Energy in America

Energy as a Source of Economic Growth and Social Mobility

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A Report of the CSIS ENERGY AND NATIONAL SECURITY PROGRAM
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Introduction

The CSIS Energy and National Security Program, as part of its Energy in America initiative, held the second of two workshops devoted to the changing role of energy in the U.S. economy. The purpose of these workshops and their resulting reports is twofold:

1. to improve our understanding of the ways in which energy impacts the U.S. economy at the local, regional, and national levels; and
2. to evaluate the performance of policies designed to create economic opportunity in the energy sector.

We published an earlier paper on the changing role of energy in the U.S. economy which can be found here. This second paper complements our earlier work and focuses on what we know and don’t know about the performance of policies designed to create economic opportunity in the energy sector. During the workshop, we and other expert participants explored several dimensions of this question. First, to frame the discussion, we explored the outlook for the U.S. economy as a whole and examined data on social and economic mobility within the United States. Second, we surveyed experts and the literature to summarize what is known about the creation of quality energy jobs and the implementation of best practices in worker re-training programs. Third, we examined whether investments in research and development (R&D) and innovation clusters have produced economic activity, jobs, and innovation. Fourth, we reviewed how the governments of oil and gas producing states utilize the revenue derived from that production and whether they can convert temporary windfalls into durable economic growth. Finally, we explored the ways in which ideas of social and environmental justice are being integrated into energy and climate policy.

To inform this discussion, we commissioned papers and presentations from outside experts on each of these topics. What follows is a compilation of insights gained from the papers, the discussion at the workshop, and subsequent research. It does not represent a consensus view of the group, but instead our distilled reflections on the research and conversation.
At its core, the purpose of energy policy is to govern the production, distribution, and consumption of energy resources. In general, U.S. energy policy attempts to ensure that the country's supply of energy is affordable, reliable, and clean. Historically, this has not always been an easy task. Not only are these goals frequently at odds with one another, but the precise definitions of these three elements—affordable, reliable, and clean—are constantly evolving, and their relative priority frequently shifts in response to larger societal changes. For example, during the 2000s, the combination of skyrocketing energy prices and a new post-9/11 security paradigm elevated the concept of “energy security” to the forefront. Energy security became the dominant lens through which energy policies were conceptualized and evaluated throughout the Bush administration, such as the National Energy Plan, the Energy Policy Act of 2005, and the Energy Independence and Security Act of 2007. But by the dawn of the Obama administration, the preeminence of energy security was slowly ceding ground to a framework prioritizing climate change and—in the immediate wake of the Great Recession—job creation and economic stimulus. It is important to stress, however, that this succession implies neither that energy security had been solved, nor that it had been forgotten. During both the Bush and Obama administrations—as well as many of their predecessors—energy policy still needed to strike a balance among competing security, economic, and environmental objectives. What changed then was the relative emphasis placed on these objectives, and the relation of energy policy to other U.S. interests.

Today’s domestic energy policy conversation is dominated by a new concern: economic insecurity. Despite the vibrancy and growth of the U.S. economy in aggregate, many Americans feel less secure than ever. While the OECD expects the U.S. economy to grow faster over the next two years than any other developed economy—with the exception of South Korea and Australia1—according to survey data, 56 percent of Americans believe that the economy “is slowing down or worse,”2 and just 37 percent of Americans believe

that their children “will be better off financially” than they are. This economic anxiety is shaping energy policy. It is no longer sufficient to show that an energy policy produces beneficial economic outcomes on net—policies are expected to not only take into account preexisting inequities and their distributional consequences, but to demonstrate how they contribute to economic opportunity across society. Again, this emphasis is not completely new—policymakers have long understood that in a democratic system accountable to voters, the most popular and durable policy is one that creates a constituency of beneficiaries. But what is new is that this extra-energy idea of economic insecurity has achieved currency at a time when the energy sector is undergoing profound—and largely unrelated—changes.

As discussed at length in our first report and elsewhere, the United States is, for the first time in decades, producing and exporting enormous volumes of oil and natural gas. The electric power sector for its part is being transformed by the displacement of traditional fuels and by growing challenges to the business and regulatory models that underpin it. And across the energy sector, technology marches on, decarbonizing power production, automating once labor-intensive processes, and digitizing everything. Amid this dynamism, and against the backdrop of a slow but steady recovery from the Great Recession, decisionmakers are shifting their focus from policies that prioritized the stemming of economic losses to those that emphasize the equitable distribution of economic gains.

The newfound emphasis on economic insecurity and inequality is understandable. According to data from the World Inequality Database, household-level income inequality has risen almost every year the data has been tracked, with the share of total U.S. pre-tax income going to the top 1 percent of earners growing from 12.6 percent in 1962 to 20.2 percent in 2014, and the share of total U.S. wealth held by the top 1 percent growing from 28.1 percent to 37.2 percent. Simultaneously, the shares of both income and wealth going to the bottom 50 percent of Americans have stagnated or declined, falling over the same period from 19.5 percent to 12.6 percent and from 1.0 percent to ~0.0 percent respectively. This divergence has many fathers, including technological progress, intensifying globalization, changing government policies, and the interplay between them. This is not a uniquely American phenomenon—technological progress and globalization, for instance, can hardly be confined to a single state—but inequality appears to be particularly acute in the United States. For instance, while the income Gini Ratio (which measures inequality between 0, representing perfect equality, and 1, representing perfect inequality) for U.S. households rose from 0.37 in 1994 to 0.39 in 2016, income inequality fell slightly in most other OECD states, whose average Gini Ratio fell from 0.31 to 0.30 over the same period.

4. See Meghan O’Sullivan’s Windfall: How the New Energy Abundance Uprinds Global Politics and Strengthens America’s Power, Bethany McLean’s Saudi America: The Truth About Fracking and How It’s Changing the World, or Daniel Yergin’s The Prize: The Epic Quest for Oil Money & Power for a sampling of this voluminous literature.
6. Ibid.
7. Uses pre-2011 methodology when post-2012 data is not available. The values for remaining OECD Gini coefficients in 1994/1995 represent 18 countries: Australia, Canada, Denmark, Finland, France, Germany, Greece,
This decoupling of the welfare of average Americans and the welfare of the economy as a whole has a number of manifestations and implications for public policy. First, there is increasing evidence that rising inequality can also slow economic growth by, inter alia, constraining the supply of people and ideas, increasing the likelihood of politically sanctioned rent seeking, and distorting demand. Second, inequality has fueled the rise of political populism, which by definition challenges the status quo authority of many institutions important for the energy sector and often elicits a tumultuous political environment. In the current context, policymakers are focusing on issues related to recalibrating economic gains both on the international stage and domestically in the United States. This unfolding policy dialogue focuses not only on remedying historical and existing inequality but also on better preparing for future vulnerabilities. Here climate change plays a complicated role both as a source of future instability and as a cause of current economic anxiety for communities affected by the transition to lower carbon fuel sources (whether driven by policy or not).

The energy sector alone cannot solve the economic insecurity and inequality issues confronting the United States and many other countries around the world. Nevertheless, energy policy and commercial decision-making will be shaped by the political and societal need to address those issues. On a practical level, this means that energy policy, regulation, and private sector investments will be judged, at least to some degree, on whether they exacerbate or alleviate concerns over economic insecurity and inequality. It therefore behooves both policymakers and industry participants to familiarize themselves with the means by which energy policy and economic policy interact at the federal and sub-federal levels. More specifically, how do public officials try to harness energy-related policies and programs to achieve economic security and social mobility? And what do we know about how effective these policies, initiatives, and investments are?

Most economists and even some economic development practitioners discount the conceptual importance of energy-related jobs, preferring to emphasize other energy priorities such as efficiency, productivity, innovation, equity, or sustainability over energy’s immediate employment impacts. Energy jobs matter, however, for several reasons. First, although most parts of the energy system are relatively labor unintensive, its vast scale requires an immense number of workers, with the U.S. Energy and Employment Report (USEER) estimating that just over 4.31 million U.S. workers worked in the traditional energy sectors of fuels, electric power generation and transmission, and distribution and storage in 2016.\(^8\) Even if the energy system’s transformation is most visible through changes in technologies and fuel mix, the labor that manufactures, constructs, operates, and maintains those technologies will also have to change. In the short term, surveys by the Center for Energy Workforce Development suggest that approximately 34,000 key jobs in the electric power sector alone will need to be replaced due to worker retirements by 2021,\(^9\) with the U.S. Department of Energy’s Quadrennial Energy Review finding that in the longer run, “by 2030, the energy sector overall, including the TS&D [transmission and distribution] segment, will employ an additional 1.5 million workers.”\(^10\) This demand for new energy workers is likely to be further exacerbated by a perceived “skills gap” between the skills employers want and the skills prospective employees have, with the 2017 Global Energy Talent Index noting in its survey of companies that “the overwhelming majority (83%) of hiring managers believe there is a skills shortage in the power sector, compared with 28% in oil and gas” and that “all respondents felt that a skills gap does exist in the industry.”\(^11\)

Second, the 4.31 million Americans who work in the energy industry are also 4.31 million Americans who can vote. When combined with the votes of their families, neighbors,

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and affected businesses, these energy voters can form a powerful political constituency—particularly when they are concentrated in one area. This is not, however, to say that the political preferences of energy voters are monolithic—consider, for instance, the running battles between the environmental and utility lobbies over climate legislation or the tripartite dispute between the coal, renewable, and natural gas lobbies over the Department of Energy’s proposal to subsidize “resilient” base-load generation. Rather, it is important to acknowledge that there are political actors in the energy space who are highly motivated and well-resourced. Energy proposals that fail to account for this are not merely quixotic, they are irrelevant. Simply put, any energy policy that cannot pass is not a serious energy policy. Finally, jobs are also an essential element of ensuring a just transition. In communities that are transitioning from one type of industry to another, or where there isn’t enough economic opportunity, policymakers often look to energy as a potential source of economic growth and job creation.

Before turning to the tools through which policy can affect energy jobs, it is worth first evaluating what is known about these jobs. Although estimates of the rough number of jobs industry-wide are reasonably accurate, as discussed in greater detail in the project’s first paper, parsing out more granular details can be difficult due to misalignment between the categorization structures of government reporting frameworks and how actual energy firms operate (for instance, how contractors are counted), disputes over the magnitude of employment multiplier effects (i.e., how many indirect jobs are created by a given amount of direct investment and employment), and the exclusion of energy efficiency jobs in official reporting altogether, to name a few. By comparing the official account to alternative surveys, Joe Hezir shows in his submission that these complications are not trivial, and result in the U.S. government’s primary statistical estimate—the Quarterly Census of Employment and Wages by the Bureau of Labor Statistics (QCEW-BLS)—grossly “undercounting [the number] of jobs in all energy technologies.” The energy sector’s employment impact is still, however, significant, even in the lower QCEW-BLS estimate. As shown in Table 1 below, the number of jobs associated with electric power generation alone are significant, with between 92,817 and 212,669 jobs for fossil fuel generation, and a further 75,611 to 286,610 jobs across the rest of the fuels. In summary, whether one uses a conservative or more expanded definition of energy jobs, energy plays a significant role in U.S. employment, with David Foster concluding in his workshop paper that ultimately “both approaches validate the strategic importance of energy and jobs in the American economy.”

16. While not the only part of the energy value chain, the estimates for electricity generation are arguably the most directly comparable.
Table 1: QCEW-BLS and USEER Employment by Electric Power Generation

<table>
<thead>
<tr>
<th>FUEL SOURCE</th>
<th>QCEW-BLS EMPLOYMENT</th>
<th>2018 USEER EMPLOYMENT</th>
<th>DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuels</td>
<td>98,817</td>
<td>212,669</td>
<td>+119,852</td>
</tr>
<tr>
<td>Nuclear</td>
<td>44,753</td>
<td>64,743</td>
<td>+19,990</td>
</tr>
<tr>
<td>Wind</td>
<td>6,050</td>
<td>107,444</td>
<td>+101,394</td>
</tr>
<tr>
<td>Solar</td>
<td>2,848</td>
<td>250,271*</td>
<td>+247,423</td>
</tr>
<tr>
<td>Combined Heat &amp; Power</td>
<td>1,649</td>
<td>27,239</td>
<td>+25,590</td>
</tr>
<tr>
<td>Hydro</td>
<td>17,501</td>
<td>66,872</td>
<td>+49,371</td>
</tr>
<tr>
<td>Geothermal</td>
<td>1,117</td>
<td>7,927</td>
<td>+6,810</td>
</tr>
<tr>
<td>Biomass</td>
<td>1,693</td>
<td>12,385</td>
<td>+10,692</td>
</tr>
</tbody>
</table>

* Majority of Time

Information on the quality of these jobs is, unfortunately, less clear. As can be seen in Table 2 below, according to the Bureau of Labor Statistics, the mean wages for the most common energy jobs within each of the major energy fuel types (as defined by the NAICS scheme) are roughly similar to the $24.4 per hour (or $50,620 per year) that the average American earns. To answer the question of whether these are “quality jobs” or not, an issue that came up a number of times in the workshop, requires more investigation. First, it is likely that the selected jobs are relatively concentrated in areas with different costs of living. Most oil and gas workers, for instance, are likely to be concentrated in cheaper rural or peri-urban areas, while solar photovoltaic installers are more likely to be concentrated in more expensive urban areas with large markets for residential solar. Second, the mean (or average) figure obscures significant differences in the organization of that labor. As noted by several participants, there are significant differences in unionization rates. For 2016, 3.4 percent of solar industry workers belonged to a union, compared to 11.1 percent of coal miners, 2.5 percent of oil and gas extraction workers, and 10.7 percent of all other non-energy workers. Furthermore, there are also notable differences in who employs energy workers. For example, just 1.9 percent of extraction workers are self-employed, compared to 20.3 percent of solar installers and 16.9 percent of wind turbine technicians.

18. Adapted from Joseph Hezir, 2018.
19. As can be seen in Figure 2: Distribution of Private Sector U.S. Energy Jobs (2017), the bulk of U.S. fossil fuel jobs are located in the relatively sparsely populated states of Texas, New Mexico, Oklahoma, and Nebraska, which in 2017 were the 26th, 45th, 35th, and 43rd most densely populated states. Conversely, the largest number of solar jobs are located in the relatively urban states of California (11th), New York (7th), Florida (8th), and Hawaii (13th).
22. Ibid.
23. Ibid.
24. Extraction workers consists of all workers under the 47-5000 detail, specifically (1) Derrick, Rotary Drill, and Service Unit Operators, Oil, Gas, and Mining; (2) Earth Drillers, Except Oil and Gas; (3) Explosives Workers, Ordnance Handling Experts, and Blasters; (4) Mining Machine Operators; (5) Rock Splitters, Quarry; (6) Roof Bolters, Mining; (7) Roustabouts, Oil and Gas; (8) Helpers—Extraction Workers and (9) Miscellaneous Extraction Workers.
26. There does not, however, seem to be as much difference in intra-job wage variation as might be otherwise expected. The wages of solar workers, for instance, are in fact only slightly less compressed than their fossil fuel
Finally, there are also differences in educational needs across the different types of energy jobs. The division is not, however, a simple cleavage between fossil and non-fossil fuel jobs. As Figure 1 below shows, the most common energy jobs are roughly analogous in terms of their educational requirements. With the notable exception of power plant operators, most energy jobs require only a technical certificate or associate degree and typically less than 10 percent of workers in these selected energy occupations have a bachelor’s degree or more. Most of the energy jobs included in the Bureau of Labor Statistics data are also generally better paying than those in other industries with comparable levels of postsecondary educational attainment—denoted in Figure 1 by being “above” the trend line. This can likely be attributed to several factors, including higher risks of accidents or death, gender imbalances, the relatively high concentration of economic rent earning firms, and the aforementioned differences in costs of living.

Energy and non-energy jobs can also be separated along several demographic lines. First, according to the Bureau of Labor Statistics (BLS), most energy jobs are, in general, more likely to be filled by whites than non-whites, particularly those in the fossil fuel sector. While in 2018 an estimated 78 percent of all employed Americans over the age of 16 were white, this share is notably higher in most energy industries, where whites occupy 86

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percent of all oil and gas extraction jobs, 88 percent of all coal mining jobs, 94 percent of pipeline transportation jobs, 86 percent of natural gas distribution jobs, and 86 percent of jobs associated with electric power generation, transmission, and distribution.\footnote{31} Whites are, however, relatively underrepresented in some downstream sectors, most notably in petroleum refining and gasoline stations, where they fill 75 percent and 74 percent of jobs respectively, while still accounting for the majority of the workforce.\footnote{32} In the non-fossil fuel sector, the demographic picture is muddled by an imprecise reporting framework—according to the BLS, for instance, the bureau “does not have wage [or demographic] data specific to the wind [or renewable] energy industry,” which in turn leads it to suggest looking at aggregated data for larger parent clusters that hopefully include the specific renewable energy jobs.\footnote{33} There is, however, better demographic data on the solar industry. While not completely comparable to the BLS statistics, the 2017 U.S. Solar Industry Diversity Study—produced by the Solar Foundation in collaboration with the Solar Energy Industries Association’s Women’s Empowerment Committee—estimates that 74 percent of “solar worker[s]” were white in 2017.\footnote{34} Using the same data sets, it also seems fair to conclude that gender representation is slightly more equitable in the solar sector than in the fossil fuel sector, with men occupying 73 percent of solar jobs, compared to 81 percent oil and gas extraction jobs, 94 percent of coal mining jobs, 92 percent of pipeline transportation jobs, 81 percent of natural gas distribution jobs, 78 percent of electric power generation,

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Selected Energy Careers and Educational Attainment}
\end{figure}

\begin{table}
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Occupation} & \textbf{Median Annual Earnings} & \textbf{Bachelor’s Degree} \\
\hline
Extraction Worker & \$58,000 & 30\% \\
Power Plant Operator & \$80,000 & 25\% \\
\hline
\end{tabular}
\caption{Median Annual Earnings and Share of Occupations with at least a Bachelor’s Degree}
\end{table}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Median Annual Earnings by Share of Occupations with at least a Bachelor’s Degree}
\end{figure}


\footnotesize{32. Ibid.}
transmission, and distribution jobs, 85 percent of petroleum refining jobs, and 49 percent of gasoline station jobs.

These jobs are distributed unevenly across the country. As Figure 2 below shows, the relative and absolute importance of energy jobs can vary considerably: while the 20,721 workers who work across Wyoming’s various energy industries are considerably less numerous than the 38,551 in California, they play an outsized role in former’s economy, where they represent 10.7 percent of the private labor force, compared to just 0.3 percent in the latter. Generally speaking, most energy workers in most states work in the oil and gas industries, and they constitute a majority of energy workers in 42 states. As expected, the largest absolute numbers of oil and gas workers are located in states with similarly significant shares of the country’s oil and gas deposits—and by extension production—namely Texas, Oklahoma, Louisiana, New Mexico, and Alaska—but they also constitute sizable populations in less obvious states such as Washington, New York, California, and South Carolina, where they are typically employed in downstream operations such as refining and distribution. Coal workers are even more concentrated, being confined primarily to Virginia, West Virginia, Kentucky, Pennsylvania, Texas, and Alabama. But even in these states, the absolute number of coal workers is small, with West Virginia’s 13,261 coal workers—the most of any state—constituting just 2.5 percent of that state’s total private labor force. While these trends in fossil fuel employment are relatively easy to pick out, the analysis of non-fossil fuel jobs (i.e., those in solar, wind, hydro, geothermal, nuclear, and biomass) is complicated by the aforementioned difficulties with their tabulation, with the absence of solar installers proving particularly consequential. Notwithstanding these important qualifications, a cursory inspection of the data shows that while non-fossil fuel jobs are relatively more distributed than their fossil fuel peers, they constitute a majority in zero states, with the largest single state renewable energy workforce being the 1,292 jobs in California’s hydroelectricity sector—a group dwarfed by the 3,622 jobs in crude petroleum extraction alone.

Taken together, differences in overall employment numbers, wages, organizational structures, education, demographics, and geographic characteristics suggest that energy jobs are not necessarily easy substitutes for one another. Generally speaking, while there are more and better paying jobs in the fossil fuel sector than there are in the renewable industries—with the exception of wind—most energy jobs typically require similar levels of educational attainment. Although the definition of a “quality job” is inherently subjective, the existing statistical evidence suggests that U.S. energy jobs are, on average, better paying, less heavily unionized, less schooling-intensive, and faster-growing—again, with the exception of coal—than other jobs. According to BLS projections, relative to

35. Data from the Bureau of Labor Statistics’ Quarterly Census of Employment & Wages. Energy jobs are calculated as the sum of NAICS 211110 (crude petroleum extraction), NAICS 211130 (natural gas extraction), NAICS 213111 (drilling oil and gas wells), NAICS 221116 (geothermal electric power generation), NAICS 221112 (fossil fuel power generation), NAICS 221117 (biomass electric power generation), NAICS 221111 (hydroelectric power generation), NAICS 221115 (wind electric power generation), and NAICS 221114 (solar electric power generation).
2016 levels, by 2026, the U.S. economy will need 11,800 more solar PV installers (+104.9 percent), 5,600 more wind turbine technicians (+96.3 percent), 36,200 new extraction workers (+36.2 percent), and 3,400 fewer coal workers (-6.7 percent). Over the same period, total U.S. employment is projected to grow by 7.4 percent. Energy jobs are, however, also more geographically concentrated, less diverse, and more accident prone.

What then is the role of public policy? And what should it be? Participating experts were nearly unanimous in their belief that government policy—both at the federal and sub-federal levels—plays a role in influencing the supply of, and demand for, energy workers. A more holistic review of the employment discussion in the energy sector reflects a variety of circumstances, including the strategic importance of the sector; the political salience of energy jobs; the size of the industry; the industry’s integration into domestic supply chains; and its interactions with other climate, economic development, trade, and defense policies.

Government interventions, however, are numerous and can vary considerably in terms of form, effectiveness, and jurisdiction. Furthermore, not all of these interventions are necessarily energy specific. For these reasons, both our assembled experts and the energy economy literature largely focus on three silos of labor market interventions: education and training initiatives, stakeholder agreements, and economic development. We take up the economic development argument in Section 2, as well as the role of sector-agnostic labor market policies such as unemployment insurance and employment subsidies, as their impact on energy workers is not significantly different from their impact on workers of other sectors.36

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36. This approach has been criticized by Rhiana Gunn-Wright and others as lacking a holistic vision.
Education and Training

The first of these interventions is arguably the most important: education and training. Also known as workforce development, energy education and training initiatives are typically used to address mismatches between the skills that workers have and the skills that employers want. Consequently, these programs are most needed at times of sectoral upheaval, as the skills employers need shift. Mary Alice McCarthy argues that these initiatives “are critical for helping smooth out...disruptions, preparing new workers for growing sectors, upskilling workers in sectors experiencing technology-driven change, and retraining workers in the sectors experiencing permanent losses.”

Energy workers, of course, are not the only workers who can benefit from workforce development programs, nor are most education and training programs designed expressly for them. But energy workers are particularly exposed to the problems that these programs are intended to address. Fossil fuel employment, for instance, is arguably more volatile than other sectors, with Mark Partridge noting in his paper a telling example: “from the peak in Q4 2014 to the trough in Q1 2017 Williams County [an oil- and natural gas-rich area that serves as the hub of the Bakken drilling play] lost 44% of employment” during the latest oil price downturn—significantly more than the 12 percent losses North Dakota experienced as a whole over the same period, and vastly more than the 8% of workers lost from peak to trough during the Great Recession.

For their part, coal worker payrolls are under pressure from a variety of factors, including the increasing mechanization of once labor-intensive mining jobs, competition at home from cheaper and cleaner sources of power generation such as natural gas and renewables, competition abroad from cheaper producers, and a long-term trend toward more stringent environmental regulations. Even solar and wind jobs are, to some extent, vulnerable to disruption, as the number of current and future jobs in renewables is dependent upon oftentimes inconsistent federal and state energy policies.

Unfortunately, while the scale of the problem is evident and the need for solutions obvious, it is not clear that all of the country’s programs are up to the task. The Trade Adjustment Assistance Program (TAA)—which provides aid to workers whose jobs, hours, wages, or benefits have been harmed by increased imports—and the Adult and Dislocated Worker program—which provides employment and training services to unemployed or disadvantaged workers—contained in the Workforce Innovation and Opportunity Act (WIOA) are the main federal worker retraining programs, though they are not specifically geared toward the energy sector. Unfortunately, neither program has been particularly successful. According to Reynolds and Palatucci, “participating in the TAA program causes a wage loss approximately 10 percentage points greater than if the displaced worker had chosen not to participate in the program.”

funded training does not have positive impacts in the 30 months after enrollment.”

In both of these cases, the core service offerings—training programs designed to help unemployed and dislocated workers develop new skills—were at best ineffective, and at worst, actually harmful to participant outcomes, with McCarthy concluding that “recent evaluations of the country’s signature job training programs have not been encouraging”—albeit with several caveats.

**Career Services**

While these evaluations suggest that the current job training orthodoxy is unlikely to yield significant benefits for workers, they do identify some bright spots. Notably, both evaluations have positive assessments of the TAA and WIOA job search assistance services (alternatively styled in some quarters as “intensive services” or “career services”). These services do not directly address the skills of participants, but rather provide job seekers with the means to identify relevant jobs and to better meet recruiter expectations. Common services highlighted in the evaluations and the literature include providing information on job openings—typically though a publicly available job board—counseling on certification needs, resume preparation, and mock interviews. These services are perhaps less central to the current thrust of TAA and WIOA programming, but they have been shown to be effective, scalable, and relatively cost-efficient, with one of the independent reviews finding “that intensive services, when provided as a stand-alone service without training [emphasis added], increased earnings and employment” in survey participants.

**Worker Driven Training**

A closer reading of the existing economic literature also shows that, with some modifications, more conventional training and upskilling programs can be made to work. According to the literature, workshop participants, and anecdotal evidence, the key is changing the way that individuals pursue training. First, training programs typically have more buy-in from participants when they reflect their priorities and are—to the extent possible—voluntary. This logic has, to some extent, already been incorporated into the current WIOA approach through the development of training vouchers and Individual Training Accounts, which allow job seekers to purchase training and education services

43. In her discussion, Dr. McCarthy notes that “the timing of the TAA evaluation which coincided with the worst days of the Great Recession,” and thus that not all of the program’s shortcomings can be laid directly at the feet of the program’s design.
44. “Intensive services” is the preferred nomenclature of the WIOA and its predecessor, the WIA. The included activities, as set forth in section 134(d)(3)(C), are: (i) “Comprehensive and specialized assessments of skill levels and service needs”; (ii) “Development of an individual employment plan”; (iii) “Group counseling”; (iv) “Individual counseling and career planning”; (v) “Case management”; (vi)” Short-term prevocational services, including development of learning skills, communication skills, interviewing skills.”
46. There does, however, exist evidence that tying unemployment insurance eligibility to workforce development programming and/or job search activity may decrease the time spent on UI and improve worker outcomes.
from eligible providers using publicly funded vouchers.  The second key element is ensuring that the choices individuals make are informed. As Katz argued in his 2014 work, “individual choice [in employment and training programs] can lead to efficient outcomes when it works well but it can fail when individuals choose poorly,” a point confirmed by McCarthy’s conclusion that “when participants had help choosing a training program, they were more likely to pick one that led to a good job.”

**Apprenticeships**

One way to help participants make informed choices on their training and education services is to ensure that those programs are—to the extent possible—reflective of actual employer needs. There is, for instance, little value to a training program if it trains workers in skills that are outdated or irrelevant. This has emerged as a recurrent theme in the literature, one which recognizes that “there is no one-size-fits-all approach, and that workforce development efforts are grounded in local partnerships and tailored to the needs of local economies.” It is little surprise then that some of the most successful workforce development programs are also some of the most immediately relevant. Apprenticeships and other “earn-and-learn” strategies, for instance, have proved remarkably successful, with U.S. Department of Labor concluding that “over 80 percent of apprentices who complete their program transition into jobs paying, on average, over $50,000 a year.” There is, however, some concern over their ability to scale beyond the immediate needs of sponsoring employers, and today apprenticeships are notably less common in the United States than in many other countries, where they constitute only 0.2 percent of the labor force, compared to Germany’s 3.7 percent, the United Kingdom’s 2.7 percent, and Canada’s 2.2 percent. As Lerman argues in his 2014 paper, the primary impediment to enlarging the country’s apprenticeship programs isn’t an insufficient supply of apprentices, but rather a lack of employer demand for apprentices, which he in turn posits “can be attributed to a lack of public effort in promoting and supporting apprenticeship...heavy subsidies for alternatives to apprenticeship [namely career and community college systems]...limited information about apprenticeship[s]...employer misperceptions that apprenticeship will bring in unions” and a failure to provide public funding for apprenticeship programs at a level comparable to other developed countries.

**Sector Strategies**

The concept of relevance has also been central to “sector strategy” approaches, which “bring together multiple employers from a single industry, local training providers,
and relevant [public or quasi-public] intermediaries” to create a single source for new workers equipped with the skills that employers want. These programs not only simplify the hiring process for employers by reducing occurrences of skill-mismatches, but also provide material improvements for job-seekers, who “earned significantly more than control [non-sector strategy] group members…and were significantly more likely to work” according to Maguire et al.’s 2010 study. Typically advanced at the state or local levels, sector strategy approaches are usually intended to be used alongside what are known as “career pathway” programs. While “career pathway programs”—which typically include post-secondary education, apprenticeships, and trainings programs—are intended to grow and improve the supply of workers, sector strategies focus on growing, organizing, and communicating the industry’s demand for workers. To do so, sector strategies bring together stakeholders to identify and define the industry’s workforce requirements, including the skill requirements for each job, the credentialing process, union relation expectations, pathways for worker advancement, and gaps in labor market data. Sector strategies can also provide a number of more active functions, including verifying that training programs are providing the skills that employers need, providing off- or on-the-job training, and helping to craft training program curriculums. Though the degree of formalization varies significantly across sector strategies, they are often funded using an array of federal funding sources, including TANF, the Adult Basic Education Leadership program, Pell Grants, and WIOA grants. Sector strategies often also utilize state resources, including state workforce development funds and, in some instances, tax increment financing, whereby “developers are promised a portion of the future tax revenues generated by their development to help offset the costs of their project”—as is the case in Colorado. Notable examples of formal, energy-specific sector strategies include: Minnesota’s FastTRAC program, which helps provide training for “educationally underprepared adults” seeking employment in select Minnesotan industries, including energy; Arizona’s Get Into Energy Consortium, which developed, expanded, and improved educational pathways for adults pursuing careers in energy and mining; and North Dakota’s Training for Regional Energy in North Dakota project, which provided training for adults and recent high school graduates using a curriculum designed with input from a consortium of state energy employers.

**Post-secondary Education**

A final element of the job training ecosystem is at the same time the country’s most successful job training program and explicitly not a job training program: the U.S. higher education system. Intentional or not, “the most consistent and robust finding about labor
market success is that adults with postsecondary education and credentials are better equipped to weather labor market disruptions that adults with a high school diploma or less. While the author is unaware of any major characteristics or interactions with higher education institutions that are unique or especially pronounced within the energy field, enrollment data shows that students are increasingly drawn to education programs that, at the very least, are conducive to later entry into the energy sector, with data enrollment numbers showing consistent growth in the number of post-secondary students graduating with a degree or certificate in energy-related fields. However, and despite the success of post-secondary education on worker outcomes, workforce development experts suggested that there is a real risk of overreliance on the country’s higher education system for worker training—something which, in most cases, higher education curriculums are not explicitly designed for. It stands to reason, then, that while the higher education system is an indispensable part of the workforce development ecosystem, it is not a sufficient one.

**Project Labor Agreements**

Although public education and training initiatives are arguably the most significant kind of government intervention in energy labor markets, public policy also plays an important role in ensuring that at least some of the benefits energy industry activities provide are returned to local stakeholders. Much of this function is, of course, inherent in the taxes, royalties, and fees that are levied on energy firms and projects by local, state, and federal governments—revenue that is then used to fund public services. However, with the exception of payroll and income taxes, few government takings are directly related to the number and quality of jobs that a firm provides—being instead typically tied to revenue, profits, or production. Consequently, many sub-federal governments and communities have turned to alternative instruments to marry a firm’s welfare with that of its supporting community. Although its popularity is hard to measure, several workshop participants identified project labor agreements (PLAs) as one such device. Per Executive Order 13502, a PLA is an agreement whereby labor representatives, firms or sponsors, and (sometimes) communities enter into “a pre-hire collective bargaining agreement…that establishes the terms and conditions of employment for a specific. . . project.” Typically, PLAs provide higher wages and certain working conditions for laborers in exchange for their agreement not to engage in work stoppages. In their expanded form, PLAs can also provide communities with benefits beyond those accruing to laborers, who may or may not be from the impacted community. First, PLAs can be used to contractually obligate firms or sponsors to provide community amenities as part of the project—typically by co-locating public goods such as transportation infrastructure, parks, and beautification projects. Second, PLAs can also be constructed as “community


60. Uses data from the National Center for Education Statistics. Calculated as the absolute number of students graduating with a first or second major in an energy affiliated fields between 2009 and 2017 in the United States. The included energy-affiliated majors are: “Natural Resources and Conservation,” “Environmental Control Technologies/Technicians,” “Geological and Earth Sciences/Geosciences,” “Petroleum Engineering,” and “Mining and Petroleum Technologies/Technicians.”

workforce agreements,” which effectively requires the inclusion of underrepresented or politically valuable groups through mandated hiring preferences. PLAs are not, however, without their share of controversy. Though their use in the United States stretches back to the construction of the Shasta, Hoover, and Grand Coulee Dams during the 1930s, the agreements were effectively prohibited for federal projects between 2001 and 2009 by Executive Order 13202—largely on the grounds that they artificially limited competition on projects, raised construction costs and led to “discrimination against Government contractors or their employees based upon labor affiliation or lack thereof.” This effective prohibition was ultimately lifted in February of 2009 by President Barack Obama’s Executive Order 13502, which revoked 13202 and “does not preclude the use of a project labor agreement for projects receiving Federal financial assistance.”

**Community Benefit Agreements**

Another kind of stakeholder agreement that more explicitly addresses the welfare of communities—as opposed to workers—are community benefit agreements (CBAs). Usually negotiated after a project’s announcement but before it has government approval, a CBA “is a private contract negotiated between a prospective developer and community representatives…[specifying] the benefits that the developer will provide to the community in exchange for the community’s support, or quiet acquiescence, of its proposed development.” According to the Department of Energy, these agreements can provide benefits for both developers and affected communities, with the former benefiting from reductions in political risk and the latter from targeted hiring commitments, support for small businesses, and other concessions. Notable examples of successful (at least in the judgment of the Department of Energy) energy-specific CBAs include those governing Downeast LNG INC’s liquefied natural gas terminal in Robbinston, Chevron’s Richmond Refinery Modernization Project, and Vineyard Power’s offshore wind project in Martha’s Vineyard.

CBAs are not, however, immune to criticism. As a frequently cited—albeit geographically specific—analysis from the New York City Bar points out, it is difficult for the CBA counterparty negotiating with the developer to be truly representative of the community noting that “the people who negotiate the CBAs are neither elected or appointed by the community” and therefore lack accountability, which can lead to accusations that companies engage in CBAs to assuage certain portions of a community rather than serve the interests of the entire community.

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67. Ibid.
69. Vicki Been, Mark Levine, Ross Moskowitz, Wesley O’Brien, and Ethel Sheffer, “The Role of Community Bene-
Although it may be more milquetoast than profound, the most significant conclusion that can be drawn from the analysis of CBAs, PLAs, and workforce development programming is that there is no obvious single policy solution. The U.S. energy sector is a complex and highly variable system that necessitates a commensurately adaptable policy structure. There is no evidence that a single jobs policy can ensure that there are enough workers, that their welfare is adequate, and that they and their communities benefit. Throughout the literature, the workshop, and the papers that informed it, the prevailing consensus was that while federal policy can and should tinker with energy job policy at the margins, the best policy interventions are those that can accommodate divergent local circumstances and that are responsive to local and market needs.
3 | Fostering Energy Innovation

Innovation has always played an important role in the energy sector. Going forward, the scope and speed of climate change means that—barring a radical reconfiguration of the country’s economic structure—the success of any energy transition will depend, at least in part, on the pace and dissemination of innovation. Innovations can take many forms, including productivity-enhancing improvements that allow firms and consumers to do more with less; the refinement of cleaner, cheaper, and more scalable renewable energy sources; new applications of digital and information technologies to existing energy products and services; the development of carbon capture utilization and storage technologies; or the geo-engineering of the larger climate system. Innovation cannot, however, be mandated. By its very nature, innovation is an uncertain phenomenon; governments cannot order ideas to spring into the minds of scientists, nor can firms be certain that an investment in R&D will produce a commercializable product. But this is not to say innovation is determined completely exogenously, appearing only at random. As a growing body of literature shows and workshop participants pointed out, innovation can be incentivized, accelerated, and guided through the actions of both public and private actors.

Innovation is also seen as a key engine for economic growth and opportunity for the U.S. economy as a whole. Consequently, many state and local communities have created strategies to attract investment and cultivate their ability to participate in innovation and technology-oriented fields such as advanced manufacturing, biotechnology, and energy. What role then does energy innovation play in the U.S. economy and what strategies and programs are being used to encourage the development of these opportunities?

Public Sector Support for Energy Innovation

While by no means confined to it, the role of public sector actors is particularly pronounced within the energy sector. As discussed in greater detail in The Changing Role of Energy in the U.S. Economy, the scale, positive externalities, and reliance on basic science research of the energy sector creates a natural role for government involvement—though the optimal extent of this involvement remains hotly contested. To date, public sector support for energy R&D has been primarily advanced through two approaches, the first being through state government expenditures. In FY2017, this support totaled $2.5 billion, of which $307 million (12.2 percent) fell under the “Energy” heading, and a further $480
million (19.2 percent) under “Environment and Natural Resources,” according to the National Science Foundation.\textsuperscript{70} Used to support a variety of programming, these funds can be channeled to state institutions specifically charged with research—such as New York’s Energy Research and Development Authority, which received 98 percent of the $56 million dollars New York earmarked for energy R&D\textsuperscript{71}—or spread out over a wider range of state organizations—as is the approach in Colorado, whose research tasks are performed by the Office of Economic Development and Trade, the Energy Office, the Department of Natural Resources, and others.\textsuperscript{72}

Second, the public sector also influences energy R&D at the federal level, primarily through the Department of Energy’s financial support for outside researchers and the operation of its network of 17 National Laboratories. These National Laboratories are operated by the private sector under a “management and operating” model, but the government retains the leading role in “defining research objectives, while the Lab researchers are free to determine the most efficient way to achieve that objective.”\textsuperscript{73} In spite of the numerous problems with quantifying innovation,\textsuperscript{74} by the simplest measures, the Labs’ basic science research initiatives are productive, creating more than 700 patents and leading to nearly 16,000 journal articles and accepted manuscripts in 2017 alone.\textsuperscript{75} According to the Congressional Research Service, the DOE has played an outsized role in the sector, estimating that “since FY1978, DOE has been the main supplier of energy R&D funding compared to other federal agencies,” providing more than $158 billion since the Department’s inception.\textsuperscript{76} Although current DOE funding levels (estimated at roughly $4.8 billion in FY2018)\textsuperscript{77} are less than their $8.6 billion peak in FY1979, funding has grown steadily over the last two decades, with nuclear energy R&D attracting the largest share of DOE funding dollars (29 percent) over the last decade, followed by fossil energy (21 percent), renewable energy (20 percent), energy efficiency (17 percent), and electric systems (14 percent).\textsuperscript{78}

\begin{itemize}
  \item \textsuperscript{72} Ibid.
  \item \textsuperscript{75} Computed as the number of journal articles and accepted manuscripts resulting from DOE research funding as defined by DOE’s Public Access Gateway for Energy and Science database, https://www.osti.gov/pages/search/filter-results:F/display:detail/publish-date-start:01/01/2017/publish-date-end:12/31/2017.
  \item \textsuperscript{77} Hart et al., have, however, estimated an alternative budget of $7 billion, though this divergence may be due to the inclusion of the funding for the U.S. DOE Office of Science.
  \item \textsuperscript{78} Ibid.
\end{itemize}
Table 3: DOE Energy Technology Cumulative Funding Totals (billions of 2016 USD)\textsuperscript{79}

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<tr>
<td>Total</td>
<td>$48.01</td>
<td>$158.28</td>
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The DOE is also actively engaged in promoting the commercialization of its research. This principle has been embraced by both the Executive and Congress, as respectively evidenced by item 14 of the President’s Management Agenda, “improving transfer of federally-funded technologies from lab to market,”\textsuperscript{80} and a slew of legislation, including the Technology Innovation Act of 1980, the National Competitiveness Technology Transfer Act of 1989, the 2000 Technology Transfer Commercialization Act, and the 2007 America COMPETES Act.\textsuperscript{81} While there is something of an unresolved tension between the DoE’s mandate to commercialize its R&D and its directive to prioritize early-stage basic R&D—which often lacks immediate commercialization prospects—the Department has continued to expand its commercialization operations through the creation of the Office of Technology Transition in 2015 to further “the commercial impact of the Department of Energy’s research,”\textsuperscript{82} its operation of 96 technology maturation programs, which help to de-risk early-stage technologies in the eyes of outside investors by providing testing, prototyping, or other services,\textsuperscript{83} and the launch of the Lab Partnering Service in 2018, which provides a suite of services allowing interested parties to interact with DOE experts, access technical summaries of the National Labs’ technologies, and search patents produced from DOE-funded research.\textsuperscript{84} These efforts have by some estimates borne fruit, with the National Institute of Standards and Technology (NIST) concluding that the commercialization activities pursued under federal research programs—including energy—have produced a median of nine dollars of benefits per dollar invested.\textsuperscript{85} Several experts, however, have suggested that more could be done to maximize the economic impact of National Laboratories, as exemplified by Andes’ argument that their ability to create economic gain has been constrained by an outdated preference to locate their activities “in isolated regions of the country, far from urban technology clusters” and the labyrinthine

\textsuperscript{79} Ibid. Reproduced from Table I. DOE Energy Technology Cumulative Funding Totals.
rules that make it “extremely difficult for a small business...to partner with a lab outside its geographic area.”

The DOE is by far the most significant federal actor in the energy innovation space, but it is not the only one. Given energy’s essential role in military logistics—by some estimates the U.S. military is the world’s largest single institutional consumer of energy—it should come as little surprise that the Department of Defense (DOD) has long been active in the energy innovation space, where it has played a leading role in the creation of nuclear reactors, turbine engines, solar PV cells, and rechargeable batteries. This interest has been formalized in both the 2018 National Defense Strategy and more explicitly in the 2016 Operational Energy Strategy, the latter of which defines three energy objectives for the DOD: “increase future warfighting capability by including energy throughout future force deployment; identify and reduce logistics and operational risks from operational energy vulnerabilities; [and] enhance the mission effectiveness of the current force through updated equipment.” As of 2019, its research agenda is designed to address both the military’s immediate needs—such as ensuring reliable electricity for defense installations, improving the battery lives of autonomous drones, and enhancing the efficiency of energy-intensive aircraft, vehicles, and ships—as well as its longer-term strategic planning initiatives—such as the development of directed energy weapons. According to current estimates, DOD investments in energy research, development, testing, and evaluation (RDT&E) for these technologies should reach $1.6 billion in 2019, a significant outlay when viewed relative to the $13.7 billion allocated for the Department’s entire Science and Technology budget. The functional relationship between the DOD and the DOE vis-à-vis energy research is, however, complex. On the one hand, the two organizations’ research arms “have remarkably little interaction when it comes to energy innovation” with the DOE focusing on civilian energy needs and DOD on military applications—or, put another way, on price and performance, respectively. On the other hand, their efforts are to some extent complementary, and experts note that “although mission-driven, DoD energy RDT&E…contribute[s] to civilian clean energy innovation because of the military’s full-spectrum approach to innovation,” an approach that is in turn “well suited to energy innovation” by subjecting technologies to demanding testing conditions and purchasing in quantities necessary to enable economies of scale.

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91. Robyn and Marquesee, “The Clean Energy Dividend.”
92. Ibid.
Private Sector Support for Energy Innovation

The role of the private sector in energy innovation is, almost certainly, even more significant. While the public sector still provides essential research services—and these services are arguably more energy-centric than in the past, with energy's share of public R&D dollars growing from 0.3 percent in 1976 to 8.2 percent in 2018—overall spending on public energy R&D has declined in both relative and absolute terms. Although the federal government spent $8.1 billion on energy RD&D (or 2.2 percent of all federal government expenditures) in 1976, in 2017, it spent only $3.8 billion (or 0.1 percent). Conversely, over roughly the same period, the importance of private sector R&D in the United States has increased, growing from $4.9 billion (38.5 percent of all domestic R&D) in 1960 to $457.4 billion (75.1 percent) in 2018. During their deliberations, most workshop participants identified three broad types of private sector energy R&D entities: (1) individual firms, which includes both startups and their more mature peers; (2) startup assistance organizations (SAOs), which typically includes incubators, accelerators, and co-working spaces; and (3) innovation clusters.

Individual Firms

Easily the largest group of private energy research entities, individual firms are also the most diverse group and includes a vast array of entities, ranging from individual hobbyists tinkering in their garages to the research arms of world-class multinational firms. While statistical surveys are incomplete, compared to other industries, energy R&D—for both fossil and non-fossil technologies—seem to be more concentrated and more reliant on a few large companies. While roughly 21 percent of all R&D activity in domestic non-energy sectors is carried out by firms with fewer than a thousand domestic employees (i.e., small firms), for the oil and gas sector—which attracts more than 89 percent of all energy R&D spending in the United States—the share is only 8 percent. For power generation and renewables, the picture is similar—albeit less complete—with the share of research done...
by companies with fewer than a thousand employees unlikely to be much higher than 5 percent.\textsuperscript{103} These private firms are also the primary engine of patent creation. Though not a completely fair comparison, the roughly 36,000 patents private firms generated for just electricity in 2014 is several orders of magnitude greater than the 700-odd patents National Labs produced that same year.\textsuperscript{102} This does not, however, imply that private firms are objectively superior to public entities in facilitating innovation, as patents are only one part—albeit a very important one—of the innovation process, and typically build upon the complementary and frequently concessionary research that public actors provide.

\textbf{Startup Assistance Organizations}

A smaller but still vital category of actor in the energy innovation space are SAOs. While typically still firms in a strict technical sense, SAOs advance the sector’s technological progress not by carrying out research but by \textit{facilitating} the innovative activities of other firms. The exact means by which it facilitates these innovative activities varies depending on the specific structure of the SAO and the maturity of the firm that it shepherds. For early-stage firms—typically those that have been recently spun out of university labs or won technology challenge competitions—the natural SAO partner is an accelerator, which works with the firm for typically between three and six months and provides “intensive programming to help the startup refine its business plan, develop a working prototype, and raise a seed round of funding.”\textsuperscript{103} Accelerators also play a crucial role in cultivating the professional networks that nascent firms need by connecting their supported startups with outside mentors, advisers, and potential partners. For relatively more mature firms—themselves often graduates of accelerators—incubators are often the next logical step. Though the term encompasses a wide variety of SAOs, incubators generally provide a shared workspace, access to specialized machinery, laboratories, and flexible manufacturing services designed to permit rapid prototyping and incremental improvements. In return, firms typically pay a monthly fee to the incubator, though a smaller—but not insignificant—number provide their services in exchange for an equity stake in the venture. At this point in a startup’s life, incubators can contribute to a firm’s ability to survive the so-called “valley of death”—the difficult period between the time a firm raises its first capital and the time it finally begins to generate recurring revenue.\textsuperscript{104} This period can be especially harrowing for energy firms. Unlike many service- or internet-oriented startups, most energy startups revolve around a physical technology, the production of which is relatively capital-intensive. As Quintero notes in his treatment, these hardware-oriented startups are subject to both a “manufacturing hell,” which reflects the fact that “fixed costs like injection mold tooling, factory NRE (non-recurring engineering)…[and] retail program fees are amortized over a small number of units,”\textsuperscript{105}

101. Ibid. The NSF report excludes data on companies with 20-49 employees for NAICS code 22.
thus diluting economies of scale, and a “fundraising hell,” which describes the difficulty in attracting more investors at a time when cash flow is negative and there is a mismatch between the certain-to-occur upfront costs of manufacturing and the uncertain revenues from future sales.\(^{106}\), \(^{107}\) Although they are not the only solution to these difficulties, incubators can provide a cost-effective means of navigating this difficult period, with Elizabeth Reichert noting in her paper that, ideally, startups graduate from an incubator having grown their personnel, “closed their Series A round of funding . . . actively selling to multiple customers . . . [and has their] own office and lab space.”\(^{108}\)

While several SAOs have proved undoubtedly successful,\(^{109}\) it is difficult to assess the SAO model as a whole, let alone evaluate energy-specific SAO models.\(^{110}\) The literature that does exist is somewhat mixed. SAOs have been criticized in various studies for not delivering on effective business incubation as a whole and, at universities in particular, distorting the innovation process by concentrating the activity in one place rather than dispersing it throughout the economy, suggesting that “the useful outputs they generate can be partially offset by reductions in innovation elsewhere.”\(^{111}\) Similarly, according to Tavoletti’s harsh 2012 assessment, “there is increasing evidence in the literature that, despite many successful cases and public policies supporting business incubation, most . . . [SAOs] are not successful at all and serious doubts have emerged about the general effectiveness of business incubation.”\(^{112}\) Other studies have been less pessimistic, and note that the success or failure of SAOs is highly dependent on their structure, and ultimately that they “can contribute to the development of a virtuous circle for the (regional) economy in which they are embedded.”\(^{113}\) In this vein, a 2007 study commissioned by the U.S. Economic Development Administration (EDA) found that “investments in business incubators generate significantly greater impacts in the communities in which they are made...[and] funds spent on business incubators appear to have the largest correlation with future economic growth” relative to alternative EDA investments in commercial structures, community infrastructure, industrial parks, and transportation infrastructure.\(^{114}\)

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\(^{106}\) Ibid.
\(^{107}\) A similar argument has been advanced by Gaddy, Sivaram, and O’Sullivan (2016) that venture capital models of investment and cleantech are poorly matched, as “cleantech offered VCs a dismal risk/return profile, dragged down by companies developing new materials, chemistries, or processes that never achieved manufacturing scale,” concluding that “the VC model is broken for the cleantech sector, which suffers especially from a dearth of large corporations willing to invest in innovation.”

\(^{108}\) Reichert, “How Energy-Focused Startup Incubators Have Grown into Hubs for Innovation and Economic Development.” (forthcoming)

\(^{109}\) See Greentown Labs, NYC Acre, Clean Energy Trust, and the Los Angeles Cleantech Incubator for examples of best-in-class SAOs in the energy space.

\(^{110}\) Christos Kolympiris and Peter G. Klein, “The Effects of Academic Incubators on University Innovation,” Strategic Entrepreneurship Journal 11, no. 2 (June 2017). Kolympiris and Klein argue, for instance, that “measuring the net economic effect of incubators is challenging because besides the effects on innovation efforts, the presence of an incubator may attract particular kinds of faculty and students...generate economic multiplier effects, and benefit the community as a whole,” creating a host of other variables that can muddle the analysis.


\(^{112}\) Ibid.


contention, experts agreed that SAOs are more likely to succeed when they have access to predictable financial resources\textsuperscript{115} and a supportive public policy environment. Although the assembled experts did not fully explore this latter point, Ernesto Tavoletti’s four principles for good SAO public policies seem particularly instructive, namely: “(1) protect weak-but promising ventures from the market . . . (2) take the region fully into account . . . (3) consider business incubation as a process, option-driven, relational and network based, not as a tangible investment . . . [and] (4) take advantage of . . . ‘virtual incubation’ approach to bring public supported business incubation into regions that cannot support a business incubator.”\textsuperscript{116}

**Innovation Clusters**

The third group of entities contributing to energy innovation are innovation clusters. A close cousin to “industry clusters,” these clusters are “groups of firms that gain a competitive advantage through local proximity and interdependence.”\textsuperscript{117} Through a process known as agglomeration, neighboring firms in an industry cluster benefit from “labour market interactions, from linkages between intermediate- and final-goods suppliers, and from knowledge spill-overs,”\textsuperscript{118} allowing them to be, ceteris paribus, more competitive and more innovative than their more distant peers. Innovation clusters can be organized along both formal lines, which establish a series of legal and commercial relations between participants—such as the Central Indiana Corporate Partnership—and informal lines, which describe the tendency of similarly oriented firms to naturally congregate in certain areas—such as the archetypal Silicon Valley.

Creating and deepening innovation clusters is understandably attractive to policymakers. As both experts and practitioners noted during the workshop, the ability to innovate is the primary determinant of a firm’s ultimate competitiveness. While innovations—technological, managerial, organizational, or otherwise—are not limited by geography, they are more likely to occur and be incorporated in areas that possess certain characteristics. As Porter argued in his seminal *The Competitive Advantage of Nations*, “competitive advantage is created and sustained through a highly localized process”\textsuperscript{119} which in turn reflects geographically-associated differences in “values, culture, economic structures, institutions, and histories,” which “all contribute to competitive success.”\textsuperscript{120} If true, the innovation cluster approach is useful, as it offers a scope that is commensurate to the magnitude of the task. More specifically, while the actual process of research, development, and innovation is primarily advanced at the firm level, the forces that influence firms’ abilities to make those innovations result from larger municipal- and regional-level conditions—precisely the levels cluster approaches address.

\begin{itemize}
  \item \textsuperscript{115} Several experts suggested that an obvious solution to the “hand-wringing” over access to clean finance is a carbon pricing mechanism, which could directly recycle revenues into SAOs or indirectly support SAOs by enhancing the financial incentives for clean energy technologies.
  \item \textsuperscript{116} Tavoletti, “Business Incubators: Effective Infrastructures or Waste of Public Money? Looking for a Theoretical Framework, Guidelines and Criteria.”
  \item \textsuperscript{117} Forthcoming publication: Joseph Parilla and Mark Muro, “Revisiting Cluster Strategies,” *Energy in America: Energy as a Source of Economic and Social Mobility* (Washington, DC: CSIS, 2019).
  \item \textsuperscript{120} Ibid.
\end{itemize}
Both practitioners and researchers acknowledge the utility of clusters as a unit of analysis. Drawing from their review of the literature, Parilla and Muro find that “both theory and academic research suggest that firms and regions benefit from clustering” and furthermore that “clusters are simply the reality of how regional economies are organized”\(^\text{121}\)—a point echoed by Joe Cortright’s argument that “the foundation of a regional economy is a group of clusters, not a collection of unrelated firms”\(^\text{122}\) and David Hart’s observation that the geographical clustering “of related industries has been observed since the days of Alfred Marshall in the late nineteenth century.”\(^\text{123}\) Subsequent research has shown that the development and deepening of clusters can yield material benefits for firms, governments, and innovation more broadly. According to a 2007 study by the Council on Competitiveness, “three-fourths of companies collaborate with their suppliers and customers to innovate, three in eight collaborate with similar companies and industries, and almost a third collaborate with university faculty,”\(^\text{124}\) suggesting that proximity to universities, customers, and suppliers is essential to innovation. The same study also found that clusters provide several benefits aside from increased innovation, namely: higher wages, higher productivity, higher employment, higher rates of entrepreneurship (both within the cluster and in adjacent areas), and greater sectoral diversification.

The benefits associated with industry and innovation clusters are well known to policymakers and city planners. As Parilla and Muro note, there has been an “embrace of cluster dynamics and strategies in recent years by federal agencies as well as by virtually every state and by scores of U.S. metropolitan areas.”\(^\text{125}\) Consequently, federal, state, and local governments have designed a plethora of programs intended to incentivize the development of clusters. At the federal level, this typically takes the form of initiatives designed to facilitate the organization of regional clusters by assisting “with planning and structuring the cluster, recruiting participants, building capacity, and securing the sustainability of institutions that will support the cluster.”\(^\text{126}\) Although federal support for clusters can arguably be traced back to the wartime industrial policies the federal government pursued during World War II, explicit support for cluster initiatives is a more recent phenomenon, beginning in 1980 following the passage of the Bayh-Dole and Stevenson-Wydler Technology Innovation acts, and intensifying following the Great Recession with the promulgation of the America COMPETES Act in 2007 and the American Recovery and Reinvestment Act in 2009. The key programs this corpus of legislation produced include: the EDA’s Regional Innovation Strategies and i6 Challenge programs, both of which provides commercialization assistance and grants to SAOs;\(^\text{127}\)

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121. Parilla and Muro, “Revisiting Cluster Strategies.” (forthcoming)
Energy in America: Energy as a Source of Economic Growth and Social Mobility

the U.S. Small Business Administration’s Regional Innovation Cluster Initiative, which provides technical assistance and support services to small businesses involved in industry clusters;\textsuperscript{128} the Department of Commerce’s U.S. Cluster Mapping Project, which collects and publishes data on regional clusters; and the Obama administration’s now-defunct trio of the Jobs and Innovation Accelerator Challenge, the Advanced Manufacturing Jobs and Innovation Accelerator Challenge, and the Rural Jobs and Innovation Accelerator Challenge, which funded public-private partnerships (PPPs) in key sectors. At the sub-federal level, policy support for clusters is typically executed on an ad-hoc basis by state and local governments, and typically take the form of PPPs for research, investments in universities, worker training and retraining initiatives, and support for government investment funds.

An alternative to analyzing government innovation cluster policies by level of government is to adopt the approach of David Hart and others and analyze policy by its typology. According to Hart, government policies supporting innovation clusters and economic development more broadly can be roughly grouped into five (mutually non-exclusive) categories or “tracks,” namely: (1) locational incentives, whereby “state and local governments cut taxes and make expenditures to induce external investments in new economic assets;”\textsuperscript{129} (2) R&D spinoffs, which seek to leverage federal R&D funding—typically from the DOE—to grow industries organically from within;\textsuperscript{130} (3) cluster deepening, which relies on “deepening existing regional strengths, rather than recruiting assets from the outside or growing new ones;”\textsuperscript{131} (4) market demand measures, which “use[s] demand from within the region to build an export platform;”\textsuperscript{132} and lastly—and less immediately relevant to clusters—(5) energy import substitution, which works to improve a city’s or region’s earning power “by substituting domestic resources for imported energy.”\textsuperscript{133}

Regardless of how cluster policies are analyzed, it is clear that government actors at all levels are cognizant of the perceived benefits associated with successful clusters and are willing to use policy to create, retain, and grow them. It is not, however, clear that these policies are always effective or cost efficient. As Parilla and Muro find, cluster policies’ “track record has more failures than successes,” leading them to conclude that although “[c]luster initiatives need not be spurned, or abandoned…they do need a rethinking.”\textsuperscript{134} While it is difficult to identify a single flaw in the approach due to the vast array of programs that constitute cluster policies and the wildly divergent economic circumstances in which they are advanced, the literature and assembled experts identified a few difficulties. First, many sub-federal leaders regard the support of clusters as a zero-sum exercise: with a finite stock of capital and a limited number of world-class firms, many decisionmakers believe that their task is not merely to convince companies to join their clusters, but to actively compete against their peer governments for them.


\textsuperscript{129} Hart, “Clean-Energy-Based Regional Economic Development: Multiple Tracks for State and Local Policies in a Federal System.” (forthcoming)

\textsuperscript{130} Ibid.

\textsuperscript{131} Ibid.

\textsuperscript{132} Ibid.

\textsuperscript{133} Ibid.

\textsuperscript{134} Parilla and Muro, “Revisiting Cluster Strategies.” (forthcoming)
According to several workshop participants, the intensity of this competition for talent, capital, and firms is further exacerbated by the perceived stakes, with Parilla and Muro arguing that the increasing concentration of wealth in fewer and fewer areas has led to a “justifiable worry among many regional leaders that they are being left behind in an era of uneven growth.” While this anxiety has produced extensive policy experimentation as decisionmakers test new initiatives in their quest to create “the next Silicon Valley,” it can also lead to investment for investment’s sake, as it is often preferable for elected officials to be seen doing something—prudent or not—rather than nothing.

A second challenge for innovation clusters arises from the consequences of the internecine competition for firms and innovators. In order to attract them, local governments will frequently offer “locational incentives,” which typically take the form of firm- or sector-specific tax cuts, or the extension of concessional financing. Prominent examples of such incentives include the reported $1.3 billion worth of tax credits and abatements Nevada offered to Tesla to secure one of the automaker’s major battery factories, the $2 billion worth of corporate income tax breaks Oregon granted to both Nike and Intel to encourage their expansion, and, more recently, the $1.53 billion and $0.57 billion worth of incentives offered to Amazon respectively by the governments of New York and Virginia to attract the company’s second headquarters. Although firms “typically state that other factors outweigh [locational] incentives when making site decisions,” such as proximity to markets, the availability of skilled workers, and input costs, firms “nonetheless play locations off one another to maximize offers.” This is not to say, however, that the idea is without merit: incentives—often maligned as “giveaways” by their critics—can be a sound investment if the economic activity enabled by the incentives produces enough benefits—also known as “positive externalities” or “spillovers” in the taxonomy of economics—to offset their cost. Unfortunately, most (but not all\(^\text{140}\)) research suggests that such locational incentives typically fail to produce the positive spillovers needed to recoup their costs. If true, then the jurisdiction-on-jurisdiction competition for clusters could produce “races to the bottom,” benefiting only the incentive-seekers at the expense of taxpayers and, possibly, incumbent firms.

A final and more general difficulty with innovation clusters stems from their artificiality. Cluster-creating activities are more likely to succeed when they complement an existing comparative advantage. This was, for instance, the experience of the Kendall Square and Seaport Innovation District clusters, both of which leveraged their proximity to the

\(^{135}\) Ibid.


\(^{139}\) Hart, “Clean-Energy-Based Regional Economic Development: Multiple Tracks for State and Local Policies in a Federal System.”

\(^{140}\) See Greenstone et al.’s 2010 conclusion that “there are substantial spillovers flowing from large new plants to incumbent plants” and that “national welfare is maximized when payments are made to plants that produce the spillovers so that they internalize this externality in making their location decision.”

world-class universities of the Greater Boston area to realize an existing comparative advantage in scientific and engineering research. Not all areas, however, have comparative advantages that are well suited for clusters. It is not clear, for example, how a rural agricultural area that has been hitherto disconnected from the knowledge economy could compete against clusters from urban areas with pre-existing competencies. As Muro and Parilla warn, “regional leaders cannot create clusters from scratch…[and] regions often fail to identify the right clusters, often choosing unrealistic or generic targets like biotech and advanced manufacturing,” a point reinforced by Hart’s recommendation that the would-be architects of clusters take “a long-term, asset-building perspective that leverages each region’s existing strengths” and by Rodríguez-Clare’s observation that it “does not matter in choosing which [specific] clusters to promote…rather, what matters is plain old comparative advantage.”

Innovation clusters are, however, but one category of actor in the energy innovation ecosystem. During their deliberations, the assembled experts repeatedly emphasized that all four of the energy innovators identified in this survey—(1) direct public R&D entities, (2) private firms, (3) SAOs, both public and private, and (4) quasi-public innovation clusters—had their parts to play in advancing energy technologies and practices. The diversity of energy innovation entities—many of which possess characteristics that blur the lines between the four rough typologies outlined here—reflects the complexity of the energy innovation space. This intricacy in turn makes it difficult to make sweeping claims about energy innovation. It is not, for instance, true that the government has no role to play in energy innovation, and the roles of the government in, inter alia, conducting basic science R&D, supporting the universities where nearly all researchers (private or otherwise) cut their scientific teeth, and financing long-term scientific initiatives are all essential. Without government actors to shoulder the costs of the externalities associated with innovation and referee the rules of the innovation economy, it is highly likely that quantity, quality, and timeliness of the next wave of energy innovations will be significantly impaired. There is a similarly important role for the private sector. Even if the majority of energy innovations could be developed entirely independently by the public sector, the dissemination and deployment of new energy technologies all but requires private commercialization efforts given the scale and pervasiveness of the incumbent energy technologies they would supplant.

During the workshop’s proceedings, participants coalesced around several conclusions on energy innovation that, while not universally shared or explicitly articulated, nonetheless conformed with the general spirit of the debate and the literature that informed it. First, most participants agreed that while government-directed R&D could be improved—namely by addressing the lingering tension between its mandate to commercialize technology and its mandate to focus on basic R&D—it continues to be essential and should be better funded. Second, policymakers must be cognizant that due to its inherently creative nature, innovation can be incented, but never forced. Third, and on a related note, policymakers

and market participants should be aware that even if technological breakthroughs occur, any energy transition is likely to be slower than is commonly expected by and large because energy infrastructures typically require decades to transition. Finally, both experts and practitioners agreed that the economic merits of public energy innovation initiatives—such as the opening of SAOs or the launch of innovation clusters—are rarely the first-order priority of elected officials when compared to the initiative’s employment or distributional consequences.

Over the past decade, domestic oil and gas production has increased dramatically, with daily production volumes growing from just 5.1 million barrels of oil and 52.8 billion of standard cubic feet (bcf) of natural gas in 2007 to 9.3 million barrels of oil and 74.8 bcf of natural gas in 2017. The United States is now the largest oil and gas producer in the world, a net exporter of natural gas, and projected by 2020 to be a net energy exporter for the foreseeable future. As discussed in greater detail in our preceding report, this largely unanticipated boon has improved the U.S. balance of trade, provided a significant boost to the economy—largely by lowering energy prices—and drawn significant investment to both upstream oil and gas firms as well as to downstream petrochemicals producers. There are limits, however, to how much domestic production insulates the United States from energy supply disruptions or price spikes, just as there are limits to how much economic growth, jobs, or trade benefits can be derived from increased production.

Similar limitations constrain the ability of governments to capture and utilize the revenue generated by the oil and gas activities that occur near or within their jurisdictions. At the aggregate level, we know that these revenues can be significant. According to one study, “the development of unconventionals contributed $430 billion to U.S. GDP in 2014 [alone], equating to roughly $1,400 for every American,” and that this contribution “can grow to about $590 billion by 2030.” The Congressional Budget Office (CBO) has noted a similar impact, recognizing that shale activity provides a two-part stimulus to economic growth, first by increasing productivity, which should “make GDP 0.4 percent higher in 2020 and 0.5 percent higher in 2040 than it would have been in the absence of shale development,” and second by increasing the stock of capital and labor, boosting GDP by

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an additional “0.3 percent...in 2020 and about 0.4 percent higher in 2040,” yielding a total gain of 0.7 percent by 2020 and 0.9 percent by 2040.\textsuperscript{150}

Some of the economic growth generated by the shale oil and gas revolution will be, and has been, captured by governments and used to fund public services. At the federal level, the shale revolution contributes to the federal budget through two channels. First, by improving productivity, spurring investment, raising wages, and boosting returns to capital, the development of oil and gas resources generates new incomes that can be captured through income, corporate, and payroll taxes—leading the CBO to estimate that revenues derived from the overall increase in economic activity “will be higher by 0.8 percent (or about $35 billion) in 2020 and by 1.0 percent in 2040 than they would have been without shale development.”\textsuperscript{151}

Second, the federal government also collects payments from private firms that pay royalties on the oil and gas produced on federal lands and rents on the lands themselves, with the former representing about 90 percent of payments, and the latter the remaining 10 percent. According to the CBO, “after adjusting for those payments to states...net federal royalties from all onshore oil and gas leases will average about $1.4 billion a year over the 2015-2024 period,” of which shale payments “will total about $300 million a year by 2024.”\textsuperscript{152} Overall, these oil and gas payments represent a significant part of federal income, with the amount remitted by the Bureau of Land Management (which manages the federal government’s mineral, oil, and gas assets) to the U.S. Treasury surpassed only by the Internal Revenue Service.\textsuperscript{153} However, and while discussed only briefly by workshop participants, several experts suggested that the federal royalty rate structure—which assigns to each lease the percentage of the value of production that must be paid to the government—ought to be revisited, though it is not clear exactly how. According to the Center for Western Priorities, for instance, federal royalty rates—particularly the 12.5 percent federal onshore rate, which hasn’t been updated since 1920—are “antiquated... [and] are depriving taxpayers and many Western states of urgently needed revenue,”\textsuperscript{154} leading them to conclude that policymakers ought to, inter alia, increase federal royalty rates to match the higher rates charged by the states, escalate royalty rates over the life of a project, or implement a sliding scale rate that reflects prevailing commodity prices. Conversely, while the GAO found that raising federal royalty rates “could decrease... production on federal lands but increase overall federal revenue,” the Agency also concluded that “the extent of these effects is uncertain and depends, according to stakeholders, on several other factors, such as market conditions and prices.”\textsuperscript{155} Regardless of their optimality, federal resource revenues are then distributed for public use,\textsuperscript{156} with

\begin{itemize}
\item \textsuperscript{151} Ibid.
\item \textsuperscript{152} Ibid.
\item \textsuperscript{156} “Natural Resources Revenue Data: How It Works,” U.S. Department of the Interior, 2018, https://revenueda-
the $8.9 billion raised in 2018 disbursed by the Office of Natural Resources Revenue to:

(1) the U.S. Treasury’s basic operating fund, which received 39 percent, which is used to pay for two-thirds of federal expenditures, including schools, parks, and national defense;
(2) state and local governments, which received 20 percent; (3) reclamation funds, which received 13 percent and are used to support infrastructure projects like dams and power plants; (4) Native American tribes and individuals, which received 11 percent; and (5) other funds, which received the remaining 16 percent and include the Historic Preservation Fund, land and water conservation grants—which are provided as matching grants to states and local governments—and the operating costs of the federal agencies that administer the federal lands on which production occurred.\(^{157}\)

The picture of revenue generation and utilization by state and local governments is more difficult to discern and generalize owing to their greater number and diversity, but is arguably more important to understand because it is at the local level that the majority of oil and gas impacts—both positive and negative—are most immediately felt. Starting on the income side of the ledger, oil and gas-derived revenues flow to state and local government through five primary channels, two of which are controlled by the federal government, and three by the local governments themselves. First, as part of the federalist compact\(^ {158}\) between the federal government and state and local governments, the latter two receive significant transfers—known as “grants-in-aid”—from the federal government. These transfers, which include federal Medicaid payments, housing grants, infrastructure grants, and means-tested entitlement payments, represent a significant source of revenue for states, a source which in FY2016 provided 32.6 percent of all state revenues.\(^ {159}\) Because these revenues are captured by way of taxes from economic activities around the country, they are logically affected by the economic activity of shale oil and gas firms—though the author is unaware of a precise measurement of the share of transfers that are derived directly from shale activity. Second, state and local governments are also entitled to a share of the payments the federal government collects in the form of the royalties, rents, leases, fees, and bonus bids levied on oil and gas activities occurring on government lands. While the aforementioned statistic that, as of 2018, state and local governments were directly entitled to around a fifth of the take, sub-federal governments also benefit from parts of the other disbursements, with the Bureau of Land Management estimating that, when taken together, “revenue is split about half between the U.S. Treasury and the states where development occurred.”\(^ {160}\)

While the fossil fuel-derived revenues that sub-federal governments receive from the federal government are significant, state and local governments also directly administer a whole host of other revenue channels, six of which are particularly notable: (1) state leases, which represent oil and gas revenues from production occurring on state lands;


\(^ {158}\) See Article I, Sections 8 and 9 of the Constitution, the Sixteenth Amendment, and Robert Dilger’s *Federal Grants to State and Local Governments: A Historical Perspective on Contemporary Issues*, for a more extensive review of the civics.


(2) state severances taxes;\textsuperscript{161} (3) other state fees similar to severance taxes that are levied on the volume or value of production; (4) local property taxes; (5) state corporate income taxes;\textsuperscript{162} and (6) indirect state and local tax revenues, which are levied on firms and individuals throughout the jurisdiction and are captured by sales and personal income taxes from the increase in overall economic activity oil and gas activity generates.

Quantifying the size of each of these flows in a holistic manner is difficult. According to the Census Bureau’s \textit{Census of Governments}, in 2017 there were 51 state governments and more than 90,000 local governments\textsuperscript{163}—each with their own rules on who can be taxed, what can be taxed, the means of taxation, and the rates of taxation. Consequently, most analyses of the fiscal impact of oil and gas activities on sub-federal governments focus most of their attention on severance taxes or state lease revenues and often exclude the other channels.\textsuperscript{164} Furthermore, these analyses typically focus on a single or limited collection of jurisdictions, which can frustrate efforts to engage in comparative analysis and draw general conclusions. But, even incomplete, these analyses provide an excellent sense of the relative magnitude of these flows and their varying importance across key oil and gas producing states.

Starting with the pioneering 2017 analysis of Newell and Raimi, which examines the top 16 oil and gas producing states in FY2013 (collectively accounting for 97 percent and 99 percent of U.S. gas and oil production volumes that year), the research suggests a few overarching conclusions about sub-federal fossil fuel revenue collection. First, and as can be seen in Figure 3 below (reproduced from the original paper), severance taxes provide the largest share of direct fossil fuel receipts—as opposed to indirect or induced fossil fuel receipts, such as the sales taxes earned by restaurants catering to fossil fuel workers—for eight of the sixteen states, and 50 percent of the sub-federal take of oil and gas receipts overall. It is important to note that severance and production taxes are typically levied on either the value/volume of production or on the net income of the producer. As Raimi and Newell note, “most other states [outside of Alaska] apply their severance or production taxes to the value or volume of produced oil and gas, leading to less volatility in revenue collection.”\textsuperscript{165} Their data also demonstrates the important role that leases of government land play in government finances, with 23 percent and 20 percent of the total direct oil and gas sub-federal revenue originating from lease payments occurring respectively on state and federal lands. Though termed “leases” or “lease payments” by the majority of the literature, these payments refer to four related categories of payment as defined by the

\begin{itemize}
  \item \textsuperscript{162} According to the Tax Policy Center, while seven states allow local governments to levy corporate income taxes, the amount extracted by local governments is relatively insignificant and highly concentrated, with the government of New York City representing “86 percent of all corporate income tax revenue collected by local governments.” Urban-Brookings Tax Policy Center, “State and Local Finance Initiative, Data Query System,” https://www.taxpolicycenter.org/briefing-book/how-do-state-and-local-corporate-income-taxes-work.
  \item \textsuperscript{165} Ibid.
\end{itemize}
Department of Interior: (1) bonuses, which are an upfront payment paid by the winning bidder on a per acre basis in order to claim the right to a particular lease; (2) rents, which are paid annually over the time that the lessee retains the rights to the property but before production has started; (3) royalties, which are assessed on the gross (i.e., not inclusive of costs) value of the amount of oil or gas produced on the property and are paid by the lessee to the lessor (in this case, the state or federal government); and other revenues, which includes minimum royalties mandated by law, payments from legal settlements, and interest payments. Second, while severance taxes account for the largest share of the take, the other channels are still significant, with state lease payments from state lands accounting for 23 percent of the total take by state and local governments, local property taxes for 20 percent, state lease payments from federal lands for 5 percent, and other state taxes for the remaining 2 percent.

Third, the available statistical evidence also suggests that the ability of state and local governments to capture the value of the oil and gas produced within their jurisdictions can vary significantly in both absolute and relative terms. By augmenting Raimi and Newell’s 2017 dataset with data from the U.S. Department of the Interior, it is possible to compute the share of the value of production (calculated as the product of the volume of production and the market price of that production) that producers pay directly to federal, state, and local governments—though this approach does exclude what Raimi and Newell term “indirect revenues,” namely, corporate income taxes, sale taxes, income taxes, and induced tax revenues. As Figure 3 below shows, while the 16 biggest oil and gas producing states capture on average about 11.6 percent of the market value of production, there is significant variation, with the Alaska and Wyoming collecting 38.8 percent and 30.3 percent and Ohio and Pennsylvania just 1.2 percent and 3.8 percent. Raimi and Newell

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Figure 3: State and Local Oil and Gas Revenue Sources

![Figure 3: State and Local Oil and Gas Revenue Sources](image)

Center for Strategic and International Studies | Energy and National Security Program
Source: Adapted from Newell and Raimi (October 2017)

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stress, however, that because “state and local governments tailor fiscal policies to fit their needs” that the low capture percentages seen in some states “does not necessarily indicate that a government requires additional revenues from the industry, and a high percentage does not necessarily indicate that government revenues are sufficient to manage any industry-related impacts.”

Viewed on a total basis, of the $269 billion worth of oil and gas that was produced in FY2013, $31 billion (or 11.6 percent) was paid to federal, state, and local government entities, with $28 billion going directly to the latter two groups.

Figure 4: Public Capture of Oil and Gas Revenues (FY 2013)

Deciphering how local governments utilize these oil and gas revenues is a similarly difficult task. Attempts to do so are complicated not only by the large and diverse number of subnational governments but also by the fungibility of government revenues. This latter issue has been noted by some as a particularly devilish challenge, as just because a revenue source is dedicated to a certain activity, “theoretically, the process of dedicating

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167. Newell and Raimi, “US State and Local Oil and Gas Revenue Sources and Uses.”
tax revenues to specific expenditures should have no impact on the composition of expenditures, because one dollar from one tax is perfectly substitutable for one dollar from another,” with most empirical state fiscal policy studies generally finding “that only a small proportion of dedicated revenues actually stick to intended expenditures.” However, examining the intended or declared uses of fossil fuel revenues is still important, if for no other reason than they illustrate the ways that elected officials frame—truthfully or not—the public benefits of oil and gas production. Here we return to the work of Newell and Raimi, and their analysis of the 16 largest oil and gas producing states as of FY2013, the results of which are visualized in Figure 4 below. According to their study of state and local government accounts and, when necessary, the relevant statutory provisions:

Although there is substantial variation among states, some general features emerge regarding how revenue sources flow to specific purposes. State severance taxes and similar mechanisms flow primarily to state current expenditures. Revenues from leases on state lands are mostly shared between state current expenditures and education trust funds, whereas revenues from federal leases tend to flow toward education current expenditures. Local property taxes support primarily education current expenditures (i.e., school districts) and local governments (e.g., counties and municipalities).

Figure 5: Allocation of State Fossil Fuels Revenues

While public officials undoubtedly value these revenues, the development and support of oil and gas activities is not a costless affair for governments. Notwithstanding the

environmental impact and the strain on public bureaucracies, fossil fuel production also creates several localized negative externalities. For instance, the construction, drilling, and completion of an average horizontally drilled single pad oil and gas well requires on average between 1,118\(^{172}\) and 2,300\(^{173}\) truck trips to complete, as cement trucks, frac tanks, equipment carriers, mud boats, water tankers, and numerous others travel to remote job sites. Due to their size and trip frequency, these vehicles can and do damage local roads—which in many jurisdictions were originally constructed without such heavy use in mind—with the Colorado Department of Transportation noting that the most common vehicle associated with well completion, water trucks, can place between 3,500 and 14,000 times as much strain on road condition as an average passenger car.\(^{174}\) Repairing and replacing roads damaged by this strain can be expensive: Montana’s Department of Transportation estimated in 2013 that the increased traffic associated with the exploitation of the Bakken Formation would require between $51 and $58 million dollars per year in additional roadway spending;\(^{175}\) Colorado’s Department of Transportation estimated a similar annual sum of between $10 and $30 million.\(^{176}\)

Increased traffic isn’t the only impact that states must manage. While an exhaustive treatment of the ensuing local externalities would require its own volume, a sample of the most commonly referenced\(^{177}\) include: skyrocketing demand for water resources—with water use per well in major shale plays rising 770 percent between 2011 and 2016;\(^{178}\) increasing noise pollution from pumpjacks, engines, compressors, and vehicles; mounting public safety concerns, which in turn reflect increases in crime, accidents, and public disturbances; concerns from non-fossil fuel employers over wage inflation and workforce retention; and the visual disfigurement of local landscapes. Although the author is unaware of a study that aggregates these various costs—which are often calculated in ways that are not analogically comparable—into a single figure, these costs are real, significant, and ought not to be discounted.

But workshop participants—local economic development officials in particular—also stressed that these costs must be viewed alongside the benefits produced by fossil fuel development. And while the large number of cases of fossil fuel development, the diversity of the governments and their prevailing conditions, and the lack of directly comparable figures preclude a clean, empirically informed quantitative cost-benefit analysis at the local level, the available qualitative evidence suggests a few trends. First, we return to the work of Newell and Raimi, who found following their interviews with roughly 250 local

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174. Felsburg Holt & Ullevig, and BBC Research & Consulting, *Oil and Gas Impacts on Transportation*.
176. Felsburg Holt & Ullevig, and BBC Research & Consulting, *Oil and Gas Impacts on Transportation*.
government officials from major fossil-fuel producing regions that “despite volatility in
revenues and service demands…74% of local governments have experienced net fiscal
benefits, 14% reported roughly neutral effects, and 12% reported net fiscal costs” and
that these revenues have typically been deployed “to upgrade or expand services and
infrastructure, save funds for future expenditures, and/or reduced local taxes.” This
does not seem to be an anomalous finding, and is supported by, inter alia, Bartik et al.’s
finding that “allowing fracking equals about $1,300 to $1,900 per household annually…
among original residents of counties with high fracking potential,” Jacobsen’s conclusion
that “bans on drilling have negative monetary consequences for a large share of local
residents,” and Boslett et al.’s study on the impact of New York’s temporary moratorium
on development that “properties that were most likely to experience both the financial
benefits and environmental consequences of SGD [shale gas development] dropped in
value 23% as a result…[indicating] a large and positive net valuation of SGD.” Second,
the existing literature suggests that communities that directly benefit from fossil fuel
production activity are more likely to support those activities than communities that
do not—a logical finding that comports with the political science literature’s general
observation that citizens are more likely to support an activity if they benefit from it. Similarly, while support for domestic fossil fuel production at the national level is sharply
divided along political lines, with 80 percent of polled Democrats favoring the reduction
of fossil fuel usage compared to just 37 percent of Republicans, political identity
matters less to communities that directly interact with—or have the potential to—fossil
fuel production, with a 2016 study of attitudes towards unconventional oil and gas
development finding that “as respondent’s geographic distance from areas experiencing
significant development increases, political ideology becomes more strongly associated
with issue support, with the liberal-partisan divide widening.”

Taken together, these observations suggest that the communities that are closest to
fossil fuel development, and that therefore have the greatest potential to be immediately
impacted by fossil fuel development, have typically concluded that the benefits outweigh
the costs. Generally, the areas with the greatest support for further fossil fuel development
are the areas with the most experience with—and, presumably, the greatest knowledge
of—the implications of their choice. As Raimi notes in his 2017 book, “in parts of Texas,

183. According to Paydar et al.’s study of Pennsylvanian attitudes towards unconventional gas development, the disbursement of revenue associated with fossil fuel development to local communities “is positively associated with support for the project.” Naveed Paydar, Ashley Clark, John Rupp, and John Graham, “Fee Disbursements and the Local Acceptance of Unconventional Gas Development: Insights from Pennsylvania,” Energy Research & Social Science 20 (October 2016).
Oklahoma, New Mexico, and other regions where drilling rigs, pumpjacks, and pipelines have long been a mainstay of the local landscape, there tends to be far less concern over, and opposition to, fracking and all of the issues that come with it. In other parts of the country, where the sights and sounds of the industry are new, locals understandably tend to have more questions and in many cases more concerns. 

While this augurs well for the economic value proposition of domestic oil and gas activity to local communities, wise policy ought to consider and account for the impact on non-local communities and those less prevalent, though still relevant, cases where local costs have outweighed local benefits.

Historically, justice has not played a central role in U.S. energy policy, where it has typically been subordinated to competing concerns over prices, jobs, reliability, safety, sustainability, and trade. This is changing. Whether due to rising inequality and economic anxiety, growing recognition of climate change, or an increasing willingness to grapple with past wrongs, justice has emerged as a key dimension of the energy discussion. But justice—energy or otherwise—is not a concept that easily lends itself to objective and definitive analysis. According to one definition popular in the environmental law cannon, an energy just world is one that:

equitably shares both the benefits and burdens involved in the production and consumption of energy services, as well as one that is fair in how it treats people and communities in energy decision-making. In other words, we see importance to both substantive outcomes and decisional procedures. Energy justice, thus, involves the right of all to access energy services...It encompasses how negative environmental and social impacts related to energy are distributed across space and time...Energy justice ensures that energy permitting and siting do not infringe on basic civil liberties and that communities are meaningfully informed and represented in energy decisions.

While the concepts are relatively easy to understand, the methods of promoting and delivering justice are far less defined. Justice has nonetheless emerged—Salter et al. date its genesis in the academic literature to 2013—as a central preoccupation of those affected by, and working to affect, the energy transition. According to the World Energy Council, energy justice arises from the balance between the three legs of their “world energy trilemma”: energy security, environmental sustainability, and energy equity. The Paris Agreement, for its part, declares that its prescriptions must take “into account the imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities”—a sentiment echoed by the

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190. Paris Agreement.
International Labor Organization (ILO)’s conclusion that a “just transition for all towards an environmentally sustainable economy...needs to be well managed and contribute to the goals of decent work for all, social inclusion and the eradication of poverty.”\textsuperscript{191} This latter sentiment of the ILO that justice ought to be ensured for not only those affected by energy externalities but also for those workers whose livelihoods have hitherto been dependent on the production of those very same externalities is an especially prominent—and frequently contentious—theme in the labor movement, where it has a long history, with the phrase “just transition” originally used by U.S. and Canadian trade unionists to describe the quid pro quo that ought to be offered to workers displaced by environmental regulations.\textsuperscript{192} Labor organizations whose members include those employed by, or dependent on, the fossil fuel industry have typically stressed that these workers must be compensated or protected in a just energy transition, with the AFL-CIO, the largest federation of unions in the United States, stating in a 2017 resolution that “the AFL-CIO will fight politically and legislatively to secure and maintain employment, pensions and health care for workers affected by changes in the energy market,”\textsuperscript{193} and in 2019 that “we will not accept proposals that could cause immediate harm to millions of our members and their families.”\textsuperscript{194}

The last framework explicitly incorporating justice into its energy policies is also the most immediately relevant: the Green New Deal (GND). At the time of workshop’s original conception, the most developed versions of the GND had yet to be committed to paper—let alone legislation—and existed primarily in the public statements of elected officials and Twitter exchanges of public intellectuals. It is therefore something of a testament to the captivating quality of the GND that much of the workshop’s discussion either directly or indirectly referenced the GND. While interpretations differ, the GND is, at this juncture, best thought of as a framework that establishes both a climate objective and a series of requirements that the policies used to achieve it should adhere to. As David Roberts observes, “the GND resolution is not a policy or a series of policies. It is a set of goals, aspirations, and principles. It purposefully puts the vision up front and leaves the policymaking for later.”\textsuperscript{195} This does, however, complicate the analysis, not only because the GND is still evolving, but also because there are different documents that have a reasonable claim to the intellectual paternity of the GND vision. The most formal GND representation is the congressional resolution drafted by Representative Alexandria Ocasio-Cortez and Senator Ed Markey. In it, justice takes a central role, with the document proclaiming that climate change, pollution, and environmental destruction have “exacerbated systemic racial, regional, social, environmental, and economic injustices” and that the GND will work “to counteract [these] systemic injustices” and meet its climate objectives.

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A similar focus can be found in Data for Progress’s *A Green New Deal*, and New Consensus’s *The Green New Deal*—both of which have emerged as foundational but unofficial blueprints of the GND. According to the former publication, “justice requires a green new deal” and “a foundation of justice can work to resolve inequity, specifically through a set of Environmental Justice Standards and Job Quality Standards.”196 Similarly, New Consensus argues that the GND “comprehensively address[es] the crises of climate change, poverty, extreme inequality, and racial and economic injustice” by mobilizing society “to participate in a grand national project: the rapid transition to a ‘good society’—a society of broad opportunity, equal occupational and political justice, productive prosperity, and environmental sustainability.”197 Taken together—insofar as that is possible given the diversity of their authorship—the GND approach to justice folds the challenge of addressing climate change into the idea of addressing much broader manifestations of inequality. On one hand, this represents a significant departure from the justifications and objectives of past energy policies. While not a completely fair comparison given the technical nature of the latter, it is telling that the 2,600-word draft floated by Representative Ocasio-Cortez and Senator Markey references “justice” and “equity” nearly 20 times, while the word “justice” appears just once in the 264,000-word Energy Policy Act of 2005,198 the last major energy omnibus to pass Congress. On the other hand, energy policy discussions have not been heretofore completely devoid of equity and justice issues. As highlighted in our first paper, economists and policymakers have taken into consideration the distributional impacts of energy policies in some cases and there are energy policies geared toward lessening the impact of energy costs on low-income households. The GND frameworks suggest that disadvantaged communities have borne the economic and environmental brunt of energy and infrastructure policies historically and will be the least able to adapt to the impacts of a changing climate. It should, however, be noted that the justicial and distributional consequences of energy policies were not unknown to policymakers prior to the advent of the GND. According to many of the assembled experts, these issues have been addressed—albeit with varying degrees of success—and considered in previous energy policy frameworks. The novelty of the GND’s approach to justice then stems not from the simple existence of justicial concerns, but rather from the degree of emphasis placed on those concerns and the elevation of justice as a means for evaluating energy policy outcomes.

Current proposals for policies designed to address the intersection of justice and energy typically take one of four forms: first, there are those policies that lessen or provide compensation for individuals and communities affected by energy’s immediate environmental externalities; second are those that provide a just transition (typically in the form of compensation) for workers whose livelihoods would be threatened by energy policy decisions, namely those employed in the fossil fuel industry; third are policies such as climate mitigation actions and climate adaptation measures that seek to protect those groups that are disproportionately burdened by climate change; and fourth, policies that seek to harness investment in energy goods and services to benefit underserved groups.

Each of these can be difficult to implement and all of them require trade-offs—frequently with one another. For example, limited capital availability has frequently stymied efforts to promote a just transition for workers exiting the fossil fuel sector. Drawing on their experience with economic development in hard-hit coal regions of Pennsylvania, Simeone et al. notes that “it goes without saying that financial resources available to assist people and places impacted by the coal downturn are scarce...a reality that often hinders the ability to implement revitalization or redevelopment strategies.”  

The problem isn’t a lack of ideas or policy options: economic development officials have many programs to choose from, such as training programs, technology sharing, financing opportunities, community planning, and sectoral diversification incentives. But how do you evaluate which policies to use and, by extension, whom to help? Should the priority be helping workers displaced—deliberately or not—by market trends and political choices, or should it be to focus on workers who have never had a job to be displaced from?

While crafters of energy policy are increasingly embracing the importance of justice, the metrics, methods, and desired outcomes of delivering justice are not yet clearly defined. Moreover, the complex interaction of policies designed to deliver economic and environmental justice, policies designed to deliver local economic opportunity, and policies to decarbonize the energy section is often accompanied by trade-offs. Perhaps the most important trade-off stems from the tension between capital efficiency and energy objectives. It is important to note that this tension is not the same as the debate over how policies are paid for. Instead, it is a recognition that there is a limit to the amount of resources—or capital—that can be directed towards energy policy objectives. There are many laudable and vital energy objectives including job creation, social justice, climate change mitigation, and price stability. And not all of these objectives are in tension with each other, and some are even complementary. But with scarce resources, the support of one objective is likely to come at the relative expense of another priority. Perhaps the best illustration of this is the tension between job creation and climate change mitigation. According to a January 2019 Pew Research Center study, both of these issues are important to voters, with 50 percent and 56 percent of voters polled agreeing that the respective issues “should be a top priority for [President] Trump and Congress this year,” ranking them as the 8th and 10th most pressing issues for the country.

These two issues are to some extent harmonious: investing in, say, solar power will create new jobs—jobs that, in the case of solar installation, primarily accrue to less-wealthy Americans—and the new solar generation can be used to displace dirtier greenhouse gas (GHG)-intensive sources of generation, thus benefiting the climate. But not all policies are created equal. For instance, public and private capital could be used to support (or subsidize) the installation of distributed residential-scale solar assets or the installation of more concentrated utility-scale solar assets. Which approach deserves capital? A strategy that places its relative emphasis on residential-scale assets is likely to create more

jobs, as it is a more labor-intensive process. It can also be argued that residential-solar provides numerous social benefits, namely the “democratization” of electricity generation. But this labor intensity means residential-solar projects typically “pay lower wages and offer more limited benefits”\textsuperscript{201} than utility-scale projects. Furthermore, they usually produce less renewable electricity per dollar of subsidy, with one MIT study concluding that “subsidizing residential-scale solar generation more heavily than utility-scale solar generation…will yield less solar generation (and thus less emissions reductions) per dollar of subsidy than if all forms of solar generation were equally subsidized.”\textsuperscript{202}

What should the priority be? Should it be to maximize the number of jobs created or to maximize the deployment of renewables and, by extension, to minimize GHG production? Which investment provides justice? These questions are not proposed idly or rhetorically. As workshop participants noted, there are some clues that can provide partial answers. Most of the literature, for instance, concludes that economic and workforce development programs are usually best implemented through “place-based strategies” that “address the physical, social, structural and economic conditions of a community…[and use] local solutions to poverty and inequality by addressing community-level problems.”\textsuperscript{203} These strategies stand in contrast to “people-oriented strategies,” which are “focused on human capital and improving access and mobility for individuals...regardless of where they live.”\textsuperscript{204} This preference for place-based strategies over people-oriented strategies reflects not only their greater effectiveness but also their superior political legitimacy—unsurprisingly, workers seem to respond best to programs that take into account their individual circumstances, which are informed in turn by those of their community. This can help inform what energy justice ought to be, as it suggests that that justice and the policies that pursue it ought to be tailored to those that are most immediately affected. Insight can also be gleaned from recent experience. As the gilets jaunes (yellow vest) protests in France have shown, there are limits to the kinds of policies that voters will accept if those policies are perceived as unjust. While the taxes and policies that sparked the movement may have been needed and well-intentioned, their impact has been tainted—perhaps irrevocably so—by their failure to secure the acquiescence of the citizens most affected by them.


\textsuperscript{202} Ibid.


Conclusion

Energy has always been an important part of the modern U.S. economy and has in turn held a high place among the country’s political priorities. But today, energy policy is being asked to do more than ever before. The processes that control the production, distribution, and consumption of energy resources—and the rules that govern them—are increasingly expected to not only satisfy their traditional obligations on price, reliability, and cleanliness, but also to create economic opportunity in ways that address economic insecurities, alleviate multiple forms of inequality, and confront the impacts of climate change. Based on our research and our deliberations with workshop participants, we argue that these new expectations are being—or have traditionally been—targeted through four kinds of policies related to the energy sector: jobs policies, which work to affect the quantity and quality of employment either directly in the energy industry, or indirectly in the wider economy; innovation policies, which seek to generate economic activity by supporting or incenting energy research; energy revenue policies, which govern the ways that sub-federal governments capture and utilize revenues derived from the production of oil and natural gas; and, finally, frameworks for evaluating environmental and social justice.

It is clear that energy policy alone cannot solve society’s broader concerns over economic insecurity and inequality, but it will nonetheless be called upon to make a contribution toward that end. In the policy areas we examined, a few key themes emerged:

- **Jobs** - As demonstrated in our earlier companion paper, given its relative capital intensity, energy is not a large source of direct or indirect employment relative to the entire workforce, but energy-related jobs can and do make up a significant portion of the workforce in certain parts of the country. When coupled with the U.S. economy’s accelerating reorientation towards services and the decreasing energy intensity of its remaining manufacturers, energy’s capacity to induce hiring is relatively limited and therefore expectations for job creation should be tempered. This is not to say that energy is economically inconsequential—far from it. Rather, it is to stress that energy is best appreciated as an input into other economic processes rather than as an economic process itself. Thus, any economic and job development strategy should take into consideration the role of energy in the entire economy and not simply the direct economic impact of energy-related investments and activities.

- **Innovation investments** - Similarly, we also find that the government’s efforts to create innovation hubs, opportunity corridors, and startup assistance organizations
have had more failures than successes. This is not to say that the theory behind these activities is misguided but instead suggests that cluster-creating activities are more likely to succeed when they complement an existing comparative advantage and avoid the most common pitfalls of setting unrealistic or generic targets and not providing adequate fiscal and institutional capacity to last for more than just a few years. Based on the research provided for this workshop, the most successful innovation cluster strategies focus on establishing a robust ecosystem instead of quick job gains; involve industry drivers, university expertise, and government funding; place informed and carefully calculated bets on technological winners; have dedicated and passionate leadership; and are anchored around a physical center. More research and review of innovation cluster and R&D strategies to generate economic opportunity will also be necessary going forward.

- **Oil and gas revenue** - Given the wide variety of ways in which sub-federal governments capture and utilize fossil fuel revenues, additional research is necessary to evaluate the best practices among states and local communities with sustained oil and natural gas production. These include better anticipating expenditure needs to minimize lag time between collection of revenue and the impacts of production; protecting the community from fiscal volatility resulting from oil market cycles; and being careful to understand the distributional implications of spending during periods of increased revenue.

- **Justice** - Finally, while the recognition that energy policies have justicial consequences is important and long overdue, the existence of trade-offs and lack of clarity on metrics of success currently makes implementation difficult. We identified four energy-related categories of action: (1) policies that lessen environmental impacts from energy production or use for low-income communities; (2) just transition programs for workers whose livelihoods are threatened; (3) climate mitigation actions and climate adaptation measures that seek to protect those groups that are disproportionately affected by climate change; and (4) policies that seek to harness investment in energy goods and services to benefit underserved groups. Of the four, the first and third are arguably the areas where policy and regulatory measures exist to address these issues—even if they are not being implemented today in ways that can remedy the problem. Just transition policies and programs have not been tremendously successful and, if a priority, should be carefully examined for effectiveness. None of these policies, however, can be relied upon to fully alleviate environmental or social justice issues, many of which fall outside the realm of energy policy.

As was true in previous decades, energy policy must continue to deliver on the ever-present demands for affordable, reliable, and ever-cleaner energy supplies, but in today's context, energy's contributions to durable economic growth and social mobility are also extremely important—if not for the economic efficiency of the energy system then for the political viability of it. Policymakers would do well to ensure that energy policies that can contribute to these broader goals—chief among them addressing climate change in our view—are as effective and efficient as possible, but also appreciate the limitations for energy when it comes to addressing these issues in full.
About the Authors

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