2017 (Lane 2017). In contrast, several industrial policy pushes in Sub-Saharan Africa, North Africa, and the Middle East have been largely unsuccessful, with corruption, existing distortions, and weak government capacity limiting their effectiveness (Devarajan 2016). Even in cases where industrial policy has been successful in the development context, such as Japan, it is difficult to disentangle industry support from other factors that influence economic growth, such as favorable domestic economic conditions or high savings rates (Goodman 2020).

The anecdotal evidence of developed countries supporting domestic producers in emerging high growth industries offers notable successes and failures. Denmark has successfully leveraged a national strategy to build world-leading capabilities in offshore wind energy, while the billions of dollars spent by France, Germany, and the European Union in the early 2000s to fund search engines that could compete with Google were unsuccessful (Lewis 2021; Goodman 2020).

Efforts by the U.S. government to support domestic industry have similarly produced mixed results. Some of the largest anecdotal successes of government interventions have come in the face of threats, like the Space Race or the War Production Board during World War II (Chatzky, Siripurapu, and Markovich 2021). Facing intense competition from Japan in the 1980s, subsidization of the semiconductor industry created a globally competitive industry by the 1990s (Hof 2011). In contrast, the United States has provided strong support to the domestic shipping industry for a century—yet U.S. ships still cannot compete on cost with foreign vessels, in part due to poor labor standards in the industry abroad (which is also a highly relevant concern for clean energy production abroad) (Frittelli 2003, 2019; Ha et al. 2020; Kaplan, Buckley, and Plumer 2021).

and impact evaluations. This will enable policymakers to experiment with policy design, figure out what works, and take sufficient risks to reap the rewards of economy-boosting investments.

The Second Challenge: Supporting Communities That Rely on a Carbon-Intensive Economy

The geographic concentration of many of the industries most affected by the energy transition, including fossil fuel extraction and the manufacturing of high-carbon products, implies disproportionate risks for the regions of the country that rely on these industries for jobs and tax revenue, and important opportunities for public policies to mitigate these risks and invest in the residents of these same regions.

There is considerable overlap between the dual challenges of smoothing the energy transition for domestic economic sectors and for local communities. After all, clean energy-related investments in fossil fuel-dependent local economies can serve to boost *both* the industries and places most affected by the energy transition.

However, these two challenges also differ in marked ways. As described above, supporting domestic industries most effectively entails a national strategy that will lead to investments across the entire country, including but not limited to local economies that currently depend on fossil fuels. Similarly, effectively supporting fossil fuel-dependent communities will involve a commitment to these local economies with measures that are not limited to clean energy investments.

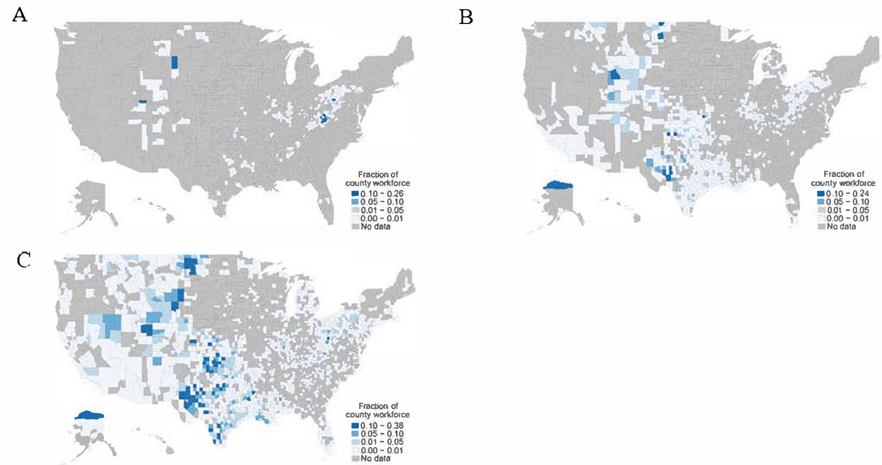
The remainder of this section describes the rationale for government interventions to support fossil fuel-dependent communities and the lessons learned from prior experience with place-based policies.

The Geographic Concentration of Fossil-Fuel-Dependent Communities

As a case study, consider the automobile industry's shift away from ICE vehicles. Certain industry jobs, including vehicle assembly and sales, may translate to jobs on the EV line relatively seamlessly. However, many of the jobs specific to ICE components and supply chains will decline. For example, the ICE and EV powertrains—the system by which the engine and motor deliver power to the wheels—require different parts. Of the 140,000 workers in the U.S. powertrain sector, 70 percent are mostly concentrated in small communities in Michigan, Ohio, and Indiana. In Monroe County, Michigan, more than one-quarter of employment relates to ICE vehicle powertrains (Raimi et al. 2021).

The risks of the energy transition may be even more acute for communities dependent on the extraction and combustion of fossil fuels. The U.S. fossil fuel industry is highly geographically concentrated, as shown in figure 7-6. The coal extraction industry (panel A) is largely located in Appalachia and portions of the Mountain West—about 90 percent of U.S. coal production takes place in 50 counties (U.S. Energy Information Administration

Figure 7-6. Fossil Fuel Employment by County



Sources: Quarterly Census of Employment and Wages; Bureau of Labor Statistics (BLS); CEA calculations.
Note: Figure panels, from left to right: A, coal mining; B, oil and gas extraction; C, support services for the mining and quarrying of minerals and for the extraction of oil and gas. Industries are defined by NAICS codes 211 (oil and gas extraction), 2121 (coal mining), and 213 (support activities for mining and oil/gas extraction). Each panel displays the fraction of the county's workforce in the NAICS industry. Cells with small employment are suppressed by the BLS.

2021h). In some counties, fossil fuel employment is as high as 30 to 50 percent of all employment (panels A, B, and C); these figures are higher when including jobs directly supported by the region's dominant industry, such as in the service sector, supply chain, and local government (Tomer, Kane, and George 2021).

Employment and economic activity associated with fossil fuel production is already declining in many regions of the country. Coal-mining jobs have decreased by about three-quarters since 1980, and employment in the oil and gas sector has declined by about 30 percent in the last decade (Interagency Working Group 2021; Federal Reserve Bank of Saint Louis 2022). The underlying reasons are myriad: automation; cheap natural gas causing a shift away from coal-fired electricity; lower prices of renewable energy; resource decisions that account for the damage caused by climate change and air pollution; volatility in oil markets; and weak international demand, which may continue to fall as countries seek to meet their Paris Agreement commitments (Look et al. 2021; Bowen et al. 2018).

Fossil fuel-dependent communities that are unprepared for the energy transition risk further reductions in employment and economic activity (Larson et al. 2020). These areas are often rural, undiversified, and have pre-existing economic challenges—poverty rates are higher in fossil fuel-reliant communities than in neighboring counties and the Nation as a whole, as are mortality rates due to such issues as opioid abuse and black lung disease (Interagency Working Group 2021; Bowen et al. 2018; Metcalf and Wang 2019; National Institute for Occupational Safety and Health 2018). Large populations in coal communities depend on pensions and other benefit funds with questionable solvency (Randles 2019).

More broadly, rural locations often lack both the basic infrastructure (e.g., roads and broadband Internet) and the financial infrastructure (e.g., easily accessible credit) necessary to transition to new industries (Raimi et al. 2021). Many rural locations also suffer from a dearth of opportunities, with undiversified economies and workers that are specialized for the jobs in the region. For instance, workers in Appalachia are 25 percent less likely than the national average to have a college degree (Appalachian Regional Commission 2022).

The loss of dominant employers can precipitate fiscal spirals from which jurisdictions struggle to recover, as previously shown in the experiences of steel towns in Pennsylvania, coal-producing regions of the United Kingdom, and the automobile-dominated economy of Detroit, among others. When major industrial firms depart, the supporting service sectors and nearby supply chains shrivel in size. Reduced economic activity leads to reduced government revenues from property and sales taxes, which often results in cuts to government services. Combined with reduced employment opportunities, these factors make it difficult for distressed communities to attract new businesses and for dislocated workers to find new job opportunities (Morris, Kaufman, and Doshi 2021).

The Inadequacy of Place-Neutral Policies

The geographic concentration of the risks of the energy transition does not, by itself, imply that government support should specifically target these regions. Instead of targeting economically distressed regions, policies could target struggling people, regardless of where they live. Indeed, many government programs already support people in communities that face economic shocks, even though they are often not targeted at specific communities. For example, Federal and State governments have implemented trade adjustment assistance programs to directly compensate workers who lose their jobs because of increased exposure to trade,[1] and assistance programs such as the Supplemental Nutrition Assistance Program (formerly known as Food Stamps) and Medicaid help people during times of economic hardship (Higdon and Robertson 2020).[2]

[1] Multiple reports have found limited effectiveness of trade adjustment assistance (TAA) programs at transitioning workers to new, higher-paying lines of work (Rodrik 2017; U.S. Government Accountability Office 2012a, 2012b). While TAA has a large, positive causal effect on employment and earnings, take-up of TAA is low, so some of the limited effectiveness of TAA may be explained by how few people use it (Hyman 2018; Autor et al. 2014).

[2] Social safety net programs may be especially important for aiding fossil-fuel-reliant communities, given preexisting economic challenges and the growing concerns about the solvency of industry-funded pension programs (Higdon and Robertson 2020; Walsh 2019).

However, new evidence suggesting that people largely do not move in response to economic shocks has challenged the argument for targeting people rather than places for transition assistance. For example, researchers who have studied the effect on U.S. communities of increased trade with China have found that trade-induced manufacturing job losses led to nearly one-to-one decreases in the employment-to-population ratio in affected communities, indicating that workers were not migrating to other communities or sectors (Autor, Dorn, and Hanson 2021). Similarly, Hershbein and Stuart (2021) find persistent decreases in employment-to-population ratios after severe recessions. Over half of Americans spend most of their career in their childhood metropolitan area (Bartik 2009). The reasons people do not move in response to shocks likely include their attachment to local communities (including support from family and neighbors), the falling housing prices in declining communities, and lower wages for noncollege workers in high-income cities (Notowidigdo 2020; Autor, Dorn, and Hanson 2021).

What often sparks migration is opportunity elsewhere, not the shock in one's community. Monras (2020) finds that the local differences to migration in response to recessions are driven by differences in *in-migration*, not in out-migration. In other words, conditional on deciding to move, people respond to local economic conditions when choosing a new location. The workers most likely to stay behind are those with lower earnings capacity (Notowidigdo 2011; Bound and Holzer 2000). For minority households, housing discrimination has also restricted mobility (Neumark and Simpson 2015).

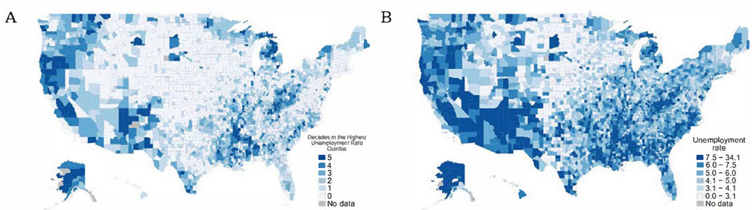
This tendency to remain in economically distressed communities and the inadequacy of assistance programs alone in ameliorating long-standing economic hardships (see box 7-4) implies the need for policies that help people where they are. This has led to an increase in scholarship on place-based, economic development policies aimed at improving the well-being of individuals in particular areas. Though the earlier literature highlighted the potential for inefficiencies, more recent findings focus on the conditions that may justify place-based policies. These include the invariance of location choices to local economic conditions; geographically segregated income groups that make investing in regions a reasonable proxy for investing in lower-income individuals (Akerlof 1978; Fajgelbaum and Gaubert 2021); the desire for insurance against location-specific economic shocks (Neumark and Simpson 2015), which may become more important as temperatures continue to rise; differences in the optimal hiring subsidies across regions based on local productivity levels (Kline and Moretti 2013); heterogeneity in local public goods provisions (Bartik 2020); and the desire to take advantage of agglomeration effects (Kline 2010).

Box 7-4. The Broader Issue of Distressed Local Economies

A proactive energy transition could prevent exacerbating problems in already distressed areas. The economies of many local communities are struggling, and some local economies have been distressed for a long time. Before the COVID-19 pandemic, in 2019, about 14 percent of U.S. counties had an unemployment rate above 8 percent (see figure 7-ii). Distressed local economies are concentrated in portions of the Black Belt, Appalachia, industrial Midwestern cities, and rural Western areas.

The causes of these struggles vary—the "China trade shock" (Autor et al. 2013), migration to urban centers, and technological change (Acemoglu and Restrepo 2020), to name a few—and the struggles are often persistent: about one-third of the counties with unemployment rates above 8 percent in 2019 also had unemployment rates in the worst quartile of U.S. counties in 1980, 1990, 2000, and 2010. Similarly, Kline and Moretti (2013) find that a plot of unemployment rates in 1990 and 2008 across 239 metropolitan areas shows "a remarkable degree of persistence," with a regression coefficient of 0.509 (.045) and R^2 of 0.35; they note that European labor markets show a similar (perhaps larger) degree of persistence.

Figure 7-ii. Distressed Counties in the United States



Source: American Community Survey, Census Bureau.
Note: Figure panels, from left to right: A, number of decennial censuses in which the county is the highest quintile of unemployment rate; B, unemployment rate in 2019.

Strategies for Place-Based Policies

While there is no established playbook for policymakers to follow in designing policies to support local economic development (Rodrik 2014), the following are general principles, drawn from the literature, for the design of place-based policies to support communities affected by the energy transition.

First, revitalizing communities requires a sustained commitment from the Federal Government to forming partnerships with local communities to fund suitable opportunities for economic development—a type of high-level national mission called out above in the context of industrial policy design.

Indeed, perhaps the most important cause of our limited understanding of successful place-based policies is how few resources have been devoted to these efforts at the Federal level. According to Bartik (2020), the U.S. government spends about $10.1 billion a year on Federal programs and tax credits that could fall under the umbrella of place-based policies. Such spending is a drop in the bucket compared with the resources spent on other Federal Government priorities, such as the annual grants of $417 billion to States and localities for Medicaid and the Children's Health Insurance Program (Shambaugh and Nunn 2018). If the Federal Government committed to providing communities with opportunities to rebuild after economic shocks, the subsequent policy experimentation would likely lead to a far better understanding of the most successful strategies for implementing place-based policies.

State and local governments spend above five times more per year than the Federal Government on place-based policies (Bartik 2020), and some State governments are an important source of support for distressed communities within their jurisdictions. However, for struggling regions facing binding budget constraints, economic development programs come in lieu of other public services—or, even worse, create a race to the bottom, in which local governments outbid one another to attract new businesses, depleting government coffers (Mast 2018). The Federal Government is the sole entity that can fund and implement a nationwide strategy to revitalize distressed areas.

A second principle for the design of place-based policies is to target the communities that will benefit most from the support. Austin, Glaeser, and Summers (2019) note that spending to boost employment is more effective in areas where unemployment is high. Bartik (2020) estimates that the benefits of added jobs are at least 60 percent greater in distressed regions than in booming local economies. Designing effective place-based policies therefore requires a process of selecting which communities to target. Avoiding political influence in making such decisions will be important for a program's success and credibility.

A third common recommendation for successful place-based policies is to avoid one-size-fits-all solutions. Place-based policies can be designed so that the same measure will be applied to any eligible region; or, at the cost of additional complexity, measures can be differentiated to accommodate local conditions and the relative strengths, needs, and existing assets of individual communities. Forming partnerships with communities and catering to local circumstances may be especially important for fossil fuel communities, given their distinctive characteristics noted above. For example, ReImagine Appalachia is a think tank that has proposed a blueprint for expanding opportunities for high-quality jobs with public investments that aim to match the skills of fossil fuel workers and contribute to sustainable economic development in the region (ReImagine Appalachia 2021).

Other recommendations for successful policy design include encouraging hubs of research and development activity, including in distressed communities, to take advantage of agglomeration effects (Gruber and Johnson 2019); and directing place-based policies toward industries for which investments create larger boosts in economic activity, which are referred to as higher-multiplier industries. For example, Bartik (2020) argues that multipliers in high-technology industries are especially large because the ideas and workers of one high-tech firm boost the productivity of nearby high-tech firms (Rodrik 2014, 2020; Mast 2018). (See box 7-5.)

The Clean Energy Transition Provides Unique Opportunities to Implement Successful Place-Based Policies

Place-based policies largely have not followed the principles described above (Bartik 2020), so it is perhaps unsurprising that the empirical evidence evaluating previous attempts at place-based policies is mixed. Bartik (2020) finds evidence supportive of the potential for place-based policies to generate large long-run benefits. He points to numerous examples of successful local economic development policies, including experiences involving the Tennessee Valley Authority and the Appalachian Regional Commission. At the same time, Neumark and Simpson (2015) conclude that, though place-based policies may increase economic activity when they are in effect, it is not clear from the evidence that place-based policies typically achieve their goal of jump-starting lasting economic development.

While support for struggling communities cannot focus only on clean energy investments, there are various reasons to believe that the energy transition will provide opportunities to improve the track record of place-based policies. The first reason is scale. Climate action requires large investments in a diverse set of emerging clean energy technologies. A recent National Academies panel estimated that roughly $2 trillion in incremental capital investments needs to be mobilized over the next decade to put the United States on track to achieve the goal of net zero emissions by 2050 (National Academies 2021). Princeton University's Net Zero America report estimates the need for 0.5 to 1 million additional jobs in the U.S. energy sector in the 2020s (Larson et al. 2020).

Indeed, many clean energy investments will vastly exceed the scale of the typical place-based policies of the past. For example, the Bipartisan Infrastructure Law includes money for large-scale demonstration projects for low-carbon hydrogen production and carbon capture retrofits for large steel, cement, and chemical production (see box 7-5) (White House 2021g).

Box 7-5. The Administration's Actions on Place-Based Policies for Energy Communities

The Biden-Harris Administration has taken actions in its first year that are intended to help energy communities. On January 27, 2021, President Biden signed Executive Order 14008, which established the Interagency Working Group (IWG) on Coal and Power Plant Communities and Economic Revitalization. The IWG's initial report identifies $37.9 billion in existing Federal funding that could be used to help energy communities; so far, IWG member agencies have delivered more than $2.8 billion in direct Federal funding to 25 priority energy communities across the country.

The American Rescue Plan Act of 2021 allocates $3 billion to the Economic Development Administration (EDA) to benefit underserved communities affected by COVID-19. The EDA has allocated $300 million to support communities that are dependent on the coal industry through Build Back Better Regional Challenge grants and Economic Adjustment Assistance grants.

The Bipartisan Infrastructure Law (BIL) includes a number of place-based investment provisions for which energy communities are prioritized (see table 7-i). Over the next five years, the BIL will allocate more than $27 billion to these programs—which includes $8 billion for regional clean hydrogen hubs, $3.5 billion for regional direct air capture hubs, and $2.5 billion for carbon capture demonstration projects.

The BIL also includes programs that target support to communities in other ways, including $55 billion for clean drinking water and eliminating lead pipes, $65 billion to ensure universal access to high-quality broadband, $110 billion to repair roads and bridges, and $21 billion for cleaning up legacy pollution by reclaiming mines and plugging orphaned oil and gas wells (White House 2021f).

Table 7-i. Selected BIL Programs That Target Energy Communities

BIL Program Name	Total (thousand dollars)
Regional Clean Hydrogen Hubs	8,000,000
Regional Direct Air Capture Hubs	3,500,000
Battery Material Processing Grants	3,000,000
Battery Manufacturing and Recycling Grants	3,000,000
Carbon Capture Demonstration Projects Program	2,537,000
Carbon Storage Validation and Testing	2,500,000
Advanced Reactor Demonstration Program	2,477,000
Carbon Dioxide Transportation Infrastructure Finance and Innovation	2,100,000
Clean Hydrogen Electrolysis Program	1,000,000

Source: U.S. House of Representatives (2022).
Note: BIL = Bipartisan Infrastructure Law. This table only includes programs with at least $1 billion in funding.

Such projects can involve many millions of dollars in investments in local economies (Jones and Lawson 2021).

Though place-based policies have not historically been well targeted to individual distressed communities, the diversity of clean energy solutions provides an opportunity to tailor investments to a community's strengths and needs, including characteristics related to geography, workforce skills, education levels, and preexisting infrastructure (Bartik 2020; Tomer, Kane, and George 2021). Importantly, the employment opportunities created by the energy transition may not, absent policy intervention, arise in fossil fuel-dependent communities that often support more extractive and labor-intensive industries. Yet place-based policies can channel investment to these communities. Some are well suited for a carbon capture project, while others are better suited for projects involving wind, solar, geothermal, nuclear, or other climate solutions. In many cases, policies can leverage the existing infrastructure and workforce skills in fossil fuel-dependent communities, including measures to repurpose retired power plants or equip facilities with the ability to sequester carbon underground (Tomer, Kane, and George 2021).

The energy transition also presents a unique opportunity to implement measures that raise the quality of jobs for American workers in the energy industry. Though roughly 30 percent of the clean energy workforce will require at least a bachelor's degree, 70 percent will require fewer than four years of related work experience (Larson et al. 2020). And though some clean energy jobs are already high paying, policy measures that incentivize high-quality clean energy jobs can help to ensure that opportunities in clean industries are suitable replacements for the relatively high-paying blue-collar jobs that constitute much of the employment in fossil fuel-reliant communities (Muro et al. 2019).

Once again, the growing EV industry provides an important example. The existing auto industry presents a unique economic opportunity to build a successful domestic EV industry in many of the same locations. For instance, Ford recently announced that it is converting its Van Dyke Transmission Plant in Sterling, Michigan, into the Van Dyke Electric Powertrain Center (Ford Motor Company 2021). Though market forces alone may be sufficient to incentivize such conversions in certain instances, policy support will often be needed to encourage automakers to take advantage of opportunities to shift to EVs in the communities where they currently operate.

Finally, it is worth reemphasizing that clean energy investments often carry atypical growth potential. The world needs clean energy solutions to rapidly scale up to successfully address the risks of climate change. Though clean energy investments are not devoid of risk, the likelihood that the demand for clean products will rapidly increase in coming decades is a major advantage compared with a generic, place-based investment.

Discussion and Conclusions

This chapter has emphasized that carefully designed policies are needed to accelerate the United States' transition to a clean energy economy. The host of market failures inhibiting this transition justifies the implementation of policies that reduce the relative prices of low-carbon products, offer incentives for innovation and energy efficiency, and provide public goods and regulatory measures that effectively support the development of a clean energy economy. These policies should be designed to ensure that they help to mitigate rather than exacerbate preexisting inequities in the economy.

Policies are also needed to smooth the transition to clean energy by lessening the risks to U.S. competitiveness in global markets and by supporting vulnerable communities. The literature points to numerous principles for how government can successfully intervene to boost domestic industries by setting transparent and high-level goals, providing regulatory certainty, creating a diversified portfolio of government investments, focusing on nonmature technologies, and pursuing measures that avoid having industry stakeholders exercise undue influence on the policy process.

Governments can also make sustained commitments to supporting and diversifying fossil fuel-dependent regional and local economies, by forming partnerships with these communities for measures that fit their particular characteristics, strengths, and challenges.

Fortunately, the energy transition provides opportunities for bolstering domestic firms in emerging carbon-free industries and for economic development in the communities that are most vulnerable to the transition's risks. Taking advantage of these opportunities is at the core of the Biden-Harris Administration's economic and climate strategies.

Given the lack of an established playbook for green industrial policies and place-based policies, policymakers need to be open to experimentation and must expect failures—along with lessons learned from these failures—as necessary aspects of what will become a successful portfolio of policies and investments.

The stakes are high. Although this chapter has separated the discussion of policies that *accelerate* the transition to clean energy from policies that *smooth* it, the fates of these two policy strategies are very much intertwined. The transition to clean energy has begun, but its pace is difficult to predict. Climate policies have long faced political opposition, partly because their costs are localized and front-loaded while their benefits accrue around the entire globe and for generations into the future. Failing to smooth the transition for workers, firms, and communities could erode public support for policies that can accelerate it and, most critically, can help us avoid the ever-worsening threats to our planet as it continues to warm.

Chapter 7

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