WHITE PAPER

COUNCIL OF ECONOMIC ADVISERS

April 23, 2021

Innovation, Investment, and Inclusion: Accelerating the Energy Transition and Creating Good Jobs

> When I think of climate change, I think about jobs. Good-paying, union jobs that put Americans to work, make our air cleaner, and rebuild America's crumbling infrastructure.
>
> —President Joe Biden[1]

[1] Tweet, December 17, 2020.

Introduction and Executive Summary

On July 20, 1969, Neil Armstrong became the first person to walk on the Moon. This achievement was the result of a decade of work by hundreds of thousands of U.S. workers across a wide array of scientific and technical fields (Ghosh 2021). The moonshot was an all-of-government approach to innovation that has paid off for decades. New ideas developed in the wake of that moonwalk—from telecommunications to the Internet to silicon chips—have led to commercial advances and vital industries, which have produced strong economic growth and well-paying, middle-class, often union jobs.

Combating climate change is the 21st-century moonshot, though on a much grander scale. Extreme weather and climate events—like storms, floods, and wildfires—have already caused about $120 billion a year in damages to the United States over the past five years (NCEI 2021). These costs are on course to accelerate as higher temperatures, rising sea levels, and extreme weather increasingly damage infrastructure and coastal property, alter crop yields, and reduce labor productivity. If left unaddressed, these damages will drag down economic productivity and growth in the United States. At the same time, tackling them and building resilience against them can provide a foundation for strong, stable, and shared economic growth.

A critical challenge is to find ways of producing increasingly cheap, reliable, and clean energy. These innovations will define many of the most important industries for decades to come, and with them, the jobs of the future. There has been remarkable progress along these lines: The fastest-growing power generation technologies are solar and wind (EIA 2021; IEA 2020a), which have seen cost reductions of 70 to 90 percent over the past decade (NAS 2021, 3). Progress on clean energy technologies has led to further deployments, and the knowledge gained from these deployments has then led to further cost reductions.

Yet technologies have neither been developed nor implemented on the scale needed to stabilize global temperatures and avoid the worsening threats of climate change. Some countries are making bold attempts to foster these new technologies, while also increasing their own economic competitiveness. The European Union, the United Kingdom, and Canada have all recently announced new industrial policy strategies to prepare their domestic industries and workers for the energy transition, while China's strong support of its domestic industries has made it the global leader in clean energy manufacturing.

We can already see how the United States is falling behind in developing innovations that will define this century:

- In 2017, U.S. Federal Government research and development (R&D) was just 0.6 percent of gross domestic product (GDP), less than a third as high as its 1964 peak of 1.9 percent during the buildup to the Moon landing (NAS 2021, 102).
- The United States has fallen to 10th in the world in terms of R&D investments as a percentage of GDP and, at the current pace, will soon lose its historic spot as the largest R&D investor globally (NAS 2021, 102).

- The failure to invest in public R&D is lost economic opportunity. The fall in public R&D as a share of GDP is estimated to have cost the U.S. economy about $200 billion in lost economic output in 2019, a cost that will only grow.[2]

Innovation in new energy technologies could support both economic growth and the creation of well-paying jobs. Yet, unlike most of its major trading partners, the U.S. government has not adopted a robust strategy to encourage the innovation and deployment of clean energy or to support U.S. workers and communities through the energy transition. Absent such a strategy, workers could be hit by the dual negative effects of declining jobs in high-carbon industries alongside too few new domestic jobs in the emerging carbon-free industries of the future.

Markets alone will not accelerate the energy transition at a sufficient pace or scale to address the climate crisis. The Federal Government has a critical role to play to catalyze the private sector into actions to ensure that the U.S. economy is competitive with the rest of the world (Block and Keller 2011; Mazzucato 2013; Rodrik 2004). The goal should be to identify and intervene in the strategic areas where government interventions—often in partnership with the private sector—can help build a fairer, more productive, and cleaner economy.

Without an intentional focus on equity, the benefits and costs of the energy transition will not be fairly distributed among Americans at different income levels, geographic regions, races, and occupations (Carley and Konisky 2020). Recent government policy has failed to sufficiently protect lower-income groups from bearing a disproportionate share of previous major transitions, such as globalization (Autor, Dorn, and Hanson 2016). We must do better in managing the transition to clean energy.[3]

This report is divided into three sections. The first section lays out the innovation challenge, and how the United States is falling behind and what the implications are for investment and jobs. The second section identifies the barriers that inhibit private actors alone from sufficiently investing in clean energy innovation, and thus why Federal policy and public-private partnerships are crucial. And the third section proposes policy responses to foster clean energy innovation and create good jobs.

Specifically, the Federal Government should accelerate energy innovation through policies that:

- Support technological progress, including R&D for, demonstration of, and the deployment of clean energy. To be attentive to distributional concerns, this policy agenda needs to engage stakeholders throughout each stage of the process to shape policy interventions.

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[2] This figure is calculated assuming (1) an elasticity of output with respect to the public capital stock of 0.122, from a meta-analysis by Bom and Ligthart (2014); (2) a depreciation rate of 15 percent; (3) public expenditures on R&D equal to 1.9 percent of GDP, beginning in 2000; and (4) an immediate realization of increased output from higher R&D investment.

[3] Some have argued that it is better to redistribute income through the tax system. Bozio et al. (2020), Revesz (2018), the Washington Center for Equitable Growth (2015), and Hacker (2011) articulate myriad reasons why this is an unworkable response.

- Invest in the supportive infrastructure that energy technologies require to thrive. This should include both enhancements to existing infrastructure and the development of new infrastructure that is critical for the growth of clean energy technologies.
- Develop targeted regulations that enable markets to reflect the damages from emissions while providing a more certain regulatory environment to investors.
- Support the development of good jobs in the energy sector and other industries affected by the transition to clean energy, with the goal of ensuring that economic gains are spread across the United States. This includes the right to join a union and robust labor standards, as well as place-based policies that help communities invest in economic development and revitalization strategies.

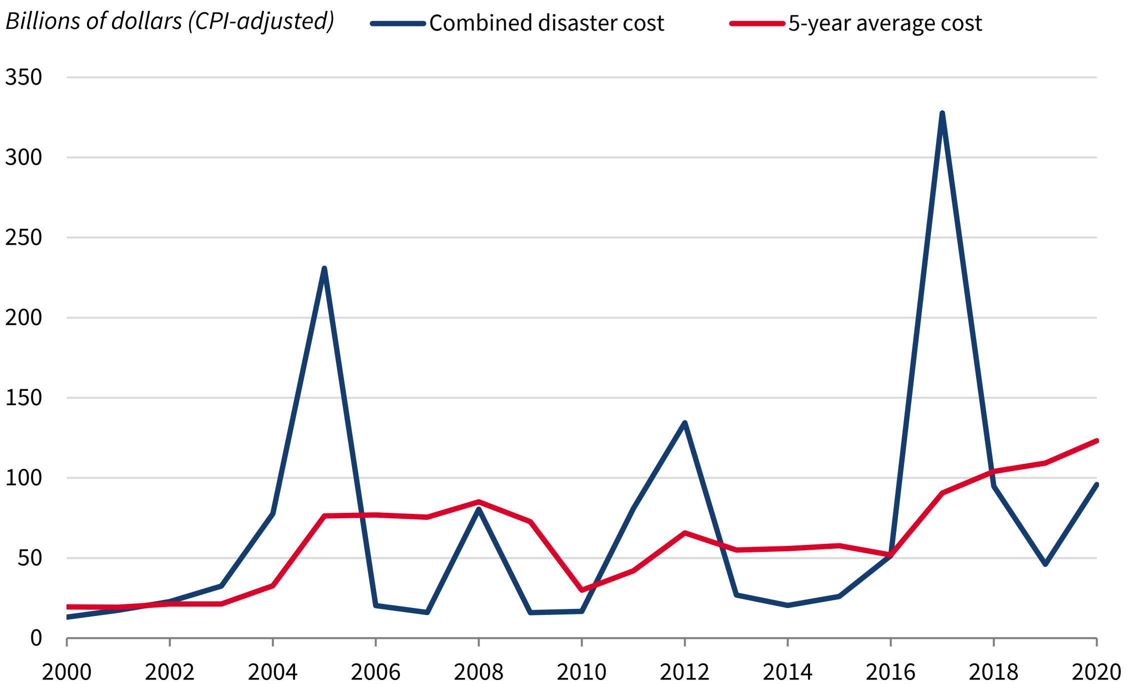
This agenda is not a comprehensive response to the climate and inequality-based threats, but together, they are a significant down payment on responding to each.

The science is clear: climate change poses a dire threat to humanity. Fortunately, creating the technologies that reduce climate risks presents a huge economic opportunity. The question is whether the United States will lead in developing and producing innovative technologies to address climate change, or accept that others will dominate this field. If it chooses the latter, it will fail to support the entry of U.S. companies and workers into a growing market. The United States’ ingenuity put a person on the Moon. It must now lead in preserving a livable planet.

Investment in Innovation Is Needed to Address This Century's Technological Challenge

Although the world is on the cusp of transformational technological breakthroughs in a variety of energy-related areas, neither the innovation nor deployment of clean energy is happening fast enough. Carbon dioxide concentrations in the atmosphere are far higher than they have been for at least *hundreds of thousands of years* and continue to grow. Climate risks involve stresses to interconnected systems—health, energy, water, food, ecosystems—with cascading effects; see figure 1. Lower-income and marginalized populations will be disproportionately harmed because they lack the resources to adequately prepare or cope with extreme weather events (USGCRP 2018).

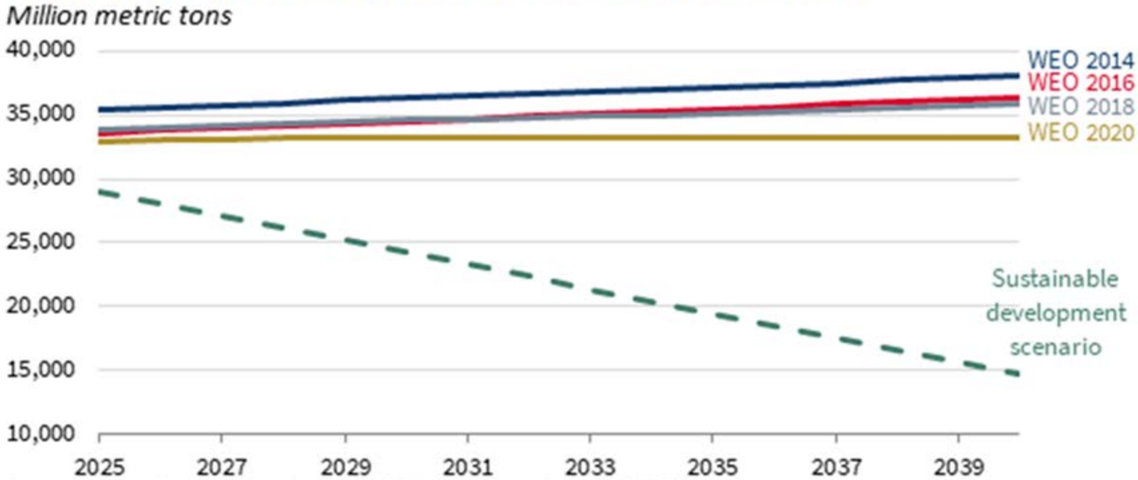
Figure 1. Costs of Disaster Events in the United States, 2000–2020



Source: National Centers for Environmental Information.
Note: The disasters covered are droughts, flooding, freezes, severe storms, tropical cyclones, wildfires, and winter storms.

In order to address the causes and consequences of climate change, there is a need for technologies that reduce carbon emissions and are deployed at scale. While both public and private actors have begun to implement strategies around the globe that reduce emissions, these efforts have been too slow and too small. Figure 2 shows that annual global carbon dioxide emissions are on pace to stay roughly at their current level through 2040, whereas the United States and all other major countries agreed to achieve net zero emissions at the global level in the second half this century to avoid ever-worsening climate threats (UNFCCC 2015, 4).

Figure 2. Projections of Future Global CO_2 Emissions



Source: International Energy Agency (IEA), World Energy Outlook (WEO) reports.
Note: These scenarios reflect projections assuming 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 impacts of air pollution, and tackling climate change.

The lack of widespread adoption of clean energy technologies to reduce carbon emissions has significant and growing economic costs. While estimates of the damages caused by ever-worsening climate change are highly speculative, a recent meta-analysis of the relationship between global temperatures and climate damages shows that, at the global level, damage could rise to roughly 7 to 10 percent of GDP at 3 degrees of warming Celsius—equal to 5.4 degrees Fahrenheit (Howard and Sterner 2017)—which could occur later this century in the absence of strong policy interventions. Focusing specifically on the U.S. economy, Kahn and others (2019) estimate the costs of economic damages using an econometric approach that links changes in climate from historical norms to changes in real output per capita. They find that increases in temperatures lead to losses in U.S. GDP per capita of between 0.3 and 5.4 percent by 2050 across a wide range of scenarios.[4]

One specific cost is in future worker productivity. The same sources that emit greenhouse gases are responsible for emissions of particulate matter and other local air pollutants that cause sickness and death. Air pollution keeps U.S. workers from their jobs and reduces their productivity when they can work (Currie and Walker 2019; Zivin and Neidell 2012), especially lower-income groups and communities of color (Currie and Walker 2019).

[4] These estimates, however, may understate—or, less likely, overstate—the true economic costs. If the relationship between temperature increases and economic outcomes changes over time—and many potential nonlinearities are easily imaginable—the usefulness of econometric estimates based on historical data may be limited. Indeed, given the nature of climate threats, including large uncertainties and the downside risks, many economists prefer to avoid best estimates of climate damages and instead treat climate change as a risk management problem, with the goal of stabilizing temperatures at levels that prevent dangerous climate change. This is also the approach agreed upon by the United States and all major nations in the UNFCCC treaty, which was signed in the early 1990s (Stern and Stiglitz 2021; United Nations 1992).

The flipside to these costs is that there are profitable opportunities for firms that can find commercially viable ways to address them by supplying both domestic and foreign consumers, as well as for the U.S. workers who gain those jobs. The fastest-growing power generation technologies are solar and wind (EIA 2021), and some estimate that annual global deployments of solar could increase by nearly 50 percent (under stated policies) to almost 200 percent (with further policy ambition), according to the International Energy Agency (IEA 2020e, 35). Projections from Bloomberg New Energy Finance show that annual sales of internal combustion vehicles are now permanently declining, and the electric vehicle share of new global car sales is expected to rise from 2 percent today to nearly 30 percent by 2030 (BNEF 2020a, 2021b).

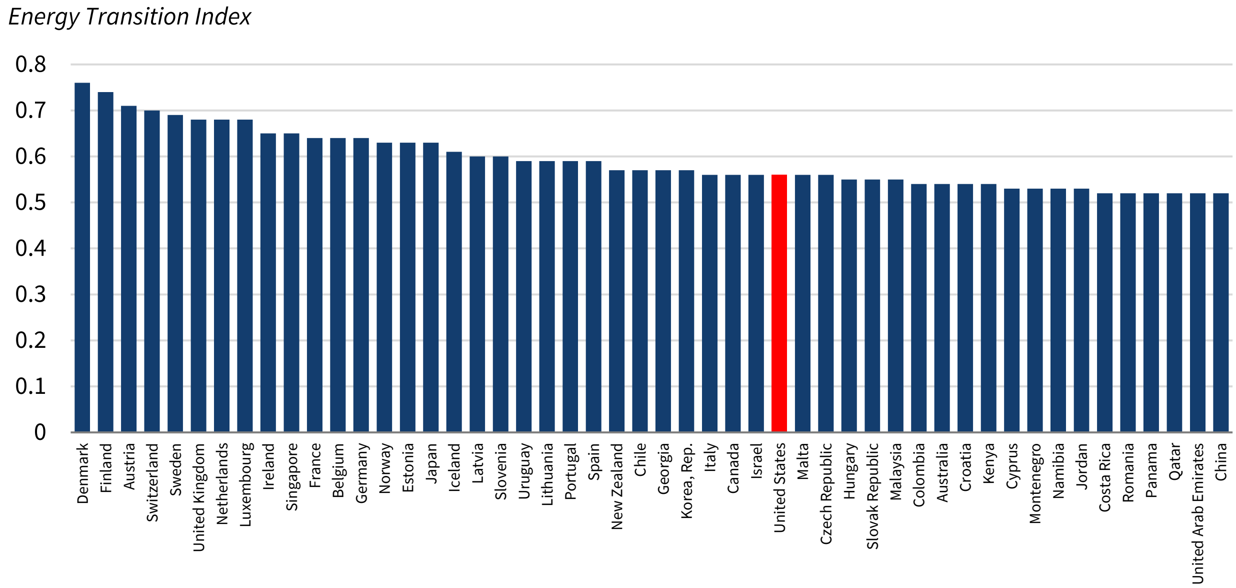
Indeed, the economic opportunities are substantial because the challenge is so large. Notably, analysis from the International Energy Agency shows that a successful global emissions pathway could require one-third to one-half of the emissions reductions over the next half century to come from technologies that are not yet commercially viable (IEA 2020b). The global nature of climate change, combined with the economic gains for those who can first come up with solutions that are brought to market at scale, underscores the economic opportunities of clean energy innovation.

There are many reasons why the United States should take an active role in the research and deployment of new energy technologies. U.S. companies have a century-long track record of becoming global leaders in industries ranging from computers to pharmaceuticals to telecommunications, among many others. U.S. workers are relatively well-trained to meet the labor demands of a new set of industries (NAS 2021, 3). U.S. firms are well positioned to make these investments, given relatively strong cash reserves and relatively low interest rates.

Indeed, some U.S. firms are taking steps toward carbon-free energy. Global companies with a combined revenue of over $11 trillion—more than half of U.S. GDP—have committed to pursuing net-zero emissions, with the majority aiming for 2050 or earlier (UN Climate 2020). Many of the most valuable U.S. companies—such as Google, Apple, Amazon, Facebook, and Microsoft—have strengthened their climate and clean energy commitments in recent years (Hook and Lee 2021). Perhaps the most telling sign of momentum toward a clean energy economy is coming from high-emitting sectors. For example, some of the nation's largest electric utilities—including Duke Energy, Xcel Energy, and Southern Company—have announced goals to achieve net zero emissions by 2050, and General Motors says it will eliminate gasoline-powered, light-duty vehicles by 2035 (St. John 2020; Boudette and Davenport 2021). Of course, pledges of future action should be taken with an appropriate grain of salt, but the increased climate-related commitments and actions from corporations in recent years is unmistakable.

Yet the scale and scope of U.S. investments in the necessary innovation, commercialization, and infrastructure are insufficient, in terms of both public and private action. In a recent report, the World Economic Forum created an index of "energy transition readiness" that evaluated how well countries were positioned for the coming transition based on factors including the level of political commitment, investment climate, access to capital, consumer engagement, development and adoption of new technologies, and stability of the political environment. The United States is tied for 28th, out of 115 countries studied, indicating the failure to invest in the transition to low-carbon energy (the top-scoring countries are shown in figure 3) (WEF 2020, 13).

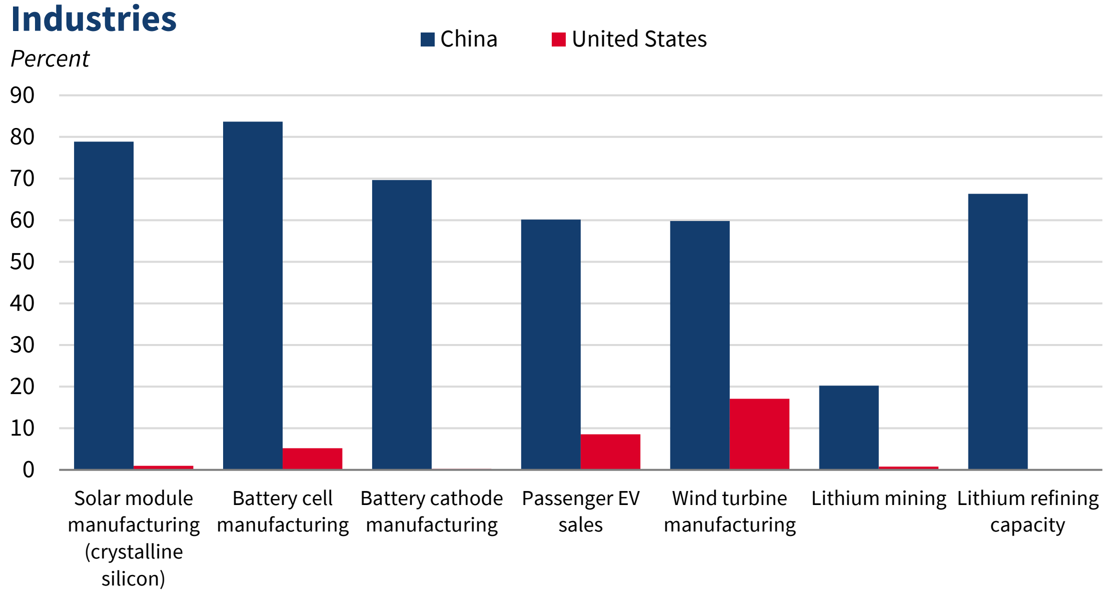
Figure 3. World Economic Forum Index of Energy Transition Readiness, 2020



Source: World Economic Forum (WEF).
Note: The WEF index of "energy transition readiness" evaluates how well countries are positioned for the coming transition based on factors including the level of political commitment, investment climate, access to capital, consumer engagement, development and adoption of new technologies, and stability of the political environment.

As U.S. investments in climate innovation have stagnated, other countries have taken the lead. For example, the market share of Chinese companies is nearly 60 percent for the manufacturing of wind turbines, nearly 80 percent for solar module cells, and over 80 percent for battery cells, which are used in electric vehicles (see figure 4). Similarly, the majority of the chips used in light-emitting diodes (LEDs)—a technology that relies on U.S.-funded innovations—are now produced in China (CEMAC 2021). This United States' lack of investment in R&D is especially worrisome given the advantages that flow to those who can first capture a particular market, and the rich body of evidence for a close empirical link between R&D spending and different measures of innovation, including patents and venture capital investments (Azoulay et al. 2019; Howell 2017).

Figure 4. United States and China Market Shares across Cleantech Industries



Source: BloombergNEF.

This lost opportunity for American leadership not only means a missed chance to satisfy the energy needs of tomorrow; it could also mean growing dependence upon more intrepid countries. Indeed, in ceding ground to economic competitors, the United States may be putting the Nation at risk, to the extent that these sectors are critical for national security or resilience. The opportunity remains, however, for the United States to play a larger role in accelerating the clean energy and supporting industries that can provide good jobs for U.S. workers.

The Economic Case for Government Policy

Innovation in clean energy is important for the U.S. economy as well as the planet. Already, the private sector in the United States is taking steps to advance low-carbon technologies. However, as the first section explained, clean energy technologies have not yet emerged at the pace and scale needed to address the risks of climate change, nor to ensure that U.S. firms are leading the way. The question is, why not? Given the economic, geopolitical, equity, and climate imperatives to accelerate the development and deployment of clean energy technologies, what is the appropriate role for government?

The answer is twofold: there are a series of barriers that discourage the private sector from developing new energy technologies, and the United States has not implemented a national strategy to address these hurdles and instead nurture this transformation.

In economics, it is well known that there are situations when private actors cannot and do not engage in economically and socially meaningful activities because market prices do not accurately reflect the social costs and benefits. Economists call these *market failures*. One special case is when the provision of goods is open and available to benefit a range of individuals, then an individual firm cannot properly recoup its investment. These are called *public goods*—think of clean air, where one person's use would not prohibit someone else from using it. Similar to investments in technological progress, the private sector will underinvest in infrastructure because the benefits spill over to people who cannot easily be charged for using the infrastructure, and this undermines the returns that flow directly back to the investor.

In the case of emerging energy technologies, there are at least six theoretical reasons why private actors alone are not taking action at sufficient scale or speed: (1) private actors underinvest in basic research that drives economy-wide innovation; (2) markets underprice the growing side effects and cost of climate change, such as the fires, floods, and droughts that continued emissions have brought and will continue to bring; (3) markets fail to ensure the adoption of low-cost energy-saving opportunities; (4) private actors alone do not supply sufficient energy infrastructure—clean or otherwise—due to their inability to coordinate sectors and workers on a large scale; (5) markets fail to account for industry-level spillovers and agglomeration; and (6) markets fail to support the kinds of high-quality jobs for domestic workers that are included in the industrial strategies of many other nations.

In practice, these barriers play out within the context of often-heated political debates over questions of distribution—who gains and who loses as the economy transforms. Today, these debates are being heightened by high economic inequality and the fact that some places have greatly benefited from the most recent economic changes, such as Silicon Valley, while others have not, such as those hit by the "China Shock" (Autor, Dorn, and Hanson 2016). This section lays out each of the six barriers in turn.

Private Actors Underinvest in Basic Research

An individual firm will continue to make investments in research and development as long as it believes the expected (marginal) benefits will outweigh the expected (marginal) costs. However, when a firm spends resources on the basic research that underlies technological progress, it also creates benefits for others, through *knowledge spillovers*. The production and consumption of new technologies also create information that benefits others, through *learning-by-doing* and *learning-by-using*. Because these spillovers do not directly benefit the firm, the firm does not count them as benefits; from the perspective of society, firms are underinvesting in technological progress.

This is underscored by the uncertain and long-term nature of investments in many cutting-edge clean energy technologies, which do not line up well with the private sector's desire for more certain and near-term profits. U.S. companies, particularly publicly traded ones, are evaluated based on their quarterly earnings and short-term outlooks, which discourages them from taking a long-term perspective (Karlsson and Palladino 2018).

On account of spillover benefits, the *social returns* of investments in R&D—that is, not only the total economic returns to the initial firm but also the returns that accrue to other firms and the public—are almost always substantially greater than the private returns to the investing firm (Hall, Mairesse, and Mohnen 2010). One study found that the social return to R&D is 58 percent, four times the private return of 14 percent (Lucking, Bloom, and Van Reenen 2019). A National Academies study reviewed over two decades of experience with the Department of Energy's research, development, and demonstration programs in energy efficiency and found that the total net realized economic benefits were about $46 billion, over four times as large as the government investment of about $11 billion (all valued in 2020 dollars) (NRC 2001).[5]

Individual private actors are "free-riders" on these large spillovers. The investments are costly, but because the benefits are diffuse, investments in public R&D are needed to ensure that there is adequate support for solving society's most important problems. Not only does public investment have high direct returns; there is also evidence that it can stimulate additional private investment (Pereira 2001). An example of public investment that helped to establish profitable new industries was the Internet, which resulted from a series of investments by the Department of Defense (Mowery and Simcoe 2002) (see box 1).

[5] In 1999 dollars, the total net realized economic benefits were about $30 billion, and the government investment was about $7 billion. Values were converted to 2020 dollars using the Consumer Price Index Inflation Calculator, which is available from the Bureau of Labor Statistics (link).

Box 1. Solar Energy Costs Decline

The solar energy revolution began with U.S. investments. In 1954, Bell Labs' investments resulted in the creation of the first solar cell, and strong and steady procurement from the U.S. Navy and NASA allowed American solar companies to serve that market (NAS 2021, 32).

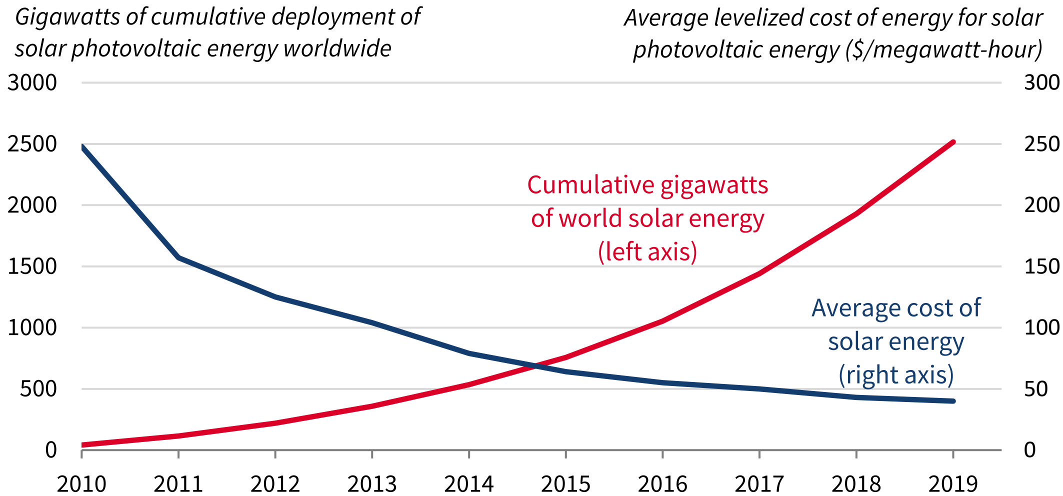
Then, in 2011, and building on previous efforts, the U.S. Department of Energy launched the "SunShot Initiative" with the mission to reduce the total costs of solar energy by 75 percent through a combination of research and support for the private sector. Combined with growing policy incentives from State and Federal governments, including subsidies and clean electricity standards, solar photovoltaic is now the cheapest source of electricity in a growing number of places and times, benefiting electricity consumers in the United States and around the world (IEA 2020d).

And not only the U.S. government was supporting this market. These U.S. investments came on top of support from other governments. For example, Germany's Renewable Energy Law, passed in 2000, and the strong support of Chinese producers from federal and municipal governments catalyzed technological improvements via learning-by-doing and economies-of-scale (Nemet 2021). Combined, these provided a robust foundation upon which solar energy could develop.

Figure 5 shows the cumulative global deployment of solar photovoltaic (left axis) and the levelized cost of energy, which is a commonly used metric of costs (right axis). As deployments increased, the cost fell dramatically, in large part due to learning-by-doing, causing deployments to increase further.

This case study also underscores how markets alone will not address distributional concerns. The solar industry remains mostly nonunion, and wages are often relatively low. While in the solar electric power generation industry as a whole, the mean annual wage is $98,000 (BLS 2021c), the mean wage for a solar panel installer is $43,000 (BLS 2021d), much less than what a fossil fuel worker of similar education would earn (BLS 2021e). In contrast, wages in the fossil fuel industry have been shaped over the years by policies that supported unionization and giving workers a voice (Atabaki, Bini, and Ehsani 2018; Loomis 2018). One recent study concludes that "high road" labor practices can coexist with the rapid expansion of the domestic solar and wind energy markets: a 20 percent increase in domestic labor costs increases installed capital costs for wind and solar power by just 2 to 4 percent, and operations and maintenance costs by about 3 to 6 percent (Jenkins and Mayfield 2021). (Making wages in these sectors comparable to those in fossil fuel sectors may often require significantly greater increases. Much of the increased labor cost is likely to be offset by higher productivity; Kochan et al. 2013—a factor that Mayfield and Jenkins did not consider—but if not, other regulation or standards may be needed.)

Figure 5. Costs and Deployments of Solar Energy, 2011–19



Sources: Lazard; International Renewable Energy Association.
Note: World solar energy deployment values are cumulative since 2010. Levelized cost of energy data are for crystalline photovoltaic solar cells.

Market Prices Fail to Account for the Damages from Emissions

A second reason the private market underinvests in clean energy is that market prices can provide misleading signals, resulting in decisions that are not socially optimal. Firms will typically invest as long as the expected benefit of doing so outweighs the cost; that is, as long as the net private benefit is positive. However, when prices are lower than their true social cost, then the net benefit of an investments will be too low from society's point of view. This is the case when individual firms do not have to internalize the large social costs of failing to address climate change. No single firm is called on to bear the costs of putting out wildfires; nor are they held responsible for helping people get water while they await having the electricity fixed, even if their actions contributed to the likelihood of such disasters. Rather, the government steps in and provides mitigation. This mismatch in private and social costs leads to an overinvestment in high-carbon technologies (at the expense of carbon-free technologies), alongside looming economy-wide costs due to inaction on addressing climate change (Jaffe, Newell, and Stavins 2005).

For these reasons, economists have long focused on addressing price signals as an important part of an optimal climate policy portfolio. Price signals can be implemented via carbon taxes or by setting emissions caps or clean energy standards along with permits than can be bought and sold. By forcing private actors to bear the true costs of their climate-harming actions, policymakers can ensure that carbon-intensive energy is not underpriced.

Combined with credible emissions targets, a policy agenda ensuring that prices reflect true costs can provide greater certainty to investors in clean energy and enable them to capture more benefits for society from their actions (Jaffe, Newel, and Stavins 2005). Carbon prices can be applied throughout the economy, which means that these policies can be designed to harmonize a portfolio of climate policies with economy-wide or sectoral emissions goals (Kaufman et al. 2020).

Markets Fail to Encourage Low-Cost Opportunities to Save Energy

There are a host of other market issues that cause private sector actors, including consumers, to forgo socially beneficial investments in clean technology. Take energy efficiency improvements, for example. Manufacturers can produce energy-efficient appliances, but the price signal may not be sufficient to induce families to swap out their older, less efficient appliances fast enough to reduce carbon emissions. Renters may not purchase the major appliances they use, or they may pay fixed rates for certain energy uses, limiting their demand for low-carbon options. And consumers may not be aware of energy-saving opportunities, or they may not want to (or have the means to) pay high upfront costs for energy savings investments that can be paid off over time.

These distortions may be especially significant among the members of lower-income households, who often confront high financial burdens from energy costs that undermine economic security and force trade-offs between spending money on energy, medicines, food, and other basic necessities (NAS 2021, 105). Policies that are associated with energy efficiency and make it easier for consumers to take advantage of cost-effective opportunities to save energy can come in many forms, including informational programs, financial incentives, and technology standards. These kinds of cost-effective energy efficiency opportunities that lower both pollution and energy bills are widely available. Putting them into place can, in turn, create greater demand for these options and spur innovation in more efficient energy technologies.

Supportive Energy Infrastructure

The deployment of technologies to address and adapt to climate change relies on investments in the infrastructure of the U.S. energy system, including roads, transmission lines, pipelines, and buildings. Unleashing investments in important emerging clean technologies, such as electric vehicles and carbon capture, will require new types of infrastructure. For example, a better system of electricity transmission lines will enable greater and more efficient utilization of wind and solar energy, and a better network of battery chargers will make consumers more comfortable purchasing electric vehicles.

Transitioning infrastructure to support a new low-carbon energy system will require coordination. For some forms of energy infrastructure, competition among firms would be inefficient and raise costs (CEA 2016, 252–53). For example, government interventions can ensure compatibility among electric vehicle (EV) charging stations, with standard plugs and communication protocols, and an efficient build-out of electricity transmission lines. The jockeying to monopolize a market will dampen overall economic gains (Hardy 2015). (Consider the famous “format wars” in the early days of videocassette players, where VHS quickly won out over rival Betamax.)

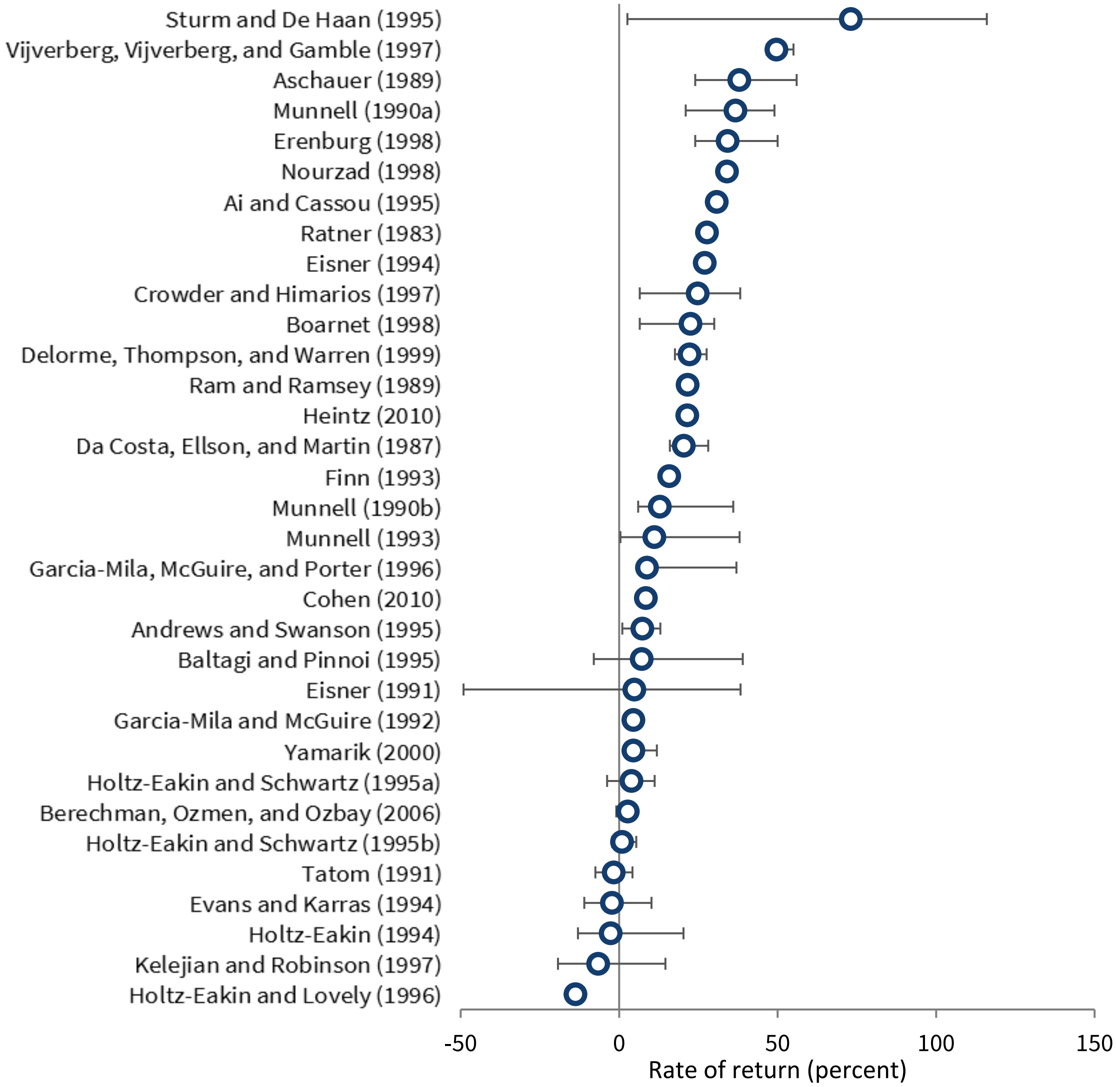
Well-targeted public investments in energy infrastructure can increase the economy's long-run growth potential in various ways: lowering costs to firms and households; increasing the productivity of private capital through improved resource utilization; and increasing workers' access to jobs (CEA 2014). Empirical research on public investment finds that increasing the public capital stock boosts private sector output. Studies show that central estimates of rates of return on public investments in U.S. infrastructure from –19 percent to 73 percent, with an average rate of return of 16.7 percent and median of 12.8 percent (see figure 6) (Bivens 2017).[6]

Further, investments in energy infrastructure can contribute to the supply of good jobs, because most of the opportunities are likely to be in construction and manufacturing.[7] According to the Quarterly Census of Employment and Wages, the average weekly wage for private construction and manufacturing employment in 2019 were 10 and 18 percent higher, respectively, than the private sector average (BLS 2020). Jobs in construction are almost twice as likely as private sector jobs overall to be covered by a union contract (13.4 vs. 7.2 percent) (BLS 2021b, table 3).

[6] Of course, the returns will vary widely for different types of infrastructure. Pereira (2001) analyzes various conventional energy and transportation infrastructure investments and finds that $1 of public investment in electric and natural gas facilities, transit systems, and airfields induces more than $2 in additional long-term private investment, whereas an additional $1 of public investment in highways and streets increases private capital investment by $0.11 (CEA 2016, 265–66).

[7] For example, the CEA's 2014 analysis shows that 68 percent of the jobs created by investing in infrastructure are in the construction sector and 10 percent are in the manufacturing sector.

Figure 6. Estimated Rates of Return for Public Infrastructure Investment in the United States (minimum, average, maximum)



Source: Adapted from Bom and Ligthart (2014, table A1), based on Bivens (2017, table E).

Markets Fail to Account for Industry-Level Spillovers and Agglomeration

In addition to the facts that clean energy investments are often accessible to a range of other firms and individuals and that it can be hard to coordinate across actors, there are also issues that play out at the industry level. Firms do not produce in isolation; there are geographic spillover effects and agglomeration, for which markets fail to account.

Many production processes use inputs from a variety of suppliers, and there is evidence that the geography of these firms matters. Geographic spillover effects occur because while for any single firm, the decision to move production elsewhere may make economic sense, their actions affect other firms, which might decide it also makes economic sense for them to leave. This in turn affects both the firms' suppliers and the local talent pool. It then becomes harder for the region to maintain its training and research programs, attract additional firms in related areas, and advance new technology. When the assembly of consumer electronics moved to Asia, shipping costs for U.S. firms making components increased, leading them to also close domestic plants (Pisano and Shih 2012). Conversely, new industries can build on the foundations left by older clusters. For instance, in Toledo, Ohio, century-old firms such as Dana and their local suppliers make electric motors based on their historic expertise in the auto industry (Dana 2021).

Agglomeration effects are the interactions between innovation and production. When production in consumer electronics migrated to Asia decades ago, the United States lost the potential to compete for follow-on innovations and subsequent production in flat-panel displays, LED lighting, and advanced batteries. Making products exposes engineers to the capabilities and problems of existing technology, generating ideas both for improving processes and for applying a given technology to new markets. Losing this exposure makes it harder to come up with innovative ideas. There is evidence that in the long run, it may not be possible to keep innovation jobs if production jobs are lost (Pisano and Shih 2012).

Markets Fail to Support High-Quality Jobs for Domestic Workers

Employers do not capture all the social benefits of high wages, and so are known to underprovide good jobs (Acemoglu 1994), since the benefits of good jobs spill over to workers themselves, communities, and other firms (which benefit from the greater purchasing power of other firms' workers).

Innovation can support a "high-road" path to creating good jobs. Along this path, employers can reap important benefits: skilled workers can facilitate deployment of innovation, such as by helping to debug new production lines. This is a strategy used by manufacturers in other countries, where they employ more highly skilled production workers and pay significantly higher wages than do companies in the United States. Germany and Denmark, for example, are able to compete in manufacturing because they have business and government support for high-road production practices, in which workers participate in innovation as well as production. The higher wages paid to these highly skilled workers are offset by their higher productivity, even within narrow industries (Helper, Krueger, and Wial 2012; Helper 2009).[8]

The Lack of a National Strategy

Although the private sector must play an integral role in the energy transition, market failures, distorted price signals, and coordination failures mean that *government is an essential partner in this important transition*. Without government support, clean energy technologies are unlikely to emerge at the pace and scale needed to address the risks of climate change. Public sector

[8] For example, firms in the highest 10 percent of productivity in the automotive stamping industry have more than double the productivity of firms in the lowest 10 percent, and pay wages that are 70 percent higher (Helper, Krueger, and Wial 2012, box 4). These firms' productivity performance is directly linked to their higher wages, which allow the firms to effectively involve workers in problem solving and preventive maintenance, and train them to do a variety of tasks.

leadership is necessary to support R&D, demonstration, and the deployment of low-carbon technologies. Moreover, markets alone do not ensure fairness. U.S. workers and small companies need support from their government, just as many other major countries are providing to their workers and companies. In addition, research has shown that an innovation process that is inclusive of the entire population can expand the economy (Boushey 2019; Cook 2019).

Yet the United States has, so far, failed to implement a national strategy to support new energy technologies at the scale and scope to fit the problem. This lack of government investment is already leading to negative economic consequences. The United States has fallen to 10th in the world in terms of public R&D investments as a percentage of GDP and, at the current pace, will soon lose its historic position to China as the largest R&D investor globally (NAS 2021, 102). This fall in public R&D as a share of GDP is estimated to have cost the U.S. economy about $200 billion in lost economic output in 2019, a loss that will only grow.[9] An analysis of data on 16 advanced countries over the years 1980–98 revealed that a 1 percent increase in public R&D investment generated an extra 0.17 percent in long-run output (Guellec and van Pottelsberghe de la Potterie 2003).

There is much to be learned from the United States' economic competitors. Europe already spends more than the United States on low-carbon energy innovation (IEA 2020c). For example, Horizon Europe, a multinational research and innovation program, has a €95.5 billion budget over the next seven years and plans to target climate research (Abbott and Schiermeier 2019) (see box 2). Table 1 lays out some of the ways that various governments around the world have begun to implement policies that will accelerate the energy transition *and* support their own domestic workers and businesses through the transition. This includes some of the United States' most important trading partners: the European Union, China, the United Kingdom, and Canada.

[9] As noted above, this figure is calculated assuming (1) an elasticity of output with respect to the public capital stock of 0.122, from a meta-analysis by Bom and Ligthart (2014); (2) a depreciation rate of 15 percent; (3) public expenditures on R&D equal to 1.9 percent of GDP, beginning in 2000; and (4) an immediate realization of increased output from higher R&D investment.

Box 2. The European Union's Clean Hydrogen Strategy

Clean hydrogen has the potential to play an important role in the energy transition, in particular to address emissions from sectors in which low-cost carbon-free alternatives do not exist today. While hydrogen's current contribution to energy systems is very small, one recent study shows that hydrogen could supply up to 24 percent of global energy demand by 2050 (BNEF 2020b). This could be a game-changing innovation if the consumption of clean hydrogen displaces fossil fuels. However, if the hydrogen is not made using methods that emit few greenhouse gasses, then using hydrogen makes no net contribution to decarbonizing. High-carbon production methods are far less costly than low-carbon ones, and, as a result, almost all hydrogen produced today is low-carbon (IEA 2019).

The European Commission has begun to address both the challenges and the opportunities of this emerging technology. In 2020, it announced a "hydrogen strategy for a climate-neutral Europe" (European Commission 2020a, 1). Its goal is to decarbonize hydrogen production while fostering sustainable growth and jobs. Alongside this strategy, a collaboration between government and industry launched the European Clean Hydrogen Alliance to develop an investment agenda and a pipeline of concrete projects (European Commission 2020a, 3). The Next Generation EU recovery package, which was implemented as part of the EU's response to the COVID-19 pandemic, also emphasizes investments in hydrogen production and infrastructure (European Commission 2020d).

It is too early to know whether clean hydrogen will play a large or niche role in future energy systems. What is clear is that strong government support is integral to figuring this out. Europe has positioned itself to be a global leader in clean hydrogen production, and its producers will gain a first-mover advantage in this important emerging market, if they can resolve the technological challenges.

Table 1. Sample National Strategies to Accelerate and Prepare for the Energy Transition

Tactic	China	European Union	United Kingdom	Canada
Emissions targets	Net zero by 2060	Net zero by 2050	Net zero by 2050	Net zero by 2050
Policies to accelerate the clean energy transition (partial list)	Emissions regulations in the power sector; subsidies and spending on clean energy	Emissions regulations across the economy; subsidies and spending on clean energy	Emissions regulations across the economy; subsidies and spending on clean energy	Emissions regulations across the economy; subsidies and spending on clean energy
Industrial policy strategies for clean energy	Global leader in clean energy manufacturing with strong government support (see figure 4)	European Commission's proposal for "a globally competitive, green and digital Europe" (European Commission 2020c)	The Prime Minister's "Ten-Point Plan for a Green Industrial Revolution" (Her Majesty's Government 2020)	A federal government strategy for "Building Canada's clean industrial advantage" (Government of Canada 2020)
Source:	(BloombergNEF)	European Commission	U.K. government	Canadian government

A national strategy could provide U.S. businesses with opportunities to become global leaders in emerging sectors while creating good jobs. The innovation brought on by R&D investment spills over into worker productivity and economic growth. Recent technological innovations have not altered this relationship: Lucking, Bloom, and Van Reenen (2019) examine panel data on U.S. firms over the last three decades and find that R&D spillovers remain as important for economic growth now as they were in the mid-1980s. As we show below, innovation can support high-road employment strategies, boosting wages as well as productivity if policies supporting high labor standards are in place.

Another outcome from having a clear U.S. plan could be the generation of good jobs, perhaps for decades to come. Consider the EV revolution. Currently, most of the content of an EV propulsion system is imported (Dziczek 2021; Dohko 2021). For example, the U.S. and Canadian content of GM's Chevy Bolt EV is only 24 percent (NHTSA 2020; Boudette 2019; AP 2021). Strategic investments to retool existing industries could ensure that as the world transitions from internal combustion vehicles to electric ones, U.S. manufacturers are able to successfully maintain—or even increase—high-quality jobs. Many of the workers in U.S. auto plants have transferable skills, in tasks such as operating computer-controlled machine tools, maintaining advanced robotics, and interpreting quality-control data (Helper et al. 2021). With existing skills or additional training, these workers could build EV propulsion systems, and their facilities could continue to be the anchors of their communities.

Finally, confronting the opportunities of the new energy technology transition would also create space to address the unique risks for local economies that are dependent on high-carbon industries. The U.S. coal industry has been hardest hit by the availability of low-cost, lower-carbon electricity sources. The contribution of coal to total U.S. electricity generation fell from nearly 50 percent in 2007 to about 20 percent in 2020, and employment in the coal mining industry has decreased by about half over the past decade (BLS 2021a). Local economies that rely heavily on coal extraction and combustion are at risk of facing growing unemployment, declining populations, and reduced tax revenue and public services (Morris, Kaufman, and Doshi 2021). In one coal-reliant county, employment across all industries fell by over 40 percent between 2011 and 2016, highlighting the important labor market spillovers in coal-reliant regions (Morris, Kaufman, and Doshi 2021).

Solutions That Fit the Scope and Scale of the Energy Technology Challenge

In order to accelerate the clean energy transition, the United States needs a national strategy. The Federal Government's role should be to develop and enact policies that strategically accelerate innovation, reduce climate threats, and create good jobs. Having a national strategy can ensure that the United States is on the path to innovation leadership, while providing U.S. workers and businesses with the strong foundation required to compete successfully in the global marketplace. Basic R&D provides a base of understanding, even when there is no clear understanding of the specific application—similar to the commercial products that flowed from the moonshot.

The United States has experience rising to the challenge of nurturing critical industries through investing in new technologies. To take one timely example, grants from the National Institutes of Health contributed to published research associated with every one of the 210 new drugs approved by the Food and Drug Administration from 2010 to 2016. This research involved grants totaling over $100 billion, more than 90 percent of which was basic research that complemented the applied research funded by industry (Cleary et al. 2018). Indeed, the underlying scientific knowledge that enabled the advent of the COVID-19 mRNA vaccines from Pfizer and Moderna relied on Federal spending (Fauci 2021).[10] At that time, this research was not seen as having a particular impact or as commercially important.

In addition to R&D support, government spending on procurement was crucial for the establishment of new industries, and for U.S. preeminence in those industries. For example, the Department of Defense accounted for over 60 percent of world semiconductor demand in the first half of the 1960s (Mowery 2011, figure 5.2). Government procurement was also a key feature in the early days of the computer and software industries (Mowery 2011).

Successfully capturing the economic opportunity of the clean energy transition requires an effective national strategy that builds on these success stories. The remainder of this section describes three major categories of actions the Federal government can take to accelerate energy innovation and good jobs, building on experience in the United States and abroad: (1) policies that support technological progress; (2) investments in building the supportive infrastructure that energy technologies require to thrive; and (3) attending to equity and distributional questions. Such actions are not comprehensive responses to the climate and inequality-based threats, but they are a large down payment on responding to each.

Support Technological Progress and Good Jobs in Clean Energy

To be effective, government actions to support clean energy technologies need to be thoughtful in targeting each stage of the innovation process. The aim of targeting is to encourage choices about which technologies the government should support as they move down the learning curve (see figure 7). To fulfill the policy goals, these choices need to be in service to innovation and

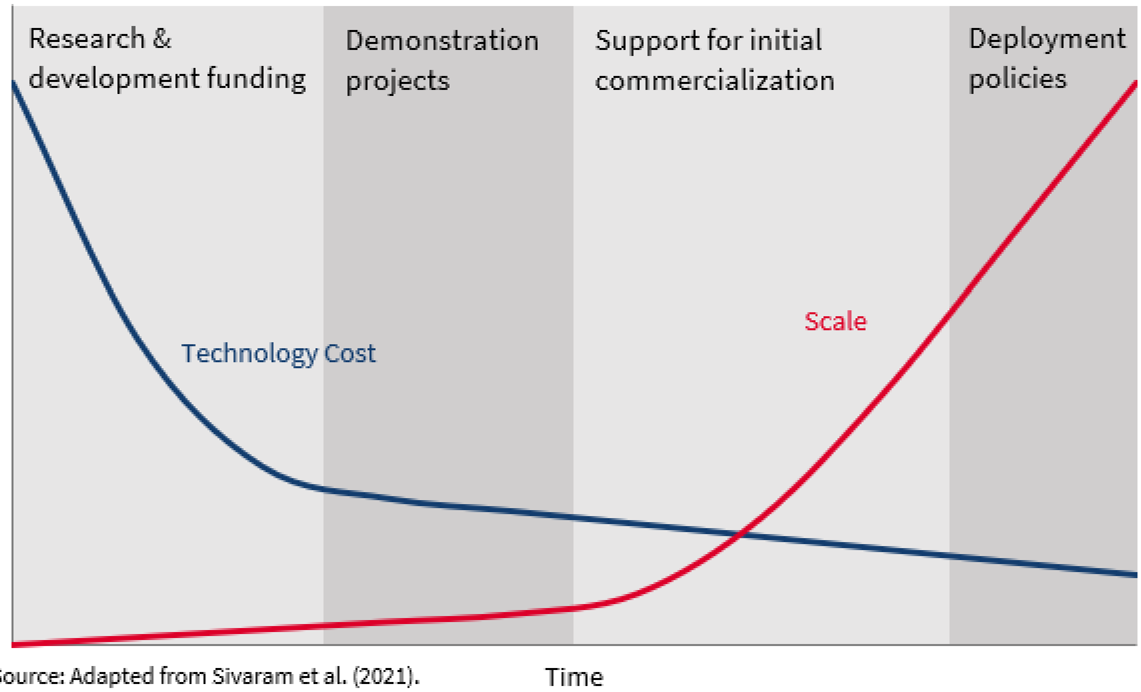
[10] However, the United States has substantially higher spending, worse population health outcomes, and worse access to care than do other wealthy countries (Papanicolas, Woskie, and Jha 2018).

the deployment of clean energy, as well as attentive to distributional concerns (both in terms of the consequences across communities of which sectors are encouraged and which are not). At each stage of this innovation process, stakeholders—including consumers, academics, businesses, workers, and environmentalists—should convene to discuss barriers, externalities, and other concerns, and to coordinate the technology and social choices available (Rodrik 2004; Mazzucato 2013). These convenings should be broad-based and include small firms, labor representatives with expertise in designing good jobs, and representatives from local communities.

Figure 7 lays out this process—the innovation learning curve—which includes R&D, demonstration projects, support for bringing new ideas to commercialization, and deployment. Policy measures along the learning curve could include:

- *Research and development funding.* Direct government investments in R&D and policies that encourage private sector R&D investments can help overcome the underinvestment problem and advance the next generation of clean energy technologies.
- *Demonstration projects.* Government support is needed for the first several commercial scale deployments of complex, large-scale technologies such as carbon capture, utility-scale energy storage, low-carbon hydrogen, and advanced nuclear energy projects. Otherwise, investors are wary of high capital costs and the risks of expensive project delays, and firms would prefer to benefit from innovation fostered by others' efforts (Sivaram et al. 2020).
- *Deployment policies.* Policy support is needed to help create early markets for promising clean energy technologies as their costs continue to fall. Such policies may include tax credits, government procurement, prize competitions, and milestone payments (Sivaram et al. 2021). Support for mature clean energy technologies can be less targeted—for example, through emissions standards or emissions prices—but is also justified because market prices would otherwise fail to account for the damages caused by emissions.

Figure 7. Policy Levers to Support the Various Stages of Clean Energy Innovation



Source: Adapted from Sivaram et al. (2021).

The process starts with ensuring sufficient government support for clean-energy technologies, through ongoing robust assessments of need. At this point, it is clear that the United States is spending too little; the International Energy Agency (IEA 2020b) finds that just 6 out of 46 technologies and sectors were "on track" with scenarios that achieve international goals related to climate change, universal energy access, and air pollution. One group of energy experts has proposed gradual annual increases in U.S. government funding for clean energy innovation, with a target of $25 billion a year by 2025, roughly three times current levels (Sivaram et al. 2020).

Funding technologies on its own, however, will not ensure that U.S. workers benefit from the energy transition. The second section above described the various reasons why the Federal government should support a clean energy manufacturing sector. Such policies can include subsidies for manufacturers to build new factories or retool existing ones, help train workers for the new jobs, give consumers incentives to buy clean and energy-efficient American-made products, and institute Federal procurement that targets domestic manufacturers, as well as thinking through place-based strategies to ensure that the benefits of innovation investments are broadly shared and do not accrue only to the coasts. Building worker power and incorporating community input are both cores of the strategy. To ensure that these programs have broad-based benefits, the producer incentives should be conditioned on providing good jobs and the opportunity to join a union, and consumer incentives should benefit most income groups (see box 3).

Box 3. Investments in Electric Vehicles

The electric vehicle market is emblematic of the opportunities and challenges facing the United States. Federal government investments can play an important role in spurring the market share of EVs and ensuring that good jobs are available to the over 1.5 million U.S. workers involved in producing motor vehicles and motor vehicle parts. (This number includes employment in motor vehicle and parts manufacturing with adjustment to correct for undercounting employees in motor vehicle parts—see CEA 2013; BLS 2021f). Currently, the U.S. EV market is only one-third the size of its Chinese counterpart. Investments are needed to enable automakers to spur domestic supply chains from raw materials to parts, retool factories to compete globally, and support U.S. workers to make batteries and EVs.

New technologies such as EVs can have a chicken-and-egg problem. Private firms need to see demand upstream or downstream, or both. For example, suppliers of charging stations will not invest without assurances that there will be sufficient demand for charging services. Downstream, consumers are hesitant to purchase EVs without assurances that charging stations will be widely available. A policy solution could involve incentives to support a national network of car battery chargers, which can help overcome range anxiety and assure a market for the producers of chargers. Another policy would be to establish an anchor customer who can ensure stable demand. A large consumer of EVs, like the Federal Government, can reduce risks for the industry through its procurement power, by ensuring a customer for both charging services and production of EVs. Government vehicles that could be electrified include school buses, transit buses, and mail trucks, among many others. Alternatively, policymakers can design incentives for consumers so that vehicle subsidies help make EVs affordable for most U.S. families, even while their sticker prices remain higher than comparable gasoline-powered models.

Government has shown it can play a role. In January 2010, the Department of Energy issued a $465 million loan to Tesla Motors to produce a new electric vehicle and to develop a manufacturing facility in Fremont, California, to produce battery packs, electric motors, and other powertrain components (DOE 2017). Within four years, Tesla fully repaid the loan and established itself as a world leader in the automotive industry.

While the story of Tesla is a good example of how the government can help to nurture new companies and new technologies, it also offers lessons. While Tesla has created thousands of jobs, its Gigafactory pays between $17 and $21 per hour, far less than the wages earned by the average member of the United Auto Workers at a powertrain plant (Maddox 2021; Sherman 2020; Hansen 2017). This raises questions about how to design subsidies to producers (e.g., loans, tax incentives, or grants) to ensure that the EV transition does not increase inequality. This could include policy choices related to U.S. content, fair wages, and workers' ability to join a union.

Investments in Building Supportive Energy Infrastructure

To support the development of new energy technology, government needs to provide infrastructure that can support these investments. This could include enhancements to existing energy infrastructure systems as well as the development of new infrastructure, both of which are critical for emerging clean energy technologies.

Investments in existing transportation infrastructure systems include improvements of passenger and freight rail service and the modernization and expansion of public transit systems. These investments should not only increase the economy's growth potential but also reduce emissions from the transportation sector by making it cheaper and easier to travel or ship products without the need for relatively high-emitting personal cars and long-haul trucks.

To support emerging clean energy technologies, a 2021 study by the National Academies of Sciences, Engineering, and Medicine highlighted these three energy infrastructure priorities for the next decade (NAS 2021, 7):

- *Electricity transmission.* Increasing electricity transmission capacity is necessary to fully unleash the potential of cheap but intermittent solar and wind power.[11] Long delays in siting, permitting, and financing transmissions lines have been key barriers: new transmission lines can take an average of 8 to 10 years to site and permit (NAS 2021). Clack and others (2020) find that additional private investments in the eastern U.S. transmission grid could reduce energy bills by at least 33 percent. The Federal Government can help break these logjams by supporting the financing of transmission lines and reducing the red tape associated with siting (including leveraging existing rights-of way along roads and railways).
- *Electric vehicle charging.* While the costs of certain electric vehicles models are approaching parity with comparable gasoline-powered vehicles, anxiety over the range of EVs remains a key barrier to increased market share. One recent study found the percentage of drivers in Seattle whose annual travel activities (not just commuting) could be fully provided by electric vehicles increases from about 10 to 40 percent with the strategic buildout of highway fast battery charging (Wei et al. 2021).
- *CO_2 transportation and storage.* Carbon capture and storage may be the best way to reduce emissions from energy-intensive industrial sectors, including steel, cement, and chemicals. Moreover, emerging technologies enable the capture of carbon dioxide from the ambient air and fossil fuel-fired power plants can be retrofitted with carbon capture and storage technologies. However, the captured CO_2 must be transported to places where it can be safely sequestered underground or utilized in products. One recent study found that a carbon-neutral U.S. economy could require carbon capture at over 1,000 facilities and around 110,000 kilometers of new CO_2 pipeline infrastructure (Larson et al. 2020, 231).

On top of these, worsening climate threats heighten the importance of building resilient energy infrastructure, including power plants and transportation networks that can withstand extreme weather. Targeted investments to improve the resilience of infrastructure to floods, fires, and storms can protect communities across the United States from climate threats, and often pay off even in the near term (USGCRP 2018, 1323). This includes revisiting existing infrastructure *and* building new infrastructure to make sure they can withstand new weather extremes.

Investments in an Equitable Transition

Without an intentional focus on equity, the benefits and costs of the energy transition will not be fairly distributed among those of different income levels, geographic regions, races, and occupations (Carley and Konisky 2020). While a shift to domestically produced clean energy could create hundreds of thousands of additional jobs in the energy supply sector, the energy

[11] For example, Bloom et al. (2020) find that investments in increased intercontinental transmission capacity have cost-benefit ratios ranging from 1.2 to 2.9.

transition also creates risks for workers (Larson et al. 2020, 296). As noted earlier in the report, clean energy jobs will not automatically provide high salaries or sufficient protections. Without a Federal strategy for the transition, well-paying jobs could be lost, and new, well-paying jobs may not be created.

Two important examples are labor market standards and support for disadvantaged communities, both rural and communities of color. Labor standards can encourage high-road strategies, which can be deployed effectively in clean energy. Federal investments can require that employers follow strong labor standards, maintain prevailing wages, and remain neutral when their employees seek to bargain collectively.[12]

Ensuring that communities are not left behind is a second place for policymakers to intervene. Distressed local economies exist throughout the United States; one study found that prime-age employment rates in local labor markets were respectively 84.5 percent, 80.9 percent, and 75.5 percent for the 90th, 50th, and 10th percentiles. These large differences persist for decades (Bartik 2020). Investments in energy innovation, manufacturing, and infrastructure can support economic activity in economically distressed regions and for disadvantaged groups, especially when layers of government and community stakeholders work in partnership. These partnerships can ensure that while the Federal Government identifies goals—and, often, standards—effective implementation requires a *process* at the local level that is inclusive so that workers and socially disadvantaged groups have a say in directing how the money is used. Such processes can promote economic development in regions beyond the current handful of high-growth centers, and they can close the current gaps in access to the innovation economy for communities of color and rural communities that have suffered from years of disinvestment (White House 2021).

One effective strategy to address both labor standards and disadvantaged communities is to focus on what are called "place-based" policies, that is, policies that encourage job growth in a particular local labor market. These can take many different forms—tax incentives, cash grants, public services, or investments (Gruber and Johnson 2019). The energy transition provides certain unique opportunities to implement place-based policies that can simultaneously accomplish important societal goals. For example, the Federal Government's funding for large-scale demonstration projects for emerging climate solutions—including low-carbon hydrogen, carbon capture, and grid-scale energy storage—could support these communities. Such funding is a proposal in the American Jobs Plan. Establishing such projects in distressed communities, where the assets of a community match project requirements, could seed new industrial hubs.

The Federal Government's support for environmental remediation is another opportunity to create good jobs in distressed regions. Hundreds of thousands of "orphaned" oil and gas wells and tens of thousands of mines across the United States have no solvent owner and pose

[12] Making wages in clean energy sectors comparable to those in fossil fuel sectors may require substantial wage increases. Much of the increased labor cost is likely to be offset by higher productivity (Kochan et al. 2013), but if not, other regulation or standards may be needed. Although this chapter does not address trade policy implications, it is important to note that where the costs of American firms are higher due to internalizing social costs that other countries do not, changes in trade policy may be necessary. For example, changes in trade agreements may be necessary to allow "Buy America" policies in some instances, and to ensure that U.S. firms adhering to higher social standards can compete in private markets as well.

environmental, health, and climate hazards. For some (though not all) of this work, the skills of unemployed fossil fuel workers match the requirements needed to provide environmental remediation (Bordoff, Raimi, Nerurkar 2020). For many distressed regions, clean energy projects alone will not be enough to spur economic revitalization. Support for these communities can be provided in the form of public infrastructure investments, economic development assistance, dislocated worker programs, and environmental remediation projects, among other options.

These investments will accomplish more than just reducing inequality. Policies that encourage a more inclusive innovation process can also boost economic growth and build and maintain political support for important national objectives (Alic 2020). There is now strong evidence across economies that addressing economic inequities can support growth that is strong, stable, and broadly shared (Boushey 2019). To cite one data point: Cook and Gerson (2019) estimate that GDP per capita could rise by 2.7 percent if more women and minorities were included in the innovation process.

Conclusion

America won the Moon race because it had a national strategy. Government led the way and brought together the top minds in public service, industry, and academia. But success did not stop there and did not stay at the water's edge. In just the first four months of 2021, we saw a rover land and helicopter fly on Mars, and the launch of the commercial SpaceX with an international crew en route to the International Space Station. What started as an American goal to be first has evolved into a multinational public-private partnership of exploration.

We can do the same for the climate. Investing in clean energy will not only ensure that we have a livable planet to leave to future generations but will also help U.S. businesses stay competitive and U.S. workers secure good, meaningful jobs. Thanks to the fruits of earlier investments in innovation, if we now come together on a national strategy, we have a chance to deliver a better future for all Americans, including the good jobs that come along with a more productive, cleaner, and fairer economy. And just as with the moonshot, accelerating clean energy is not a zero-sum game; by working in collaboration, the benefits of climate-friendly policies will spill over, from government to industry to our international partners. Accelerating clean energy innovation can provide developing countries—which will be hit hardest by climate effects and can least afford to take actions in response—with the technologies that enable a low-cost transition to clean energy economies.

President Biden has made the case that in building back from the pandemic-induced economic crisis, we must "build back better." Economic transitions of the past have left certain regions and professions in economic distress. Thus, today's economic agenda needs to emphasize investments that are distributed across the country and are focused on disadvantaged communities so that all of America can reap the benefits of this economic transformation.

The U.S. government is poised to lead at this historic juncture. U.S. experts are ready to innovate and build a climate-friendly infrastructure. Federal investment, coordination, and leadership will ensure that we see the expansion of the "production possibilities frontier," and thus create a more productive society. And in the process, we will ensure that our planet is sustainable for our children, grandchildren, and beyond.

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